ABSTRACT

Title of Thesis: Protective Laboratory Measures for the Flexible Wall Permeameter and the Atterberg Limits Tests using Hazardous and Toxic Chemicals

Robert A. Tetla Jr., Master of Science in Environmental Engineering/Toxicology, 1985

Thesis directed by: Professor John Schuring Jr.

Safety procedures for performing geotechnical testing with hazardous and toxic materials, excluding radioactive wastes, are developed for the Flexible Wall Permeameter and the Atterberg Limits Tests. The tests were evaluated in detail to determine the critical points at which the technician would be exposed to the hazardous and/or toxic permeant. It was found that the following safety measures should always be taken; 1) the apparatus and all testing should be undertaken in a sliding sash hood using the proper face velocity, 2) air monitoring using a personal dosimeter and/or a detector tube is required to assure that the concentration of the permeant in the atmosphere does not exceed the Threshold Limit Value Time Weighted Average, 3) safety goggles must be worn at all times while in the laboratory, 4) protective gloves must be worn whenever handling the permeant or soils contaminated with the permeant, and 5) a properly fitting respirator that is specifically designed for the permeant being used should be readily available in case of an emergency.

If the Flexible Wall Permeameter cannot be placed in a sliding sash hood, the above protective measures are still followed, however, the the following things are modified; 1) an open canopy type hood should be placed above the apparatus, 2) the reservoir on the apparatus is replaced

with an air tight reservoir, 3) there is a more stringent requirement on the frequency of air monitoring, and 4) all venting lines and de-airing lines which are connected to the permeant are positioned under the open canopy hood.

To develop these procedures, properties of the permeant, chemical, such as; 1) solubility, 2) reactivity, 3) toxicity, 4) vapor pressure, and 5) its allowable exposure limits (Threshold Limit Values), were evaluated. A general chemical information form was developed to expedite data gathering and to allow a methodical determination of protective procedures for each individual chemical. For illustration purposes, this form is completed for: benzene, trichloroethylene, and phenols.

PROTECTIVE LABORATORY MEASURES FOR THE FLEXIBLE WALL PERMEAMETER AND THE ATTERBERG LIMITS TESTS USING HAZARDOUS AND TOXIC CHEMICALS

by
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SECTION 1

INTRODUCTION

Millions of pounds of chemicals are transported and stored annually, and a large portion of these chemicals are hazardous and toxic. The Consumer Product Safety Commission defines a hazardous substance as: "any substance or mixture of substances which (i) is toxic, (ii) is corrosive, (iii) is an irritant, (iv) generates pressure through decomposition, heat, or other means, if such substance or mixture of substances may cause substantial personal injury or substantial illness during or as a proximate result of customary or reasonably foreseeable ingestion by children."[1] A toxic substance defined by the same commission: is "applied to any substance (other than a radioactive substance) which has the capacity to produce personal injury or illness to man through ingestion, inhalation, or absorption through any body surface."[2]

Spills or leakage of such materials into the ground may result in contamination of: 1) the ground water table, such as in Love Canal; 2) surface water, such as "the complete destruction of aquatic life in a lake by less than 1 kg of endrin;"[3] or 3) the soil itself, such as unsaturated soil contaminated by a leaking storage tank. These leaks or spills may occur from many different sources, including: 1) accidental surface spills; 2) leaking lagoons or storage tanks; and 3) hazardous

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1. Allen M. Kohan, Summary of Hazardous Substance Classification Systems, p. 6
2. Ibid., p. 6
3. J. E. Zajic and W. A. Himmelman, Highly Hazardous Materials, Spills and Emergency Planning, p. 5

waste landfills.

With a large emphasis to cleanup the environment, ways have to be developed to improve liners in lagoons and/or landfills, and new ways have to be developed to improve the cleanup of such spills or leakages. In order to do this soils must be tested to: 1) determine how these chemicals interact with the soil; and 2) identify which soils would be the best to use as liners in lagoons and landfills.

New geotechnical tests, such as the Flexible Wall Permeameter, along with older tests, such as the Atterberg Limits, are now used to test the permeability of the soil and the interaction between the soil and the chemical. However, since geotechnical testing requires the intimate contact with the permeant and the soil being used, protective measures are essential to protect the technician from exposure to the chemicals, either hazardous and/or toxic, that will be used.

Traditionally, laboratories which handle hazardous and toxic chemicals use various protective measures such as; ventillation hoods, protective gloves and aprons, respirators and face protection. These were used as a basis for the evaluation of which measures should be taken in the geotechnical laboratory. In addition, since the flexible wall permeameter is a relatively new piece of equipment, some hardware modifications are necessary to further protect the technician.

The protective measures and equipment that will be used also depend on the properties of the chemical. The important properties include: vapor pressure; toxicity; flash point; reactivity; solubility; and its allowable exposure limit (Threshold Limit Value). Since these properties vary for each chemical, each individual chemical must be evaluated for each geotechnical test. A uniform, simplified procedure for accomplishing this was an essential goal of the research.

The body of this thesis will begin with a presentation of background information on Threshold Limit Values, chemical classifications, general laboratory protection, and the Right to Know Law (section 3). Pertinent chemical properties of non radioactive substances will then be identified and discussed (section 4). The two subject geotechnical tests will then be evaluated to determine the critical exposure points culminating with specific recommendations for protective measures and procedures (section 5).

SECTION 2

STATEMENT OF THE PROBLEM AND JUSTIFICATION FOR RESEARCH

Hazardous and toxic liquids in the subsurface environment may originate from many different sources including: 1) accidental surface spills, 2) leaking lagoons and storage tanks, and 3) hazardous and toxic waste landfills. Evaluation of sites containing hazardous and toxic wastes usually requires an accurate determination of the soil permeability and other mass transport properties. These soils may be either natural, eg. a water supply aquifer, or man-placed, eg. a clay landfill liner.

It is now well established that chemical liquids, other than water, may interact with the soil and change its properties. As a result, geotechnical laboratory testing has become popular to determine the nature of these interactions. This requires that highly toxic chemicals be handled and used in apparatuses which are not necessarily designed for these substances. Furthermore, since geotechnical testing is usually partially or totally manual, it frequently requires intimate contact with the soil. Technician exposure to the hazardous and toxic permeant is therefore unavoidable. This thesis project is a direct response to these new hazards in the geotechnical laboratory.

The purpose of this thesis is to develop safety measures and procedures for performing two geotechnical tests using hazardous and toxic chemicals. These tests are the Flexible Wall Permeameter and the Atterberg Limits (liquid, plastic and shrinkage limits). In order to accomplish this, test apparatuses and procedures had to be carefully evaluated to determine the critical points where exposure to the technician may occur. Protective measures were then developed for the apparatus and for the technician.

The protective measures to be used for a particular geotechnical test will of course vary, since the properties of the chemicals differ. It is first necessary to define the toxicity of the chemical, its toxic effects as well as its allowable exposure limit (Threshold Limit Values). Since this information is scattered in a variety of sources, a general "chemical information form" was developed to expedite data gathering and allow for uniform determination.

SECTION 3

BACKGROUND INFORMATION

3-1 Threshold Limit Values. The Threshold Limit Values (TLV), represent concentrations of airborne substances, either chemical or physical, believed to cause no adverse effects to most workers exposed to them on a day by day basis. The susceptibility to these substances at concentrations equal to or below the Threshold Limit Values may vary from worker to worker, depending on the worker's sensitivity to that chemical. Therefore, some workers may show discomfort while working with them.

The Threshold Limit Values "are based on the best availible information from industrial experience, from experimental human and animal studies, and, when possible, from a combination of the three. The basis on which the values are established may differ from substance to substance; protection against impairment of health may be a guiding factor for some, where as reasonable freedom from irritation, narcosis, nuisance or other forms of stress may form the basis for others."[4]

These values, were adopted by the American Conference of Industrial Hygienists (ACGIH) in 1963 and are also used by both the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA), as exposure limits. These values (TLV) should be used as a guide in the control of hazardous and toxic chemicals in the work place and laboratory, and should not be used as criteria to distinguish between safe and dangerous

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[4] American Conference of Government Industrial Hygienists, Threshold Limit Values., 1980, p. 2

concentrations.

The Threshold Limit Values are broken into four categories, which are: 1) Threshold Limit Value-Time Weighted Average (TLV-TWA); 2) Threshold Limit Value-Short Term Exposure Limit (TLV-STEL); 3) Threshold Limit Value-Ceiling (TLV-C), and, 4) Threshold Limit Value for Mixtures.

3-1.1 The Threshold Limit Value-Time Weighted Average (TLV-TWA), represents the average concentration of a substance that a worker may be exposed to over an eight hour workday, and a forty hour workweek, without suffering any adverse effects. For some substances, the worker may be exposed to concentrations higher than the time weighted average, as long as it is compensated by an equal exposure at a lower concentration during the workday. The Threshold Limit Value Time Weighted Average of substance may be calculated using the following equation:[5]

$$(1) \qquad E = \frac{(C_1T_1)+(C_2T_2)+\ldots\ldots\ldots(C_nT_n)}{\text{Daily hours of exposure (usually eight)}}$$

Where: E= eight hour time weighted average of exposure

C= concentration of the substance during which time the concentration remains constant

T= time in hours that the worker is exposed to concentration C

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[5] Paul N. Cheremisinoff, Management of Hazardous Occupational Environments, p. 30

3-1.2 The Threshold Limit Value-Short Term Exposure Limit (TLV-STEL), represents the maximum concentration, of a substance, that a worker may be exposed to for a period of usually fifteen minutes (unless otherwise noted), with at least sixty minutes between exposures, and not exceeding more than four exposures at this level per workday, without suffering any adverse effects. When working with this value, the Threshold Limit Value-Time Weighted Average (TLV-TWA) should not be exceeded.

3-1.3 The Threshold Limit Value-Ceiling (TLV-C), represents the maximum concentration of the substance that should not be exceeded at any time. This notation is usually used when the substance is fast acting and is one "whose threshold limit is more appropriately based on this particular response."[6]

In addition to these three categories, some substances will have the notation "skin" next to it. An example of this would be toluene (toluene-skin). This notation means that exposure to the substance, usually in liquid form, can occur through both cutaneous absorption as well as inhalation. The following table gives examples for each category discussed herein.

Table 1. Threshold Limit Values for chosen substances.

Substance	TLV-TWA	TLV-STEL	TLV-C
Benzene	10 ppm	50 ppm for 10 minutes	25 ppm
Trichloroethylene	100 ppm	200 ppm for 30 minutes	*****
Toluene-skin	100 ppm	150 ppm	*****

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6. American Conference of Government Industrial Hygienists, p. 4

3-1.4 The Threshold Limit Value for Mixtures, is based on whether or not two or more hazardous and/or toxic substances affect the same organ system. If the substances affect the same organ system, the combined, and not the individual, effects of the substances should be considered. The Threshold Limit Value for the mixture in this case may be calculated by using the following equation:[7]

$$T_m = \frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{\cdots\cdots\cdots\cdots \; C_n}{T_n} \qquad (2)$$

Where: T_m = Threshold Limit Value of the mixture

C = Concentration of each individual substance in the atmosphere

T = Threshold Limit Value Time Weighted Average of the substance

The Threshold Limit Value of the mixture is not exceeded if the sum sum of all fractions ($C_1/T_1 + C_2/T_2 + \cdots\cdots C_n/T_n$) is less than or equal to one.

If it is determined that the substances in the mixture affect different organ systems or do not have an additive effect, the individual effects of the substances in the mixture should be used to calculate the Threshold Limit Value of the mixture. In this case, the Threshold Limit Value of the mixture is not exceeded as long as none of the individual fractions (C/T) is greater than one. For examples of these, see Appendix A.

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7. Ibid., p. 45

3-2 <u>Chemical Classification using the Threshold Limit Values</u>. Upon determination of the substances Threshold Limit Value-Time Weighted Average, it may then be classified into one of five groups. These groups are as follows: 0) Insignificant Hazard; 1) Slightly Hazardous; 2) Hazardous; 3) Highly Hazardous; and 4) Extremely Hazardous. These determinations are used by OSHA and "are based on Title 29 (Labor), Code of Federal Regulations, Section 1910.93."[8]

Group 0, Insignificant Hazard, is given to all substances which have a Time Weighted Average of 1000 parts per million (ppm) or higher; Group 1, Slightly Hazardous, is given to all substances with a Time Weighted Average between 100 and 1000 parts per million; Group 2, Hazardous, is given to all substances with a Time Weighted Average between 10 and 100 parts per million, Group 3; Highly Hazardous, is given to substances with a Time Weighted Average between 1 and 10 parts per million; and Group 4, Extremely Hazardous is given to substances with a Time Weighted Average of less than 1 part per million. Table 2 summarizes these classifications.

Table 2. Classification of Substances

Substance Classification	Threshold Limit Value Time Weighted Average (ppm)
Insignificant Hazard	> 1000
Slightly Hazardous	100 - 1000
Hazardous	10 - 100
Highly Hazardous	1 - 10
Extremely Hazardous	< 1

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[8] Kohan, p. 15

If the Threshold Limit Value cannot be found in the current publication of Threshold Limit Values, which is updated annually, and it is suspected that the chemical is hazardous and/or toxic, treat it as you would a highly hazardous substance.

3-3 Routes of Exposure and General Protection. There are three main routes through which a substance may enter the body. They are ingestion, inhalation, and absorption through the skin. The simplest route of exposure to eliminate, is ingestion. This may be accomplished by using proper laboratory procedures. These procedures include: keeping food and drinks out of the laboratory; not chewing gum or smoking in the laboratory; when pipetting use a bulb and not one's mouth; wash one's hands before leaving or immediately after leaving the laboratory.

To reduce or eliminate exposure through inhalation and absorption through the skin, protective measures must be taken. These include: 1) the use of ventilation hoods or glove boxes; 2) monitoring the laboratory atmosphere; the use of: 3) respirators; 4) protective clothing; and/or 5) eye protection. If hazardous substances are used, it may also be necessary to use protective shields or barriers.

3-3.1 Ventilation Hoods and Glove Boxes. When working with hazardous and toxic substances in the laboratory, ventilation hoods or glove boxes provide good protection for the user against exposure through inhalation. The two types of ventilation hoods usually used are the sliding sash hood and the open canopy type fume hood.

The sliding sash hood, shown in figure 1[9], has an ajustable sash

[9] Michael E. Green and A. Turk, Safety in Working With Chemicals., p. 110

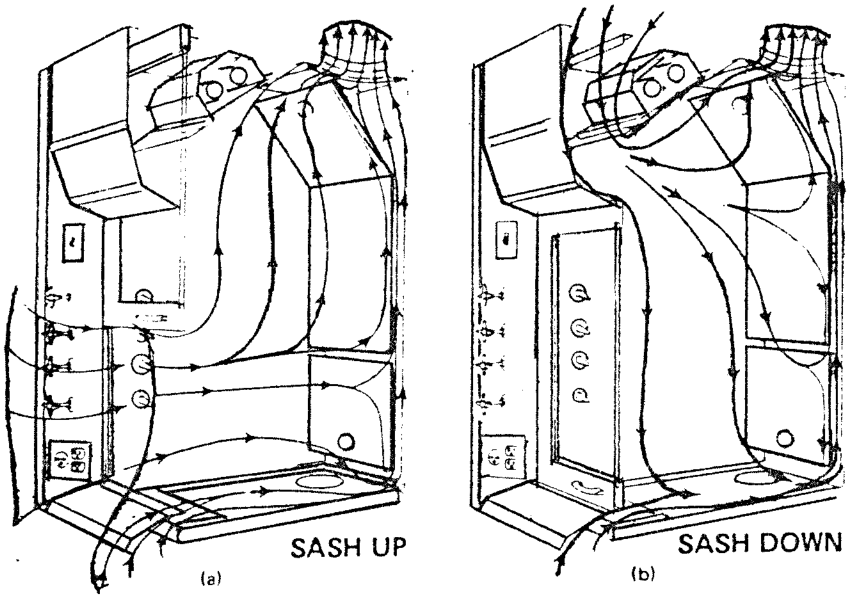

Figure 1. Sliding Sash Hood

that is used to regulate the flow rate of air at the face of the hood, also known as the face velocity of the hood. The linear relationship between the face velocity and sash height is shown in figure 2.[10] The face velocity of the hood should be checked twice a year to assure that there is no reduction in the air flow which may occur due to blockage of the vents or clogging of the filters.

The glove box is used when extremely toxic materials are used, as the glove box is a totally closed system that typically works under a negative pressure. Therefore, if leakage occurs, it is into the box. It is usually constructed of stainless steel, with a coated interior of enamel or epoxy paint, a plastic plexiglass window, and a glove panel, to which the gloves are attached. The glove panel is removable, and is capable of being used with or without gloves.

10. Ibid., pg 110

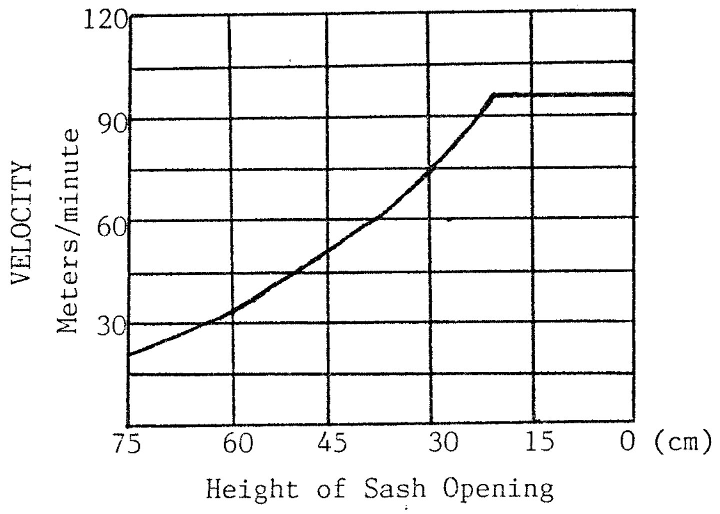

Figure 2. Face Velocity vs. Sash Height

In contrast to the glove box, which is capable of handling extremely hazardous and toxic substances, the open canopy type of fume hood is not capable of handling these materials, since it is an open system. It is usually constructed of a flexible ventilation duct which has a flaired conical shaped end. This type of hood is usually placed over the area where the substance is being used.

When working with hazardous and toxic materials, the exhaust air from all types of hoods, should be connected to at least a charcoal sorbent filter. This filter will absorb most of the substances drawn into the hood, thereby not releasing them to the outside atmosphere. One should also be certain that, when working with hazardous and toxic substances, the exhaust air is not recirculated into the laboratory, and that there is adequate ventilation, in the laboratory, to compensate for the air that is removed by the hood.

3-3.2 Sampling and Monitoring the Laboratory Atmosphere. Air sampling and monitoring is an important aspect in the evaluation of worker safety and of the work environment. Sampling and monitoring the laboratory atmosphere will enable the worker to see whether or not protective measures have to be taken, or whether the protective measures being taken are sufficient. Once protective measures are taken, such as use of hoods or glove boxes, periodic sampling and monitoring should be done to assure that the worker is not exposed to the substance, being used, through inhalation.

Sampling and monitoring of the laboratory atmosphere may be accomplished in one of two ways, by constant monitoring the atmosphere throughout the workday, or by periodically monitoring the atmosphere at different times of the day. The first type of air monitoring, constant monitoring, may use either a dosimeter badge or a charcoal tube and pump monitor.

Personal dosimeter badge monitors come in two types, one which tests organic vapors and another which tests inorganic vapors. The organic type of dosimeter, shown in figure 3,[11] is activated by removing the badge from its protective package and removing its protective covers. It is worn near the breathing zone of the worker, usually on a shirt collar, and it works as a passive monitor, a monitor which absorbes the substance, in the atmosphere, onto the activated carbon by diffusion. To deactivate the badge, all one does is replace the covers, place the badge in the protective package, and reseal it.

To determine the exposure of the worker to the chemical, expressed as a Time Weighted Average, the activated carbon is removed from the

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11. William J. Lautenberger, Ph.D., et al., "A new personal badge monitor for organic vapors," American Industrial Hygiene Association Journal, 41, October 1980, p. 738

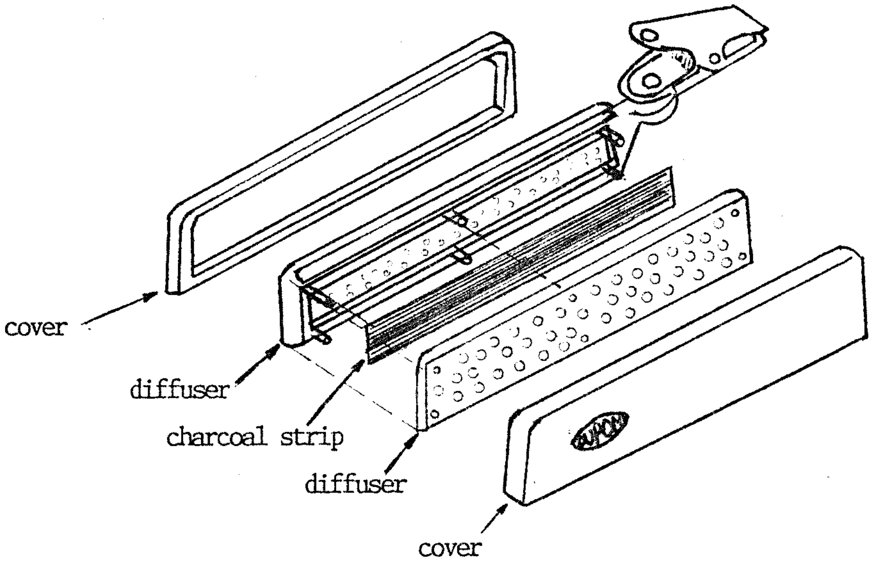

Figure 3. PRO-TEC G-AABadge Components

badge, and is placed directly into a vial containing one milliliter of desorbing solvent. The vial is then placed into a gas chromatograph (GC) for analysis. Once the sample time is recorded, along with the amount of material that was collected, and the sampling rate of the badge, a Time Weighted Average may then be determined. This type of badge has been proven accurate for ranges from 0.5 ppm to 1100 ppm for many different organic substances and mixtures.

The other type of constant monitor is the pump and sorbent tube. This type of monitor can be used for either organic or inorganic vapors. The sorbent tube is attached near the breathing zone again, on a shirt collar for instance, and is attached by plastic tubing to a small constant flow pump, which is usually attached to the workers shirt pocket or belt. Since this type of monitor is not passive, the pump is used to draw air into the tube which is absorbed by the sorbent. Upon

Upon completion of the monitoring period, the tube is then connected to a gas chromatograph and heated. Heating causes the release of any toxic substances absorbed, by the sorbent, at which time the concentration of the substance is determined. From this the Time Weighted Average can be calculated.

The second type of air monitors that are used, monitor the atmospheric concentration of the substance, the moment the air is tested.
This type of monitor will give the worker an immediate reading at the time of sampling. Monitoring equipment used for this type of sampling include; detector tubes, photoionizers, and the gas chromatograph.

A detector tube is a small tube which contains a chemically reactive agent which reacts with the substance, to produce a stain, when the air containing the substance is drawn into the tube. This type of monitor is shown in Figure 4.[12] The length of the stain is proportional to the concentration of the chemical in the atmosphere.

Finally, both the approximate concentration range and the chemical have to be known when sampling with this type of detector, because the detector tubes are specific to both, the chemical being used and the concentration range of the chemical.

The photoionizer consists of a small pump which draws a continuous stream of air into the detector. Ions are produced by having the air either pass through a small electric current or through an ultraviolet light. This causes ions to be converted into electrical current which are then amplified to give the concentration of the substance in the atmosphere. The same holds true for the gas chromatograph, with the

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12. Cheremisinoff, p. 67

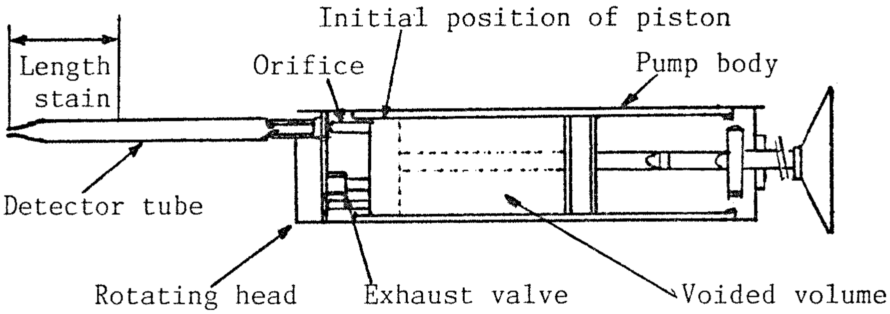

Figure 4. MSA universal sampling pump

exception that instead of having a pump to pull the air into the system, a syringe is used to sample the air and inject it into the chromatograph. The advantages of these types of detectors (photoionizer and gas chromatograph) are; they give accurate on the spot readings, and once they are purchased they are capable of giving readings for a variety of substances and concentrations. The disadvantages are that they are relatively expensive, and that workers have to be trained on how to use them and how to read the output.

3-3.3 Respirators. Respirators are used to protect workers from hazardous and/or toxic substances in the atmosphere when engineering controls, such as closed systems and ventilation hoods, can not be used. Respirators work either by removing or reducing the amount of contaminants in the atmosphere before being inhaled, or by supplying the user with breathable air from a self contained source.

Respirators are classified into two general catagories, either tight fitting or loose fitting. According to J. J. Keller and Associate, Incorporated: "Tight fitting respirators are generally constructed of a molded, impervious rubber or plastic facepiece that covers either the nose and mouth or the entire face. Loose fitting respirators include hoods, helmets, blouses or full suits, all of which cover the head completely. Their configuration varies widely, depending upon the use for which they are designed."[13]

These classifications are then divided into two major classes: either air-supplying or air-purifying respirators. An air-supplying respirator, either loose or tight fitting, supplies breathable air from a source other than the surrounding atmosphere. The main advantage of this class of respirators is that they may be used at almost any time, such as in an oxygen deficient atmosphere.

The second class of respirators, air purifying respriators, fall into two subclasses, one which uses filters to remove particles from the surrounding atmosphere before entering the breathing zone of the user, and one which uses a canister or chemical cartridge, to entrap gas and vapor particles before they enter the breathing zone of the user.

To assure that respirators remain in proper working condition, a proper maintenance program, supervised by a qualified individual, should be set up. This program would include, "inspection for defects (including a leak check), cleaning and disinfection, repair and storage."[14] OSHA, in the Code of Federal Regulations (CFR) 1910.134, requires that respirators be inspected at least once per month, and before and after each use. This inspection should also include examining the respirator for worn and damaged parts. If repair is necessary, it should be done by

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13. J.J Keller & Associates, Inc., Occupational Exposure Guide, p. PER PRO page 5

14. OSHA Safety and Health Standards, Title 29 Code of Federal Regulations (Revised July 1, 1984), p. 350

an experienced person and only parts specified for that respirator should be used.

After the respirator is inspected, cleaned and disinfected, and all repairs completed, the respirator should be stored in a convient area, away from "heat, extreme cold, sunlight, excessive moisture and damaging chemicals."[15] In addition, OSHA 1910.134 requires that both the supervisors and the workers be trained and given the opportunity to: "handle the respirator; have it properly fitted; test its facepiece-to-face seal; wear it in normal air for a long familiarity period; and wear it in a test atmosphere."[16]

Finally, OSHA requires that each user of a respirator recieve instructions on fitting, and practice in; adjusting, fitting and wearing it properly.

3-3.4 Protective Clothing. While the preceeding sections dealt with protecting the worker from exposure through ingestion and inhalation, this section will cover protecting the worker from exposure through skin absorption.

To protect workers from chemicals such as benzene, phenols and nitroanilines which are capable of passing directly through the skin, and chemicals, such as acetone and carbon tetrachloride, which remove fats and oils from the skin causing it to dry and crack, protective clothing is needed. This may include gloves and laboratory coats.

Gloves are used when there is direct contact with hazardous and or toxic chemicals. The type of glove that should be used, depends on the

15. Ibid., p. 351

16. Ibid., p. 350

rate of permeation of the solvent through the glove and its breakthrough time, the time it takes for the chemical to first enter the inside of the glove. The best type of glove, for any particular solvent, is one which has the longest breakthrough time, and the smallest permeation rate. As can be seen in Table 3, using acetone as a solvent, the glove which should be used is the polyethylene glove.

Table 3. Acetone breakthrough times and permeation rates for various types of gloves.

Type of glove	Breakthrough time (minutes)	Permeation rate (ug/min/sq. cm)
Polyethylene	>60	<30
Surgical Rubber Latex	2.2	210
Natural Rubber Latex	8.0	46
Nitrile Rubber	5.2	2000

The permeation rate and breakthrough time for a glove will vary, depending on the thickness of the glove and the number of layers it has. Appendix B contains tables with both the physical characteristics, the solvent breakthrough time and permeation rate for various types of protective gloves.

A second type of protective clothing is a laboratory coat. Laboratory coats are generally used to protect the workers clothing from substances in the laboratory. Cloth laboratory coats provide some protection to the worker, but since they are not usually thoroughly washed on a regular basis and because they have a high permeability, these coats may acutally create a hazard to the wearer.

Laboratory coats constructed of plastic or rubber, which may be disposed of or rinsed off after something is spilled on them, provide better protection for the worker, especially if hazardous and toxic chemicals are used. This is because plastic or rubber laboratory coats have low permeabilities, therefore, it takes some time for the chemical penetrate the lab coat, thus providing better protection for the wearer.

3-3.5 Eye Protection. Safety goggles are used to protect the worker's eyes from damage which may occur from chemicals getting into them. In some laboratories, prescription glasses worn by the worker are sufficient. However, when working with hazardous and toxic chemicals one should wear safety goggles, even with regular eye glasses since eye glasses do not have side shields.

Contact lenses should never be worn in the workplace because vapors of the chemical being used are capable of accumulating under the lenses, and causing sever eye damage. Also, since contacts act as a barrier, if a chemical is rubbed or splashed into the eye, not all of it will be removed, and sever eye damage may result.

3-4 The Right to Know Law. It is important to note that in the near future, a "Right to Know" Law will be promulgated in New Jersey. This would require NJIT to: " 1) Report to the Department of Health those hazardous substances present at the University; 2) Maintain a file of basic safety information (supplied by the Department of Health) for employees' use about these hazardous substances; 3) Provide employees with education and training on how to handle these substances; 4) Label containers of hazardous substances by June 30, 1985 and all containers by August 31, 1986 with the CHEMICAL NAME and CAS number of their contents;

5) Disclose to the Department of Environmental Protection basic information concerning the storage, treatment, and emission into the environment of hazardous substances."[17]

This law is presently being challenged in federal court on grounds that it may violate the "trade secrets" of chemical manufactures.

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[17] NJIT Office of Academic Affairs, "Compliance with Right-to-Know", Memorandum, p. 1

SECTION 4

CHEMICAL PROPERTIES

4-1 Chemical Properties. When working with hazardous and toxic chemicals, evaluation of the chemical properties should be done to aid the technician in developing safety procedures. The properties which should be evaluated are: 1) Flash point; 2) Solubility; 3) Vapor Pressure; 4) Physical State; and its 5) Reactivity.

4-1.1 The flash point, tells the flammability of the substance, and is defined as "the lowest temperature at which vapors above a volatile combustable substance will ignite in air when exposed to a flame."[18] For example, benzene, a flammable liquid has a flash point of -10 to -12°C, whereas, trichloroethylene, a practically non flammable liquid has a flash point of 32.2°C. Therefore, when working with benzene, any work with open flames should be done away from the area containing benzene.

4-1.2 The solubility of the chemical, tells the technician which solvents the chemical is soluble in. This is needed when the permeameter has to be cleaned. The solvent that should be used to clean the Flexible Wall Permeameter, should be soluble with both permeant and water. The reason for this is that after the test is completed, the permeant is removed, and it is replaced with the solvent which is passed through the apparatus, to clean out the lines. Upon completion, the solvent is then removed and replaced with water, which is used as a final rinse. For example,

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[18] Noyes Data Corporation, Hazardous Chemical Data Book, p. 7

if phenol is used as the permeant in the apparatus, since it is water soluble the only solvent needed to clean the apparatus is water. If however, benzene is used, which is insoluble in water, a solvent such as alcohol may be used for the initial solvent, since it is soluble in both benzene and water. Once the alcohol is removed, water may then be used as a final rinse.

4-1.3 The vapor pressure, will give the technician an idea of the volatility of the chemical, and is defined as "the pressure exerted by a solid or liquid in equilibrium with its own vapor. The vapor pressure is a function of temperature."[19]

A chemical, such as methane, which has a high vapor pressure at a low temperature, 760 mm Hg at a temperture of -161.5°C, has a high volatility, whereas, a chemical such as succinimide, which has low vapor pressure at a high temperature, 1 mm Hg at a temperature of 115.0°C, has a low volatility.

4-1.4 The reactivity of the chemical, is used to determine what substances will react with the chemical permeant. This is useful especially if the chemical is reactive with water or some part of the apparatus, such as stainless steel. Most of the permeants that will be used in the apparatus are unreactive with the materials on the apparatus and water. Problems may arise if concentrated acids are used, because acids such as hydrochloric and sulfuric will corrode stainless steel, which is used on the apparatus. These parts would have to be replaced if acids are used over a long period of time.

Another problem that may arise is that the chemical permeant used

[19] Robert C. Weast ed., CRC Handbook of Chemistry and Physics, p. F-119

in the apparatus may react with (dissolve) the membrane. For example, the membrane that comes with the apparatus is made of LATEX rubber, a solvent such benzene which is used as a plastics solvent, will pass through the membrane into the water which surrounds it. Therefore, when working with benzene, a membrane other than latex should be used, e.g. a nitrile rubber membrane is fairly resistent to benzene might be used. Because of this the membrane, should be tested with the permeant before using it in the system, to see whether or not it will contain the chemical.

SECTION 5

APPARATUS AND RECOMMENDED CONTROL TECHNIQUES

5-1 General Apparatus. The apparatuses that will be used to test the soil are the flexible wall permeameter and the liquid limit device. The flexible wall permeameter will be used to test the permeability of the soil using hazardous and toxic permeants. The liquid limit device will be one of the Atterberg Limits Tests used to see how permeants affect the soil.

5-1.1 The Flexible Wall Permeameter System. This system consists of three parts; 1) the master control panel, 2) the burette panel, which is schematically shown in figure 5[20], and 3) the permeameter sample confining chamber. Optional auxillary control panels may also be connected to the system, which will allow the user to run different samples at identical burette pressures. This system is also capable of using toxic permeants since it is equipped with stainless steel fittings and teflon coated tubing in all areas except the air and water lines.

1) The Master Control Panel. This panel consists of three regulators, which independently control the pressures in the upper burette, lower burette and sample confining chamber. Above each of these regulators is a two inch diameter gauge, which allows the user to have an approximate idea of the pressures in the system. The panel also consists of a six inch diameter master gauge, accurate to one quarter pound per square inch (1/4 psi), which is used to accurately set all pressures in the system. This is accomplished by using a four

20. Soiltest Operation and Service Instructions, pg 3-14

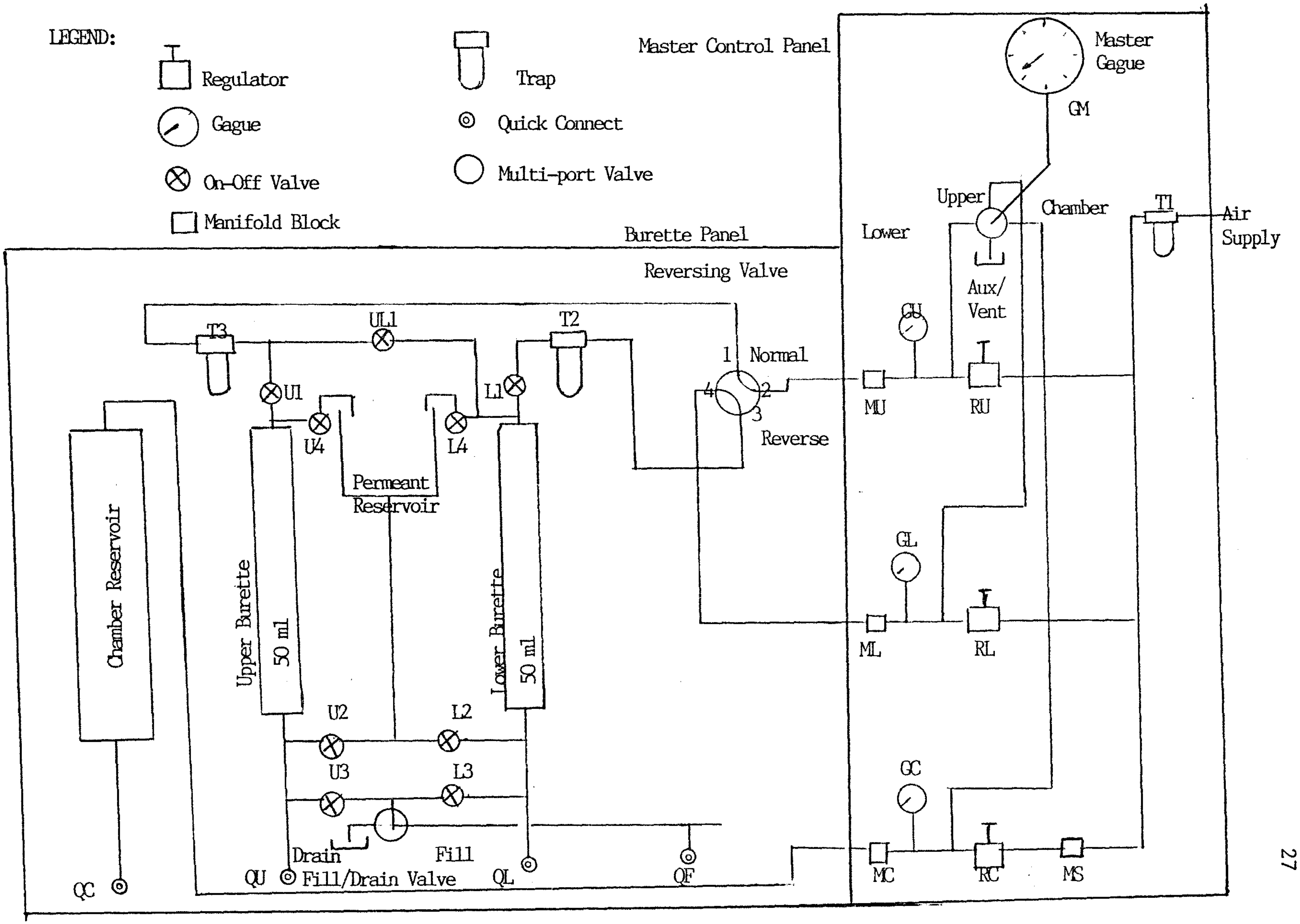

Figure 5. Master Control Panel and Burette Panel

position selector valve (V1), which may be set to one of four positions; upper burette, lower burette, sample confining chamber, or the auxillary panel, if it is used. This system is capable of handling pressures of up to one hundred pounds per square inch (100 psi).

2) The Burette Panel. This panel consists of two reservoirs; a chamber reservoir, and a permeant reservoir. The chamber reservoir, in which there is an air/fluid interface, is used to pressurize the sample confining chamber. The permeant reservoir is open to the atmosphere and holds the permeant being used. This reservoir is connected to two fifty milliliter burettes, an upper burette and a lower burette, which have an air/fluid interface and allows the user to measure the flow of the permeant into and out of the specimen. The upper and lower burettes are connected to the upper and lower parts of the spample, respectivly.

The panel also consists of a reversing valve which allows the user to reverse the flow of the permeant during the test. Toggle valves "(U1, U4, L1, L4) are used to apply or vent the burette pressures. Toggle valve UL1 permits interconnection of the upper and lower lines, thus ensuring identical burette pressure during back pressuring. The three-position valve (V3), external fill line and downstream toggle valves (U2, U3, L2, L3) are used for adjusting the fluid levels in the burettes or introducing different permeants during a test."[21] Finally, the four ports leading from the chamber reservoir, upper burette, lower burette, and the filling port, are all equipped with quick connect fittings. These fittings make connecting and disconnecting the sample

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[21] Soiltest Operation and Service Instructions, pg 1-3

confining chamber to the burette panel a simple task and also assure that there is minimal to no leakage of the permeant and water from the lines, when the sample confining chamber is connected or disconnected.

3) The Sample Confining Chamber. This pressure chamber, shown in figure 6[22], consists of a plexiglass wall, a septum, and a top and bottom plate, to which the upper and lower platens are connected. This chamber is capable of holding a 2.8 inch diameter specimen up to six inches in height. Valves CC1 and CC2 allow the chamber to be filled or pressurized, and valves CU1, CU2, CL1 and CL2 enable the convient flushing of the porous discs.

A septum was inserted into the side of the sampling chamber and is connected to the top platen. A syringe will be inserted into the septum and a sample of the liquid which has passed through the specimen will be taken. By evaluating the liquid in the syringe, the breakthrough time (the time it takes for the sampling permeant to pass through the sample) may then be determined.

5-1.2 The Liquid Limit Device and Testing for the Atterberg Limits.

Upon completion of the permeability test, the soils liquid and plastic limits will be tested (Atterberg Limits). The apparatus used to test the liquid limit is the liquid limit device and grooving tool, the liquid limit device is shown in detail in figure 7[23]. This device is nothing more than a cup with a crank attached to it. Turning the the crank causes the cup to rise and fall againt the base of the device

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[22] Soiltest Operation and Service Instructions, pg 3-15

[23] William T. Lambe, *Soil Testing for Engineers*, p. 152

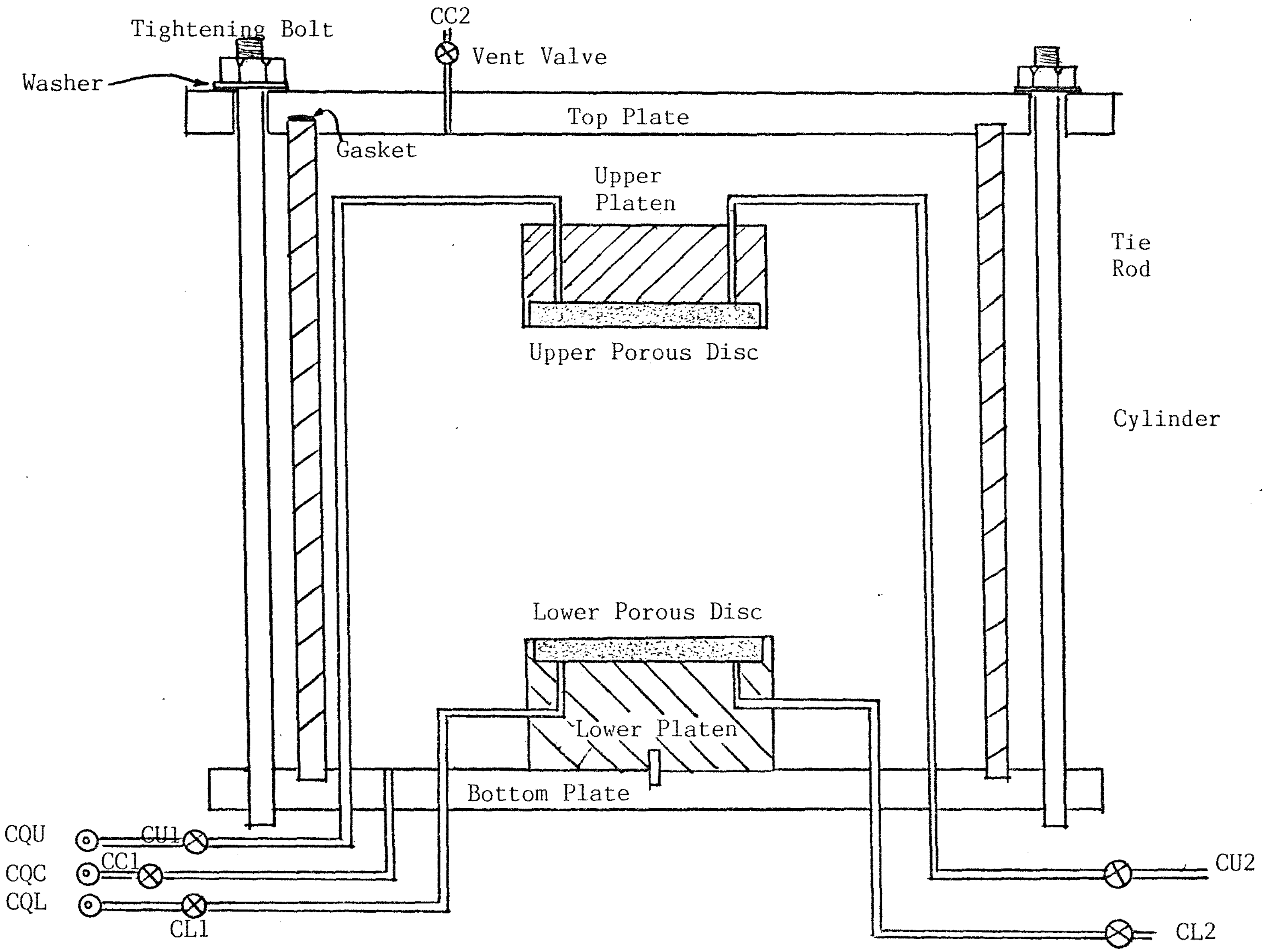
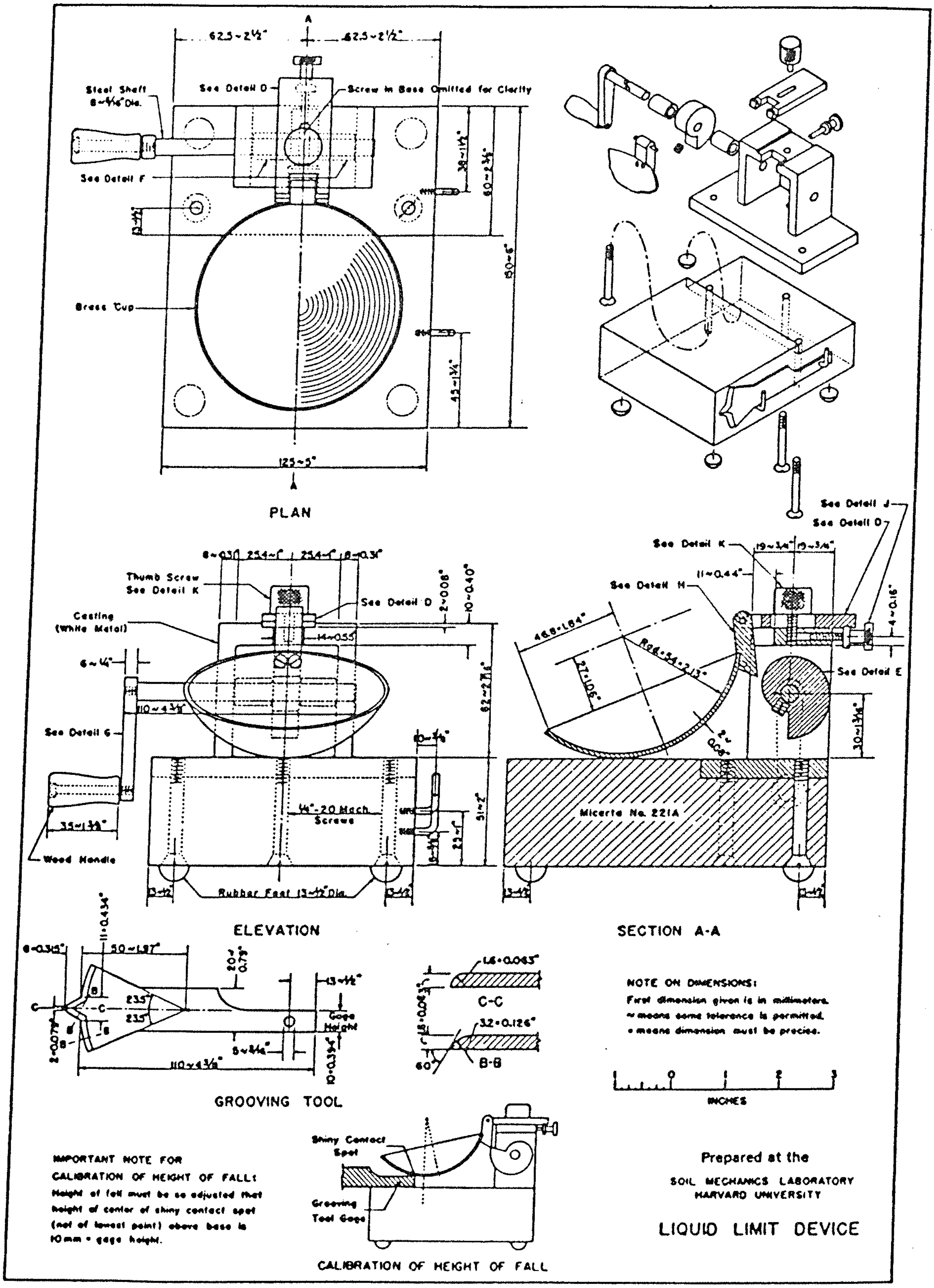


Figure 6. SCHEMATIC OF PERMEAMETER CHAMBER



IMPORTANT NOTE FOR CALIBRATION OF HEIGHT OF FALL: Height of fall must be so adjusted that height of center of shiny contact spot (not of lowest point) above base is 10 mm = gage height.

NOTE ON DIMENSIONS: First dimension given is in millimeters. ~ means some tolerance is permitted. = means dimension must be precise.

Prepared at the SOIL MECHANICS LABORATORY HARVARD UNIVERSITY

Figure 7. Liquid Limit Device and Grooving Tool

which in turn causes the two pieces of soil to come together.

All that is required to do the plastic limits test is a flat glass plate. The procedure is that, first, the soil is rolled on the plate until a 1/8 inch diameter piece of soil starts to crumble, at this point the results obtained are compared to those obtained before the permeability test was run. By doing this the technician is able to see how the permeant effected the soil.

5-2 Critical Points and Protective Procedures for Operating the Permeameter. The flexible wall permeameter is a partially open system that will be using hazardous and toxic substances as permeants. Therefore, the apparatus and testing procedure was evaluated to determine where the technician may be exposed to the permeant. In this way protective measures and equipment modifications were developed.

Evaluation of the testing procedure and the apparatus indicates that the technician may be exposed to the permeant, either through inhalation or absorption through the skin, from: 1) the permeant reservoir, and/or during; 2) the deairing and purging of the permeant lines and porous discs, 3) mounting the specimen, 4) testing, removing, and handling the specimen, 5) draining and cleaning the apparatus whenever a new permeant is used and 6) during any accidential spills should they occur.

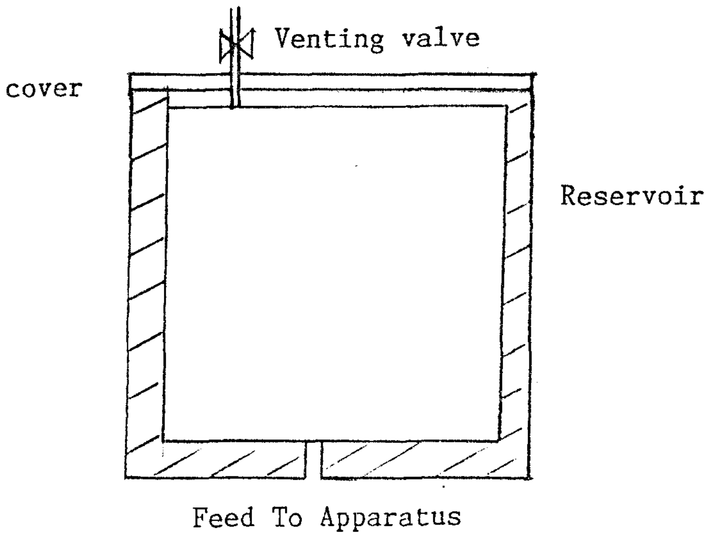
5-2.1 The Permeant Reservoir and Deairing the Permeant Lines. The permeant reservoir, is attached to the burettes and is open to the atmosphere. If left completely uncovered, while using a toxic permeant, the concentration of the permeant in the ambient air would exceed the Threshold Limit Value Time Weighted Average (TLV-TWA) in a few hours, depending on the volatility, concentration and toxicity of the permeant.

In order to reduce the concentration of the permeant in the ambient air, a cover is provided by the manufacturer. This cover fits into the reservior and floats on top of the permeant, but is not air tight. Therefore, some of the permeant is capable of diffusing around the sides of the cover and accumulating in the ambient air. However, when a cover is used the time it takes to reach or exceed the Time Weighted Average of the permeant is greatly increased, because the surface area of the permeant exposed to the ambient air is reduced.

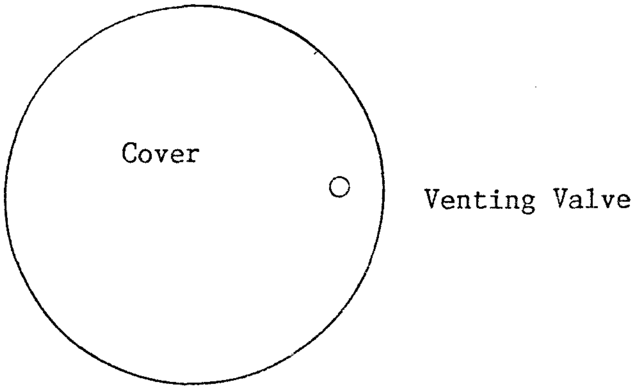
One way to keep the permeant from diffusing out of the permeant reservoir would be to replace the permeant reservoir on the apparatus with an air tight reservoir which has a venting valve attached to it. This type of reservoir is shown in figure 8. An alternative to this would be to directly fill the burettes. This may be accomplished in one of two ways, by attaching the air tight reservoir to either, 1) the burette drainage lines, or, 2) the drainage lines on the sample chamber. The first method, attaching the air tight reservoir to the burette drainage line, which is attached to the fill/drain valve (V3), is shown schematically in figure 9.

To fill the burettes, the permeant reservoir is placed above the top of the burettes, vent valves U1 and L1 are opened, and the fill/drain valve (V3) is set to the drain position. When the technician wants to fill the burettes he open either valve U3 or L3 which are connected to the upper and lower burette respectively. Once filled this valve is closed, and the permeant lines are deaired. If it should become necessary to refill the burettes the preceeding procedure is repeated.

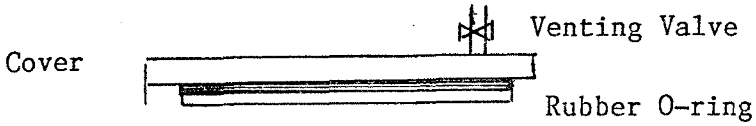
While filling the burettes the technician may see the flow of the



a) Side View



b) Top View



c) Cover Side View

Figure 8. Air Tight Reservoir

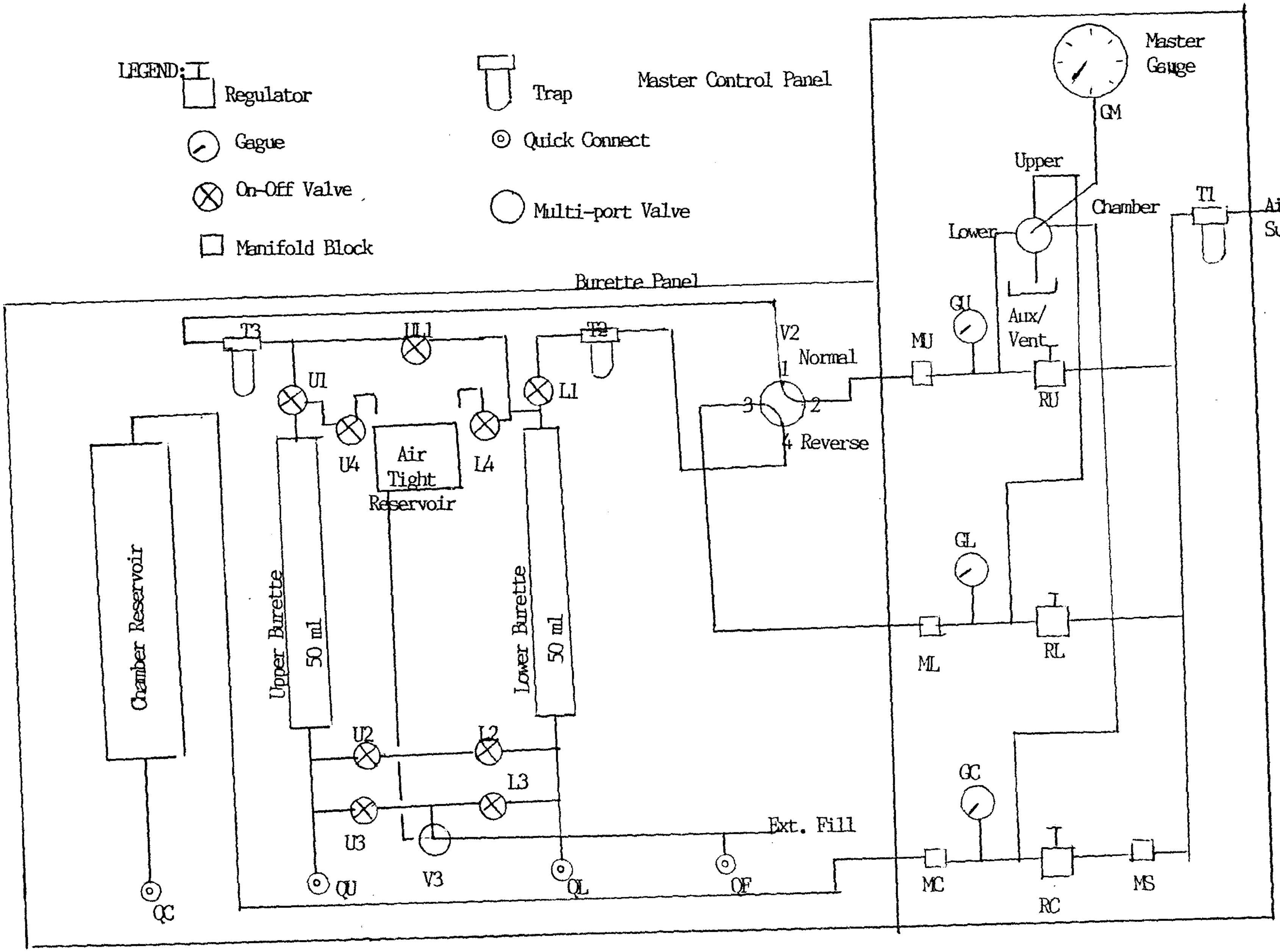


Figure 9. Air Tight Reservoir attached to Burette Drainage Lines

permeant into the burettes decrease or stop. This is caused by negative pressure that is built up inside the air tight reservoir resulting from a volume difference caused by the flow of the permeant out of the reservoir. This may be alleviated by opening and closing the vent valve on the reservoir.

The second way is to fill the burettes attaching the air tight reservoir to the sample drainage lines (the lines connected to valves CU2 and CL2). To fill the burettes using this method the technician places the de-airing cylinder, shown in figure 10,[24] on the lower platen,

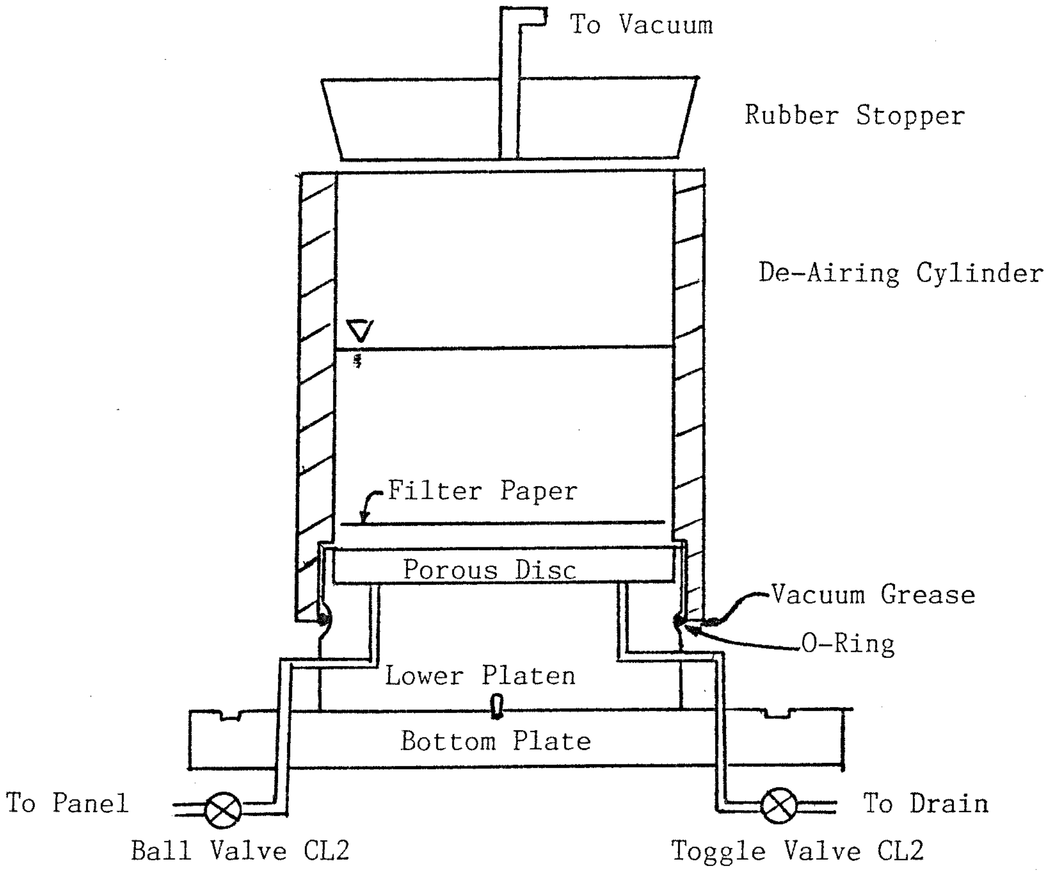


Figure 10. DE-AIRING BOTTOM POROUS DISC, FILTER PAPER AND LINES (PROCEDURE SIMILAR FOR TOP)

[24] Soiltest Operation and Service Instructions, pg. 3-17

and then either blocks the vacuum line on the rubber stopper, or replaces the rubber stopper and the vacuum line, with a solid stopper. This is done so that the permeant is confined to the porous disc. By doing this the permeant cannot flow onto the the base of the sample confining chamber and expose the technician to the permeant.

Once the deairing cylinder is in place, valve CL2 and CU2 are opened which allows the permeant to flow into the cylinder. Because no air is allowed to leave the cylinder, positive pressure is built up inside of it. Therefore, the flow of the permeant into the reservoir will stop. After this happens the burettes are filled by using the following procedure: 1) open the burette venting valves U1 and L1; 2) open valve CL1 or CU1 to fill the lower and upper burettes, respectively; and 3) close the open valves, either CL1 and CL2 or CU1 and CU2.

While filling the burettes the permeant lines should also be deaired. This is accomplished by raising the permeant lines slightly higher than the base of the sample confining chamber, removing any air bubbles in the lines.

Since an air tight reservoir is used in this method, the flow of the permeant may decrease or stop due to negative pressure inside the reservoir. This problem may be eliminated by using the venting valve on the permeant reservoir.

The advantage of this type of reservoir is that the permeant cannot diffuse out of the reservoir, thus reducing the exposure to the technician. The reason being that negative pressure inside the reservoir draws air into it to replace the volume lost by the permeant thereby stopping any diffusion out of the reservoir. Finally, when the reservoir is not being used to fill the burettes the vent valve, on the reservoir should remain closed so that no permeant may diffuse out of it. However, because the burettes are vented to the atmosphere when filling them with permeant, some exposure to the permeant may result. The only way to eliminate this would be to place the apparatus in a ventilation hood, or attach lines to the burette venting valves U1 and L1 and place the free ends in a ventilation hood or into a charcoal sorbent filter with an exhaust to the outside atmosphere. Once the burettes are filled, the valves are closed and the porous discs and filter paper are de-aired.

5-2.2 Deairing the Porous Discs. After the burettes are filled and the permeant lines deaired, the porous discs are deaired. To accomplish this the technician either opens the vacuum line, if it is blocked, or replaces the solid rubber stopper with a stopper which has a vacuum line attached to it. A slight vacuum is applied, and, when no bubbles are seen rising from the disc, the vacuum is turned off and the permeant drained, from the de-airing cylinder, leaving just enough permeant in the cylinder to cover the filter paper. Since hazardous and toxic substances are going to be used, the exhaust air from the vacuum should be either vented into a working hood or filtered with a charcoal sorbent filter and vented to the outside of the building, thereby eliminating exposure to the technician. A charcoal sorbent filter is used to absorb any permeant which is removed when a vacuum is applied.

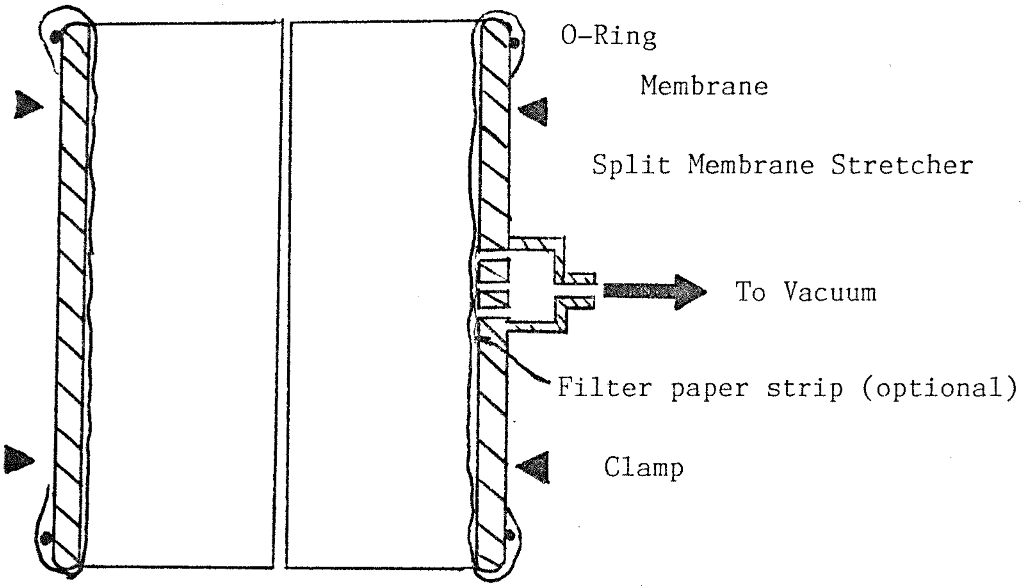
To drain the deairing cylinder after the porous disc is deaired, the reservoir is lowered below the base of the sample confining chamber, and valve CL2 is opened and is closed before the permeant enters the filter paper on the porous disc. The deairing cylinder is removed, thus exposing the permeant on the porous disc to the ambient air, which may result in some exposure to the technician. The only way to eliminate this exposure is to place the sample confining chamber with platens attached, or the apparatus, under, or in, a ventilation hood.

After the lower platen is deaired, the upper platen is de-aired, by the preceeding procedure using valve CU2. Once the discs are de-aired the specimen is mounted.

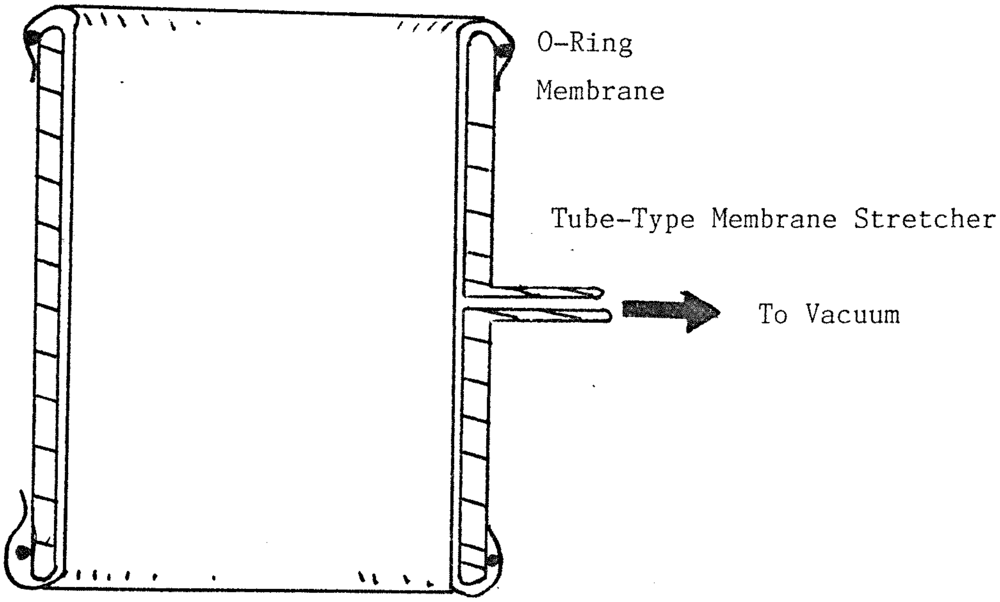
5-2.3 Mounting the Specimen. The specimen is placed on the lower platen after the lower porous disc is deaired. A membrane is placed around both the lower platen and the specimen. To do this the membrane has to be stretched, which is accomplished by using a membrane stretcher. There are two types of membrane stretchers, the split type and the tube type, as shown by figure 11.[25] After the membrane is secured inside the membrane stretcher, the membrane and stretcher are placed over the specimen. At the same time the upper platen, after it is deaired, is placed on top of the specimen. Once the upper platen is in place, the membrane is removed from the membrane stretcher, attached to the platens with O rings, and the membrane stretcher is removed from around the platens.

To remove the split type stretcher, the technician removes the clamp from around the stretcher and pulls the two halves apart, thus causing minimal or no exposure to the technician. However, if a tube type of stretcher is used, the technician will be exposed to the permeant, as the only way to remove it once the membrane is secured to the upper platen would be to: 1) disconnect the permeant lines from the base of the sample confining chamber; 2) lift the membrane stretcher

25. Soiltest Operating and Service Instructions. pg 3-18



ASSEMBLED SPLIT MEMBRANE STRETCHER



ASSEMBLED TUBE-TYPE MEMBRANE STRETCHER

Figure 11. Membrane Stretchers

over the platen and its lines; and 3) reconnect the permeant lines to the base of the sample confining chamber.

By disconnecting and reconnecting the permeant lines some of the permeant will escape, thus exposing the technician to the permeant. In addition this allows air to enter the sytem. If air gets into the system the permeant lines have to be purged. However, before the lines can be purged the sample confining chamber has to be assembled and filled. Once this is completed, the permeability test on the soil may be run.

While using the second method (air tight reservoir attached to the sample drainage lines), if the burettes have to be re-filled, the procedure is as follows: 1) raise the permeant reservoir above the top of the burettes, if it is not positioned there already; and, 2) open and close either valves CU1 and CU2 to refill the upper burette or CL1 and CL2 to refill the lower burette.

5-2.4 Testing, Removing and Handling the Specimen. After the sample confining chamber is assembled, filled with water and all permeant lines purged, if necessary, the permeability test is run. During the testing period usually one week per specimen, if the permeant reservoir of the apparatus is used and no protective measures are taken, the concentration of the permeant in the ambient air may exceed the Time Weighted Average. This would be caused by the permeant diffusing around the sides of the cover and accumulating in the ambient air.

The time it takes to exceed the Time Weighted Average for the permeant will depend on the following: the permeant's, 1) toxicity; varying from extremely toxic to non toxic; 2) its volatility; 3) the concentration, from very dilute to pure; 4) the length of the testing period; and 5) the type of permeant reservoir that will be used, air tight or non air tight. For example, a pure, highly toxic, volatile permeant in the permeant reservoir of the apparatus may exceed the Time Weighted Averge in a day or two, whereas the same permeant in an air tight reservoir, assuming no accidental spills or leaks, may never exceed the Time Weighted Average.

Furthermore, upon completion of the experiment the specimen, saturated with permeant, is removed from the platens, weighed, measured (diameter and height of the specimen), and its moisture content determined, in addition, the Atterberg Limits may be tested. Therefore, to avoid exposure, protective measures must be taken, including the use of a ventilation hood, air monitoring, safety glasses, and protective gloves.

5-2.5 Draining and Cleaning the Apparatus. Once testing is completed, or if after completing one test a different permeant is going to be used, the apparatus must be drained into a special waste container and cleaned. This requires that the permeant reservoir be drained and rinsed out with an appropriate solvent, soluble in both the permeant and water, and finally rinsed out with water. All laboratories should be equipped with hazardous and toxic waste containers, both organic and inorganic, for disposal of waste. Under no conditions should the apparatus be rinsed in a sink.

Exposure may result during the cleaning of the permeant reservoir, if external protective measures, such as use of a ventilation hood and protective gloves, are not taken. Exposure occurs because the air which is between the permeant in the reservoir, and the cover on the reservoir, is saturated with the permeant. Therefore, when the cover is removed, when no external protective measures are takne, the technician will be exposed briefly to the permeant. The only other time that the technician will be exposed to the permeant is if a spill occurs in the laboratory.

5-2.6 Accidental Spills or Leaks.

Exposure to the permeant will occur if the permeant leaks out of the apparatus or if a spill should occur in the laboratory. If the apparatus is placed in a ventillation hood, and a leak occurs, the technician would be able to repair the apparatus and clean the permeant, without being exposed to it, wearing only protective gloves. However, if a spill occurs in the laboratory, away from the ventilation hood, if available, and no external protective measures are taken, exposure to the technician would result.

If a spill occurs the technician should; 1) open all windows and doors, which increases ventilation into the laboratory, thereby reducing the concentration of the permeant in the atmosphere, 2) protective gloves must be worn while cleaning up the spill, thus eliminating exposure through skin absorption, and 3) finally, once the spill is cleaned up, all cleaning material should be disposed of properly. In addition, it may be necessary to wear a respirator while cleaning the spill if there are no windows in the laboratory or if the spill is large.

5-3 Critical Points and Protective Measures for the Atterberg Limits.

While doing the Atterberg Limits tests, liquid limit, plastic limit and shrinkage limit, exposure through both inhalation and absorbtion through the skin may result. The most likely route of exposure is absorption through the skin, because doing these tests requires the technician to handle the soil, as these tests will be conducted with soil saturated with hazardous and toxic chemials. The only way to eliminate exposure through this route is by wearing protective gloves.

The second route of exposure, inhalation, may be eliminated if these tests are conducted in a ventillation hood.

In addition, since samples containing the permeant, hazardous and/or toxic, have to be dried in an oven to determine its moisture content, a ventilation hood, such as the open canopy type, should be placed over the oven. This prevents dangerous vapors from entering the laboratory.

5-4 External Protective Measures During Testing. By placing the apparatus in a hood, and using modified equipment such as an air tight reservoir, the need to vent the exhaust air from the vacuum source and lines attached to the burette vents may be eliminated, thereby reducing the number of extra lines and equipment needed if a hood is not used. However, a hood should be used when the porous discs are de-aired, and when the specimen is weighed, measured and tested using the Atterberg Limits. In addition, the following protective measures should be taken: 1) when handling the specimen which is saturated with the permeant, protective gloves should be worn; 2) occasional air monitoring should be done to assure that the Time Weighted Average is not exceeded; 3) a respirator should be easily accessible, in case of an emergency or in case a spill occurs outside of the hood; 4) it is recommended that a laboratory coat or apron (not made of cloth) be worn to protect the the technician and his/her clothing from spills that may occur; 5) safety glasses must be worn at all times while in the laboratory; and, 6) all laboratory safety rules for NJIT should be followed, as listed in Appendix D.

5-4.1 Recommended Ventilation Hood. The Flexible Wall Permeameter System should be placed in a sliding sash hood. This type of hood is recommended because: 1) it is capable of holding the whole apparatus and still leaves room to do other testing, such as the Atterberg Limits tests; 2) it is capable of maintaining face velocities of 150 feet per minute; and, 3) if a leak or spill occurs at or near the apparatus, it is confined to one area.

When working with most substances in a sliding sash hod, the face velocity of the hood should range from 50 to 100 feet per minute. When more toxic substances are used, such as benzene, the face velocity of the hood should not be less than 150 feet per minute. Table 4,[26] lists the recommended face velocities for various classes of toxic and hazardous chemicals.

Table 4. Recommended Face Velocities

Degree of Hazard	Approximate TLV-TWA (ppm)	Minimum Measured Velocity at any Point Across the Hood Face. (fpm)
Low Toxicity Levels	> 1000	50
Average toxicity levels involving a wide range of materials	251-1000	75
Low-level radioactive tracer materials with nominal toxicity hazards	11-250	100
Significant chemical toxicity levels and moderately radioactive materials	1-10	150
Higher levels of toxicity and highly radioactive materials.	<1	Consider the use of glove boxes and total enclosures if velocities in excess of 150 fpm are required.

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[26] R.C. Weast and G.L. Tuve (eds), CRC Handbook of Laboratory Safety, p. 155

To assure that proper face velocities are used when working with various substances, one should mark the maximum sash heights and their corresponding face velocities on the side of the hood. By doing this one can easily set the sash height to the desired face velocity.

When using the sliding sash hood in the laboratory, occasional air monitoring should be done to assure that there are no leaks in the ventilation system of the hood and also to assure that the hood is properly working.

5-4.2 Air Monitoring. Air monitoring may be accomplished by using either a personal dosimeter badge monitor or detector tubes. The advantage of using a personal dosimeter badge is that it is worn during the work day and is normally used for one week of testing. This enables the technician to see whether or not the Time Weighted Average for the permeant is exceeded (one week average). The disadvantage of this type of monitor is that it must be sent out to a laboratory capable of analyzing it, therefore, the technician may not receive the results for a week or two from the date it was sent out for analysis. Therefore, if badges are used, during the first two weeks of testing samples should also be taken with detector tubes so that during this time period the technician has an idea of the concentration of the permeant in the atmosphere. That way, corrective measures may be taken if concentration levels of the permeant in the atmosphere exceed the Time Weighted Values.

Use of detector tubes, normally requires that samples of the atmosphere be taken every fifteen to thirty minutes to get an accurate measurement of the TLV. This is because the detector tubes only give an instantaneous reading of the concentration in the atmosphere at the time the measurement

If the apparatus is placed in a sliding sash hood, air monitoring may be done by either method. Personal dosimeter badges are recommended for the following reasons: 1) they give and accurate readings, on a weekly average basis; 2) because a hood is used, any permeant released from the apparatus will be removed by the hood, and 3) it does not require that samples be taken every fifteen to thirty minutes.

If detector tubes are used, the following sampling times should be followed: 1) while preparing the apparatus, deairing the lines and porous stones, mounting the specimen, etc. sampling should be done every fifteen to thirty minutes; and, 2) while running the test (usually one week), sampling should be done twice per day, preferably, once at the start of the day, as this is the time when the maximum concentration of the permeant would occur, resulting from having the hood turned off at night or over the weekend; and once at the end of the day. If significant levels of the permeant, higher than the Threshold Limit Value, determined, the hood should be turned on and windows should be opened, this should lower the concentration level in a couple of minutes. While this is being done the technician should stay out of the laboratory. After, about 10 to 15 minutes resample the air to see if the level has dropped to a safe concentration.

Upon completion of the permeability test, when removing the sample, and when the sample is measured, weighed, and tested using the Atterberg Limits the air should again be monitored every fifteen to thrity minutes.

If, after monitoring the air for the first two weeks of testing a new permeant, the concentration of the permeant is half of the Time Weighted Average for that permeant or below, air monitoring using the detector tubes, if used, may be performed once per month (one week of testing).

In addition to air monitoring, a respirator should be available in case of an emergency or spill outside of the hood.

5-4.3 Respirators. When working with hazardous and toxic chemicals, a respirator should be available in case a spill or emergency occurs. The respirator should be properly fit, and designed for the chemical being used. This respirator should be selected and fitted by a qualified individual.

5-4.4 Protective Gloves. Whenever handling a specimen which is saturated with a toxic permeant protective gloves must be worn. The type glove that should be used for any specific permeant should have the longest breakthrough time and the lowest permeation rate. These times and rates may be obtained from the tables in Appendix B. For example, when using pure benzene as a permeant, the glove which should be used is a made of nitrile rubber with an average thickness of 0.35± 0.02 ml in thickness produced by Edmont-Wilson (Stock no. 37-155).

Finally, in addition to protective gloves, a ventilation hood, air monitoring, a respirator which is easily accessible, and following the laboratory safety rules for NJIT, it might be a good idea to use a lab coat or apron (not made of cloth) to protect the technician and his/her clothing from accidental spills or splashing chemicals in the laboratory.

If the apparatus cannot be placed in a sliding sash hood, because there are not any in the laboratory, or none is acessible at the time, etc., and the permeability tests must be run, modifications will have to be made in the equipment that is used, or in the protective measures taken.

5-4.5 Using the Apparatuses When a Sliding Sash Hood is Not Available.

If a sliding sash hood is not available or easily accessible, an open canopy type of hood may be used, with the following modifications in the apparatus and protective measures: 1) use an air tight reservoir if available, if it is not available place the open canopy type hood above the permeant reservoir of the apparatus (making sure it remains covered); 2) connect lines to the burette venting valves U1 and L1 and place the free ends under the open canopy hood; 3) using a second open canopy hood, do all de-airing of the porous lines and discs under the hood; 4) assure that there is proper ventilation in the laboratory; 5) handle, measure and perform the Atterberg Limits tests under a hood; and, 6) perform air monitoring every thirty minutes while setting up the apparatus and while handling, measuring and doing the Atterberg Limits tests on the permeant saturated specimen. In addition, air monitoring during the permeation test should be done once per hour. The reason for the less stringent limit while the test is being run is that the only area where the chemical is exposed to the amient air at this time is the permeant reservoir, and this is covered. The above monitoring specifications apply to all monitoring done by detector tubes. If dosimeter badges are used, during the first week of testing, samples should be taken using both detector tubes and badges, after which if the concentration levels remain below the Time Weighted Average, just badges may be worn while testng the specimen. If levels remain above the Time Weighted Average, the hoods will have to be evaluated and changes made. Possiblely placing the apparatus in a sliding sash hood or getting larger open canopy hoods might eliminate the problem.

If the open canopy hood is used, these procedures along with all others previously mentioned, in the preceding section, should be followed.

5-6 Summarization Form and Reference Information. To simplify the information about the permeant, chemical properties, toxicity, experimental procedure and emergency procedures along with the decontamination of the equipment, the following form should be used:

CHEMICAL INFORMATION FORM

I. CHEMICAL PROPERTIES

A. Chemical Name:

B. Vapor Pressure and Flash Points:

C. Solubility in water:

D. Solubility in other materials:

E. Chemical Reactivity:

II. TOXICITY

A. Time Weighted Average (TLV-TWA):

B. Short Term Exposure Limits (TLV-STEL):

C. Ceiling Limit (TLV-C):

D. Major Known Toxic Effects:

  1. Acute:

  2. Chronic:

  3. Reference books used:

CHEMICAL INFORMATION FORM

III. PROTECTIVE MEASURES

A. Type of hood:

B. Recommended Face Velocity:

C. Type of Air Monitoring:

D. Frequency:

E. Recommended Respirator:

F. Recommended type of Protective Gloves:

G. Hygienic Precautions:

H. Hygienic Treatment:

1. Reference Book:

IV. SAFETY PROCEDURES FOR DECONTAMINATION OF EQUIPMENT

A. Procedure for Cleaning Flexible Wall Permeameter:

B. Procedure for Cleaning Liquid Limit Device:

V. EMERGENCY PROCEDURES

A. For Spills and Leakage:

The forms on the following pages are completed for the following permeants; benzene, trichloroethylene and phenols. Completing the form not only makes it an easy reference but it also enables the technician to become familiar with the chemical that is being used. Most of the information needed to fill out the form may be found in the following publications:

1) NIOSH/OSHA Pocket Guide to Chemical Hazards, U.S. Department of Health and Human Services, and U.S. Department of Labor (OSHA). Washington D.C.: U.S. Goverment Printing Office, 1978

2) Toxic and Hazardous Industrial Chemicals Safety Manual for Handling and Disposal with Toxicity and Hazard Data. Japan, The International Technicial Information Institute, 1981

3) Threshold Limit Values. Committee of American Conference of Goverment Industrial Hygienists, Cincinnati, OH 1980 (annual publication)

4) Hygienic Guide Series, American Industrial Hygiene Association

5) The Hazardous Chemical Data Book, Noyes Data Corporation 1980

CHEMICAL INFORMATION FORM

I. CHEMICAL PROPERTIES

A. Chemical Name: Benzene, Benzol

B. Vapor Pressure: 95.14 mm Hg at 25°C

C. Flash Point: -12 to -10°C

D. Solubility in Water: 0.06%

E. Solubility in other Materials: Infinitely soluble in alcohol, ether, and most organic solvents.

F. Chemical Reactivity: No Reaction with water or other common materials

II. TOXICITY

A. Time Weighted Average (TLV-TWA): 10 ppm

B. Short Term Exposure Limit (TLV-STEL): 50 ppm for 10 minutes

C. Ceiling Limit (TLV-C): 25 ppm

D. Major Known Toxic Effects:

1. Acute:[27] Euphoria, excitement, headache, vertigo, incoherent speech, narcosis; stimulation of the central nervous system, then depression, with death via respiratory paralysis; respiratory irritation and pulmonary edema; gastrointestinal irritation with vomiting and colic; red skin (erythema), blistering.

2. Chronic:[28] Anorexia, nausea, loss of weight, fatigue weakness, headache, dizziness, nervousness, irritability.
hemorrhagic manifestations: pallor, epistaxis, purpa, petechiae, menstrual disturbances.
hematologic changes: aplastic anemia, macroxytosis, leucopenia, thrombocytopenia, hemolysis.

3. Reference: _Toxic and Hazardous Industrial Chemicals Safety Manual for handling and disposal with toxicity and hazard data_, The International Technical Information Institute, Japan 1981

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[27] The International Technical Information Institute, _Toxic and Hazardous Industrial Chemicals Safety Manual for handling and disposal with hazard and toxicity data._, p. 63

[28] Ibid., p. 63

CHEMICAL INFORMATION FORM

III. PROTECTIVE MEASURES

A. Type of hood: Sliding sash hood, preferred

B. Recommended Face Velocity: 150 fpm

C. Type of Air Monitoring: Personal dosimeter badge and detector tubes

D. Frequency of analysis: weekly

E. Recommended Respirator: Organic Vapor Canister (for emergency use)

F. Recommended type of Protective Gloves: Nitrile Rubber

G. Apron: hydrocarbon insoluble (neoprene)

H. Hygienic Precautions: Adequate ventilation.

I. Hygienic Treatment:[29] EYES flush with plenty of water until irritation subsides, SKIN flush with water followed by washing with soap and water, remove contaminated clothing and wash skin. INHALATION: remove from exposure. Call physician. If breathing irregular or stopped give oxygen and artificial respiration if necessary.

1. Reference Book: same as before.

IV. SAFETY PROCEDURES FOR DECONTAMINATION OF EQUIPMENT

A. Procedure for Cleaning Flexible Wall Permeameter: 1) drain system of permeant, 2) place a non toxic solvent such as alcohol in permeant reservoir and flush it through the lines, placing contaminated alcohol (with benzene) in a suitable disposal container, 3) after system is flushed with solvent, drain remaining solvent from permeant reservoir, 4) place water in permeant reservoir, and flush lines again, after flushing is complete, check for damaged parts and replace if necessary.

B. Procedure for Cleaning Liquid Limit Device: wipe inside of cup with suitible solvent such as alcohol, and then rinse with water.

V. EMERGENCY PROCEDURES

A. For Spills and Leakage: Absorb on paper. Evaporate on a glass or iron dish in a hood. Burn paper.

[29] Ibid., p. 63

CHEMICAL INFORMATION FORM

I. CHEMICAL PROPERTIES

A. Chemical Name: trichloroethylene

B. Vapor Pressure: 100 mm Hg at 31.4°C

C. Flash Point: 32.2°C (practically nonflammable)

D. Solubility in Water: slightly soluble

E. Solubility in other Materials: soluble with common organic solvents.

F. Chemical Reactivity: No Reaction with water or other common materials

II. TOXICITY

A. Time Weighted Average (TLV-TWA): 100 ppm

B. Short Term Exposure Limit (TLV-STEL): 150 ppm for 15 minutes

C. Ceiling Limit (TLV-C): N/A

D. Major Known Toxic Effects:

1. Local[30]: Conjunctivitis, skin-inflammation; neuronosis (as paralysis of thumb and forefinger) after prolonged local exposure. INHALATION: Irritation of the nose and throat; increased respiratory rate, bronchitis, pulmonary edema, lack of appetite, nausea, vomiting, jaundice, slight swelling of the liver, headache, dizziness, irritability, disturbance of sleep, incoordination, psychic disturbances, paralysis, tremors, peripheral neuritis: precordial pain, cardiac arrythmias, arrest, convulsions: disturbances of color vision; optic atrophy.

3. Reference: Toxic and Hazardous Industrial Chemicals Safety Manual for handling and disposal with toxicity and hazard data, The International Technicial Information Institute, Japan 1981

III. PROTECTIVE MEASURES

A. Type of hood: Sliding Sash Hood, preferred

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[30] Ibid., p. 537

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CHEMICAL INFORMATION FORM

III. PROTECTIVE MEASURES (cont.)

B. Recommended Face Velocity: 100 fpm

C. Type of Air Monitoring: Personal dosimeter badge and detector tube

D. Frequency of analysis: weekly

E. Recommended Respirator: Orgainc Vapor Canister (for emergency use)

F. Recommended type of Protective Gloves: Nitrile Rubber

G. Apron: hydrocarbon insoluble (neoprene)

H. Hygienic Precautions:[31] Physical examination of exposed personnel annually. Preclude from exposure those individuals with diseases of kidneys or liver.

I. Hygienic Treatment:[32] EYES flush with plenty of water until irritation subsides, SKIN flush with water followed by washing with soap and water, remove contaminated clothing and wash skin. Oxygen if necessary. No Aderenaline. Watch functions of liver and kidneys closely.

1. Reference Book: same as before.

IV. SAFETY PROCEDURES FOR DECONTAMINATION OF EQUIPMENT

A. Procedure for Cleaning Flexible Wall Permeameter: 1) drain system of permeant, 2) place a non toxic solvent in permeant reservoir and flush it through the lines, placing contaminated solvent (with trichloroethylene) in a suitable disposal container, 3) after system is flushed with solvent, drain remaining solvent from permeant reservoir, 4) place water in permeant reservoir, and flush lines again, after flushing is complete, check for damaged parts and replace if necessary.

B. Procedure for Cleaning Liquid Limit Device: wipe inside of cup with suitible solvent, and then rinse with water.

V. EMERGENCY PROCEDURES

A. For Spills and Leakage: Absorb on paper. Evaporate on a glass or iron dish in a hood. Burn paper.

[31] Ibid., p. 537

[32] Ibid., p. 537

CHEMICAL INFORMATION FORM

I. CHEMICAL PROPERTIES

A. Chemical Name: Phenol

B. Vapor Pressure: 1 mm Hg at 40.1°C

C. Flash Point: 85°C

D. Solubility in Water: soluble

E. Solubility in other Materials: soluble in alcohol, ether, chloroform, carbon disulfide, petrolatum

F. Chemical Reactivity: When heated phenol evolves flammable vapors which will form explosive mixtures with air.

II. TOXICITY

A. Time Weighted Average (TLV-TWA): 5 ppm

B. Short Term Exposure Limit (TLV-STEL): 10 ppm for 10 minutes

C. Ceiling Limit (TLV-C): N/A

D. Major Known Toxic Effects:

1. Acute:[33] Local Conjunctival burns, corneal necrosis, severe skin burns, Respiratory: Dyspnea, cough, cyanosis, pulmonary edema. Genitourinary: Oliguria, anuria; albumin, casts, red and white blood cells in urine.
2. Chronic:[34] Headache, cough, fatiguea and weakness; anorexia, nausea, vomiting, insomnia, nervousness; weight loss; pallor, partial paralysis, albuminuria.
3. Reference: <u>Toxic and Hazardous Industrial Chemicals Safety Manual for handling and disposal with toxicity and hazard data</u>, The International Technicial Information Institute, Japan 1981

III. PROTECTIVE MEASURES

A. Type of Hood: Sliding Sash Hood, recommended

B. Recommended Face Velocity: 150 fpm

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[33] Ibid., p.406

[34] Ibid., p. 406

CHEMICAL INFORMATION FORM

III. PROTECTIVE MEASURES (cont.)

C. Type of Air Monitoring: Personal dosimeter badge and detector tube

D. Frequency of Analysis: Weekly

E. Recommended Respirator: Organic Vapor Canister (for emergency use)

F. Recommended type of Protective Gloves: Natural Rubber Latex

G. Apron: hydrocarbon insoluble (neoprene)

H. Hygienic Precautions: Adequate ventilation.

I. Hygienic Treatment[35]: EYES flush with plenty of water until irritation subsides, SKIN flush with water followed by washing with soap and water, and then with olive oil or alcohol. Burns may be treated with olive oil dressings or in usual fashion. Oxygen, with use of intermittent positive-pressure breathing apparatus, if pulmonary edema seems likely.

1. Reference Book: same as before.

IV. SAFETY PROCEDURES FOR DECONTAMINATION OF EQUIPMENT

A. Procedure for Cleaning Flexible Wall Permeameter: 1) drain system of permeant, 2) place water in permeant reservoir and flush all lines, 3) dispose of contaminated water properly (in proper disposal container), and after flushing with water, check lines and connections for possible wear and replace any worn parts.

B. Procedure for Cleaning Liquid Limit Device: wash inside of cup with soap and water and rinse clean.

V. EMERGENCY PROCEDURES

A. For Spills and Leakage: Absorb on paper. Evaporate on a glass or iron dish in a hood. Burn paper.

[35] Ibid., p. 406

SECTION 6

CONCLUSION

Geotechnical Testing with hazardous and toxic materials is a relatively new area of study, and procedures to safely handle and work with these materials had to be developed. In order to accomplish this, the apparatuses and testing procedures were evaluated to determine their critical points and to decide what protective measures need to be taken. For the Flexible Wall Permeameter and the Atterberg Limits, the following critical points of technician exposure were developed; 1) the permeant reservoir; 2) the de-airing and purging of the permeant lines and porous disc, 3) mounting the specimen, 4) testing, removing, and handling the specimen, 5) draining and cleaning the apparatus, and 6) during any accidental spills.

Based on an analysis of the critical points and a review of various industry and laboratory safety standards, the following protective measures and safety procedures were then developed; 1) weekly air monitoring of the atmosphere using either detector tubes or a personal dosimeter badge is required to assure that concentration levels of the permeant do not exceed the Time Weighted Average. Air contamination may result from malfunctioning hoods, poor ventilation in the laboratory, or leaks in the ventilation system of the hood, 2) eye protection is required at all times while in the laboratory, 3) protective gloves must be worn at all times while handling the permeant or any soils saturated with the pemeant to protect the technician from exposure of the permeant through skin absorption, 4) it is recommended that the technician wear a neopene apron which would not only protect the technician from chemical spills or splattering while working with these chemicals, but it also protects his/her clothing, and 5) respirators should be available at all times in case of an emergency.

The above procedure assumes that testing will be performed in a sliding sash hood. If the Flexible Wall Permeameter cannot be placed in a sliding sash hood, an open canopy type hood should be placed over the apparatus. All previous safety procedures should be followed except that a more stringent limitation should be followed for air monnitoring.

The laboratory atmosphere should be tested once every fifteen to thirty minutes using detector tubes while preparing the specimen and the apparatus, along with disassembling and cleaning the Flexible Wall Permeameter and cleaning it when the testing is completed. Finally, the permeability test air monitoring should be done once every hour.

In addition, if a sliding sash hood is not available, the Flexible Wall Permeameter should be modified. These modifications include: 1) the replacement of the reservoir on the apparatus with an air tight reservoir, 2) use of a split type membrane stretcher to place the membrane on the specimen, and 3) all vents from the burettes and/or vacuum sources used should be vented into the open canopy hood.

By following the above protective measures while working with hazardous and toxic substances, and following all rules for NJIT's laboratories, no exposure to the technician should result. With more interest and concern being placed on improving the environment, additional testing apparatus are certain to be developed to test hazardous and toxic materials. These should focus on automating as much as possible the equipment to further protect the worker from exposure to these substances. This thesis represents an initial step towards assuring safe geotechnical testing with hazardous and toxic wastes.

APPENDIX A
THRESHOLD LIMIT VALUES FOR MIXTURES

1. When analyzing each component seperatly.

   a. If the effects of the chemical are additive: the following equation is used: $C_1/T_1 + C_2/T_2 + C_3/T_3 + \ldots\ldots C_n/T_n = 1$

Example of this would be if the air contains: 100 ppm of hexane (TLV= 500 ppm), 560 ppm of pentane (TLV= 1000), and 200 ppm of heptane (TLV= 500 ppm).

The concentration of the mixture in the atmosphere is equal to 100 + 560 + 200 = 860 ppm. The Threshold Limit Value equals:

$$(100/500) + (560/1000) + (200/500) = 0.2 + 0.56 + 0.4 = 1.16$$

Since the value is greater than 1 the Threshold Limit Value is Exceeded.

b. "Special case when the source of contaminate in a liquid mixture and the atmospheric composition is assumed to be similar to that of the original material; e.g. on a time weighted average all of the liquid (solvent) mixture eventually evaporates."[36] An approximate calculation of the Threhold Limit of the mixture may be made using the following equation[37], if the percent composition, by weight, of the chemical in the mixture is known.

$$TLV_m = \frac{1}{\frac{f_a}{TLV_a} + \frac{f_b}{TLV_b} + \frac{f_c}{TLV_c} + \ldots\ldots\ldots\ldots \frac{f_n}{TLV_n}}$$

. American Conference of Goverment Industrial Hygienists, p. 46

[36] Ibid., pg. 47

[37] Ibid, pg. 47

APPENDIX A

Where: TLV_m = Threshold Limit Value of the mixture

f = Fraction by weight of each component of the mixture

TLV = Threshold Limit Value of each component of the mixture

for example[38]: Liquid contains (by weight)

50% heptane: TLV = 400 ppm or 1600 mg/cu. meter
1 mg/cu. meter = 0.25 ppm

30% methyl chloroform: TLV = 350 ppm or 1900 mg/cu. meter
1 mg/cu. meter = 0.18 ppm

20% perchloroethylene: TLV = 100 ppm or 670 mg/cu. meter
1 mg/cu. meter = 0.15 ppm

$$\text{TLV of mixture} = \frac{1}{(0.5/\ 1600) + (0.3/1900) + (0.2/670)}$$

$$= \frac{1}{0.00031 + 0.00016 + 0.00030}$$

$$= \frac{1}{0.00077} = 1300 \text{ mg/cu. meter}$$

of this mixture

50% or (1300)(0.5) = 650 mg/cu. meter is heptane

30% or (1300)(0.3) = 390 mg/cu. meter is methyl chloroform

20% or (1300)(0.2) = 260 mg/cu. meter is perchloroethylene

These values in ppm are:

heptane = 162 ppm = (650 mg/cu. meter)(0.25)

methyl chloroform = 70 ppm = (390 mg/cu. meter)(0.18)

perchloroethylene = 39 ppm = (260 mg/cu. meter)(0.15)

TLV of mixture = 162 + 70 + 39 = 271 ppm or 1300 mg/cu. meter

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[38] Ibid., p.47

2. If the mixture has independent effects

Example if the air contains 0.1 mg/cu. meter copper (TLV 0.1 mg/cu. meter) and 0.6 mg/cu. meter of chromium (TLV = 1 mg/ cu. meter)

$$0.1/0.1 = 1 \quad \text{and} \quad 0.6/1.0 = 0.6$$

The Threshold Limit is not exceeded in this case.

APPENDIX B[39]

Table 5. Physical Characteristics of Glove Samples

Glove No.	Average Thickness (mm)	Average Weight (g)	Glove Composition	No. of Layers	Interior Liner	Manufacturer	Manufacturer Stock No.
01	0.030 ± 0.005	0.07 ± 0.01	Polyethylene	1	none	Edmont-Wilson	35-125
02	0.076 ± 0.005	0.17 ± 0.03	Polyethylene	1	none	Handgards	HR-100
03	0.12 ± 0.02	0.34 ± 0.06	Polyvinyl chloride	1	none	Pioneer	V-5100
04	0.13 ± 0.02	0.39 ± 0.07	Polyvinyl chloride	1	none	Pioneer	I-V5
05	0.31 ± 0.04	0.91 ± 0.13	Polyvinyl chloride	1	none	Pioneer	V-20
06	0.20 ± 0.05	0.58 ± 0.19	Polyvinyl chloride	1	none	Pioneer	V-10
07	0.11 ± 0.02	0.31 ± 0.04	Vinyl (PVC)	1	none	Oak Rubber	96-334
08	0.13 ± 0.02	0.35 ± 0.08	Vinyl (PVC)	1	none	Bard Parker	H8294-002215
09	0.15 ± 0.03	0.44 ± 0.12	Vinyl (PVC)	1	none	Bard Parker	2213
10	0.21 ± 0.01	0.51 ± 0.03	Surgical rubber latex	1	none	Pioneer	N-190
11	0.31 ± 0.02	0.76 ± 0.02	Natural rubber latex	1	none	Edmont-Wilson	46-929
12	0.47 ± 0.05	1.15 ± 0.10	Natural rubber latex	1	none	Seiberling	5912

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39. O.G. Nelson, B.Y. Lum, C.M. Wong, J.S. Johnson, "Glove Permeation by Organic Solvents," American Industrial Hygiene Association Journal, 42, March 1981, p. 218

APPENDIX B

Table 5. Physical Characteristics of Glove Samples

Glove No.	Average Thickness (mm)	Average Weight (g)	Glove Composition	No. of Layers	Interior Liner	Manufacturer	Manufacturer Stock No.
13	0.45 ± 0.04	1.12 ± 0.11	Neoprene/rubber latex	blend	floc	Ansell	276
14	0.52 ± 0.14	1.37 ± 0.16	Natural rubber latex	1	floc	Platex	834
15	0.29 ± 0.04	1.13 ± 0.12	Neoprene latex	2	none	Pioneer	N-30
16	0.47 ± 0.05	1.59 ± 0.42	Neoprene latex	1	none	Pioneer	GFN-8150
17	0.46 ± 0.11	1.72 ± 0.43	Neoprene latex	2	none	Pioneer	N-73
18	0.77 ± 0.18	1.73 ± 0.55	Neoprene latex	1	fabric	Edmont-Wilson	19-932
19	0.70 ± 0.07	2.36 ± 0.05	Neoprene latex	2	none	Pioneer	N-54
20	0.70 ± 0.05	1.41 ± 0.05	Neoprene latex	1	fabric	Pioneer	N-73
21	0.80 ± 0.03	2.59 ± 0.26	Neoprene latex	1	none	Norton	8N3030
22	0.35 ± 0.02	0.89 ± 0.03	Nitrile rubber	1	none	Edmont-Wilson	37-155
23	0.37 ± 0.07	0.92 ± 0.03	Nitrile rubber	1	floc	Edmont-Wilson	37-175
24	0.55 ± 0.06	1.40 ± 0.18	Nitrile rubber latex	1	none	Edmont-Wilson	37-185
25	0.32 ± 0.11	0.97 ± 0.18	Acrylonitrile rubber	1	none	Surety-Sureseal	10-116R
26	0.45 ± 0.02	1.07 ± 0.04	Natural rubber	1	none	Calif. Safety	D-7-28317

Table 5 (cont.). Physical Characteristics of Glove Samples

Glove No.	Average Thickness (mm)	Average Weight (g)	Glove Composition	No. of Layers	Interior Liner	Manufacturer	Manufacturer Stock No.
27	0.59±0.07	1.48±0.26	Nitrile rubber	1	floc	Calif. Safety	CST-4312
28	0.31±0.02	0.75±0.04	Nitrile rubber	1	none	Calif. Safety	RN-12

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APPENDIX B

Table 6. Solvent Breakthrough Times and Permeation Rates for Protective Gloves

Solvent	Glove Number													
	01	02	03	04	05	06	07	08	09	10	11	12	13	14
Acetone	>60 (<30)	4.0 (2)	C (C)	– –	C (C)	C (C)	– –	– –	C (C)	2.2 (210)	5.2 (110)	6.0 (82)	5.0 (100)	8.0 (46)
Aniline	>60 (<40)	3.0 –	3.0 (180)	– –	18 (160)	9.0 (160)	– –	– –	– –	>60 (<40)	>60 (<40)	– –	– –	5.2 (2.0)
Benzene*	0.1 (0.25)	4.0 (0.05)	0.5 (3.5)	0.4 (4.1)	2.2 (1.5)	2.2 (1.6)	0.1 (4.7)	0.3 (3.6)	0.1 (4.9)	1.5 (5.6)	2.2 (3.2)	3.0 (2.6)	3.0 (2.8)	5.2 (2.0)
Butyl acetate	2.0 (20)	12 (6)	1.0 (6000)	1.0 (6900)	2.4 (3300)	2.0 (4300)	0.5 (C)	1.5 (6400)	1.5 (4100)	2.0 (2900)	4.0 (1400)	6.4 (940)	6.4 (640)	9.2 (640)
Carbon Tetrachloride*	1.5 (0.5)	8.0 (0.08)	0.8 (1.0)	1.5 (2.0)	8.4 (0.6)	2.3 (0.8)	1.2 (2.1)	1.0 (2.5)	1.2 (2.0)	1.5 (6.0)	3.8 (1.6)	5.0 (5.1)	4.0 (4.6)	10 (3.1)
Chloroform*	0.6 (1.6)	2.8 (1.0)	0.4 (15)	0.4 (27)	0.4 (5.4)	0.8 (11)	0.4 (15)	0.7 (12)	0.6 (13)	0.8 (15)	1.6 (4)	2.6 (7.6)	2.8 (7.0)	6.4 (4.4)
m-Cresol	>60 (<1)	>60 (<1)	12 (67)	14 (59)	>60 (<1)	14 (63)	8 (44)	7.5 (55)	7.0 (56)	14 (15)	36 –	30 (2)	30 (2)	>60 (<1)
Cyclohexane	1.6 (100)	10 (28)	1.6 (500)	2.2 (340)	16 (100)	5.6 (200)	2.0 (310)	0.8 (450)	2.4 (300)	1.7 (1500)	– (10)	8.0 (1300)	5.0 (1400)	– –
Dimethyl sulfoxide	>60 (<10)	– –	3.2 (380)	– –	42 (300)	34 (320)	– –	– –	– –	>60 (<10)	>60 (<10)	– –	– –	– –
Dioxane	1.2 (300)	10 (60)	1.6 (3700)	0.8 (4000)	6.4 (1500)	3.3 (1100)	1.0 (5000)	1.2 (3800)	1.1 (4000)	2.4 (800)	8.8 (420)	12 (340)	17 (340)	18 (220)

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Table 6. Solvent Breakthrough Times and Permeation Rates for Protective Gloves (cont.)

Solvent	Glove Number 01	02	03	04	05	06	07	08	09	10	11	12	13	14
Ethanol	–	>60	3.0	5.0	20	11	3.5	3.2	2.0	12	28	>60	–	>60
	–	(<4)	(43)	(37)	(28)	(43)	(28)	(34)	(57)	(14)	(4)	(<4)	–	(<4)
Ethylene dichloride*	1.0	5.2	0.6	0.8	2.0	1.0	0.4	0.6	0.8	1.2	0.4	4.6	4.8	0.4
	(0.001)	(0.01)	(11)	(9.7)	(4.5)	(6.9)	(C)	(13)	(7.8)	(3.1)	(1.6)	(1.3)	(1.3)	(1.3)
Ethylene glycol	>60	>60	>60	>60	>60	>60	>60	>60	>60	>60	>60	>60	>60	>60
	(<10)	(<10)	(<10)	–	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)	(<10)
Freon TF	4.8	>60	2.4	5.2	11	7.6	2.4	2.5	2.8	2.2	8.8	17	16	16
	(10)	(<10)	(3400)	(2200)	(190)	(240)	(2600)	(3000)	(1900)	(3000)	(1000)	(820)	(700)	(790)
Isoamyl acetate	2.0	>60	1.0	1.0	4.8	2.0	1.0	1.0	2.0	2.0	5.6	9.6	9.6	12
	(20)	(<10)	(33000	(3300)	(1600)	(2500)	(C)	(4500)	(2100)	(1900)	(1100)	(790)	(760)	(730)
Methanol	>60	>60	1.5	2.0	2.8	3.0	1.5	1.0	2.2	2.0	20	>60	–	24
	(<4)	(<4)	(36)	(34)	(18)	(23)	(34)	(38)	(30)	(18)	(8)	(<4)	–	(4)
Methyl ethylketone	>1.0	9.6	C	–	C	C	–	–	C	1.2	2.4	7.2	5.6	9.2
	(10)	(<3)	(C)	–	(C)	(C)	–	–	(C)	(800)	(600)	(320)	(310)	(230)
Phenol	>60	>60	3.2	8.0	32	15	6.0	6.2	3.8	16	>60	>100	>60	>60
	(<3)	(3)	(190)	(120)	(77)	(100)	(130)	(120)	(120)	(15)	(<3)	(<3)	(<3)	(<3)
Trichloro-ethylene	0.4	2.2	0.6	0.8	3.1	0.8	0.7	0.4	0.8	0.8	1.6	2.8	2.8	4.6
	(1.5)	(0.4)	(11)	(9)	(3.8)	(8.2)	(13)	(13)	(6.2)	(26)	(9.4)	(7.6)	(7.3)	(5.9)
Xylene*	–	4.0	1.5	1.0	–	4.6	0.5	0.6	1.6	1.0	2.5	4.8	–	7.0
	–	(0.1)	(3.0)	(3.5)	–	(1.7)	(4.5)	(3.5)	(2.1)	(5.8)	(3.4)	(3.7)	–	(2.5)

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Table 6. Solvent Breakthrough Times and Permeation Rates for Protective Gloves (cont.)

Solvent	Glove Number													
	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Acetone	0.7 (140)	19 (140)	33 (90)	2.5 (180)	32 (170)	2.2 (310)	57 (86)	5.2 (2000)	5.0 (<800)	13 (<800)	3.0 (1500)	15 (66)	27 (45)	4.0 (800)
Aniline	>60 (<40)	>60 (<40)	>60 (<40)	– –	– –	>60 (<40)	– –	96 (120)	– –	– –	18 (180)	>60 (<40)	>60 (<40)	– –
Benzene*	4.8 (1.8)	11.1 (1.0)	16 (0.8)	1.2 (0.95)	16 (1.1)	24 (0.3)	– –	63 (0.4)	19 (.85)	46 (.51)	4.4 (1.3)	3.7 (2.2)	7.4 (1.6)	9.0 (1.1)
Butyl acetate	11 (830)	29 (320)	>60 (<21)	5.2 (220)	52 (320)	3.6 (320)	>60 (<21)	33 (480)	40 (450)	58 (250)	20 (350)	8.0 (880)	14 (510)	– –
Carbon tetra-chloride*	13 (0.8)	34 (0.8)	23 (0.9)	30 (0.1)	41 (0.9)	4.6 (0.5)	>60 (,.006)	>60 (<.006)	>60 (<.006)	12.8 (<.006)	>60 (<.006)	30 (0.8)	11 (1.6)	>60 (<.006)
Chloroform	3.6 (4.4)	9.6 (3.2)	10 (2.5)	1.2 (2.7)	13.6 (2.8)	0.7 (6.8)	21.6 (2.0)	4.8 (9.4)	2.4 (9.9)	12.8 (5.6)	4.4 (7.0)	3.2 (5.6)	2.8 (7.0)	– –
m-Cresol	>60 (<1)	>60 (<1)	>60 (<1)	>60 (<1)	>60 (<1)	– –	>60 (<1)	>60 (<1))	>60 (<1)	>60 (<1)	>60 (<1)	>60 (<1)	>60 (<1)	– –
Dimethyl sulfoxide	>60 (<10)	>60 (<10)	>60 (<10)	– –	– –	>60 (<10)	– –	>60 (<10)	– –	– –	28 (350)	>60 (<10)	>60 (<10)	– –
Cyclo-hexane	72 (100)	>60 (<10)	29 (100)	– –	– –	9.6 (70)	– –	>60 (<10)	>60 (<1)	>60 (<1)	>60 (<10)	9.6 (1100)	18 (800)	>60 (<1)
Dioxane	15 (550)	44 (300)	28 (370)	8.4 (220)	44 (240)	5.2 (330)	107 (150)	25 (860)	27 (820)	63 (3)	17 (710)	10 (280)	27 (150)	– –

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Table 6. Solvent Breakthrough Times and Permeation Rates for Protective Gloves (cont.)

Solvent	Glove Number													
	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Ethanol	>60 (<4)	>60 (<4)	>60 (<4)	>60 (<4)	>60 (<4)	>60 (<4)	>60 (<4)	>60 (<4)	>60 (<4)	>60 (<4)	>60 (<4)	>60 (<4)	>60 (<4)	– –
Ethylene dichloride*	3.6 (1.8)	16 (0.7)	8.6 (1.0)	1.6 (0.7)	28 (0.8)	2.4 (0.8)	42 (0.5)	6.4 (3.8)	7.1 (3.9)	17 (2.6)	4.9 (3.9)	3.6 (2.5)	9.7 (0.8)	– –
Ethylene glycol	>60 (<10)	>60 (<10)	>60 (<10)	>60 (<10)	>60 (<10)	– –	>60 (<10)	>60 (<10)	>60 (<10)	>60 (<10)	>60 (<10)	>60 (<10)	>60 (<10)	– –
Freon TF	>60 (<10)	>60 (<10)	>60 (<10)	>60 (<10)	>60 (<10)	180 (20)	>60 (<10)	>60 (<10)	>60 (<10)	>60 (<10)	>60 (<10)	>60 (<10)	>60 (<10)	– –
Isoamyl acetate	16 (540)	30 (350)	30 (310)	12 (140)	– –	5.6 (120)	>60 –	>60 –	65 (63)	>60 –	42 (130)	10 (660)	19 (470)	– –
Methanol	>60 (<4)	>60 (<4)	>60 (<4)	17.6 (6)	>60 (<4)	23 (5)	>60 (<4)	69 (23)	54 (36)	>60 (<4)	39 (29)	18 (4)	>60 (<4)	– –
Methyl ethylketone	4.0 (900)	8.0 (600)	10 (600)	17 (200)	27 (330)	2.4 (500)	39 (230)	6.4 (3100)	6.0 (2200)	12 (1900)	9.6 (1500)	8.0 (400)	16 (200)	3.6 (2800)
Phenol	>60 (<3)	>60 <3)	>60 (<3)	>99 (<3)	>60 (<3)	– –	>60 (<3)	56 (300)	32 (300)	>60 (<3)	36 (300)	>60 (<3)	>60 (<3)	– –
Trichloro-ethylene	3.3 (4.2)	8.1 (2.3)	12 (1.9)	1.6 (1.9)	15 (2.1)	1.6 (1.8)	23 (1.3)	9.2 (2.0)	9.6 (2.1)	26 (0.9)	7.5 (1.6)	2.8 (6.8)	4.8 (5.3)	– –
Xylene*	5.2 (3.4)	14 (1.3)	23 (0.8)	3.4 (0.5)	18 (1.4)	3.0 (0.6)	44 (0.7)	48 (0.1)	57 (0.1)	>60 (<0.05)	28 (0.3)	5.0 (2.8)	7.9 (2.4)	– –

Top values are breakthrough times (min); values in parentheses are permeation rates (ug/min/cu. cm) except those solvents with asterisk, which are permeation rates in mg/min/cu. cm

APENDIX C[40]

SAFETY RULES AND REGULATIONS FOR ENVIRONMENTAL ENGINEERING LABORATORIES

Listed below are the rules and regulations that govern ALL users of the NJIT Environmental Engineering Laboratories. EVERYONE using the environmental engineering laboratories MUST follow these safety rules. Your privilege of using the laboratories may be revoked for violation of these saftey rules. All students and staff using these facilities are required to be familiar with NJIT's "Health-Saftey Manual of Chemical Hazards" as well as the American Chemical Society's laboratory safety manual prior to working in the laboratories. Copies of these and other laboratory safety manuals are available for in-lab use, in the laboratory chemist's office.

If you encounter situations where you feel that a change in these regulations is appropiate, please immediately bring your suggestions to the attention of the laboratory director.

GENERAL LABORATORY REGULATIONS

1) Do not eat, drink, or smoke in the laboratory.

2) Everyone working in the laboratory is responsible for reading and observing all NJIT and other rules governing the disposal of waste materials in the laboratory, generally laboratory safety, and the use of special items such as radioactive materials.

3) Protective eyewear must be worn while working in the laboratory.

4) If you spill anything, water, chemical, etc., on the floor benches, clean it up immediately and properly.

5) Many environmental samples contain pathogens, organisms which cause

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40. Environmental Engineering Department of NJIT, Safety Rules and Regulations for Environmental Engineering Laboratories, p. 1 - 6

such diesase in man as typhoid, cholera, amebic dysentery, and hepatitus. The potential for the presence of such organisms is particulary great in samples of domestic wastewaters, wastewater sludges, certaine surface waters and sediments. In handling all environmental samples, be certain to take ther precautions necessary to protect youself, as well as others using the laboratories, against possible infection. Understand the etiology (source) and mode of transmission of the disease causing organisms in your samples; the American Public Health Association book, Control of Communicable Diseases in Man, is a useful source of information on this topic.

Be certain that you are familiar with proper technique in handling your sample-even if you are not doing microbiological work. Learn what disinfectants are effective against the organisms or viruses expected in the sample. Then, properly disinfect areas with which the sample has come in contact; conduct all work in which aerosis are porduced, in the hood so that the associated organisms are not spread in the laboratory; keep your hands away from you mouth, eyes, nose, etc.; if you use gloves for handling the sample, be certain that these are properly disinfected after each use; properly disinfect glassware that has come in contact with the sample or dilutions of the sample. This may require autoclaving or washing with special disinfectant preparations. The discussion in Part V, Section C-Laboratory and Field Safety in US EPA, Microbiological Methods for Monitoring the Environment-Waters and Wastes, (EPA-600/8-78-017) is a good source of general information on this topic. The Safety Check List for Micobiological Water Laboratories found on pages 272 - 275 of this document should be followed. A copy of this document is in the laboratory chemist's office in the laboratory.

6) Clean your area of the laboratory completely at least once each month, throwing away old solutions and sponging down bench tops, shelves, drawers, etc. It is important that everyone make an effort to see that the equipment he/she is using, such as balances, spectrophotometers, etc. is in good working order and clean when he/she finishes using it. DO NOT assume that because someone else had left the area in a mess when you found it that you can leave the area in a mess. Anyone who leaves equipment in a mess is subject to dismissal from the laboratory.

7) Do not leave dirty glassware on benches, in sinks, etc. Each laboratory user is responsible for cleaning up his/her own glassware in a timely manner, and putting the same away in the proper location after drying.

8) If you put glassware in the drying oven, sign the input list, identifying those pieces of glassware that are yours. Do not leave glassware in the drying oven longer than absolutely necessary. Any glassware left in the drying oven for more than two hours will be subject to removal.

9) When your are finished for the day, wipe down your work area and cover any instruments you have been using.

10) Paper toweling does not provide adequate protection of bench tops from acids and caustic materials. DO NOT put acid bottles directly on the benches or on paper-covered benches; appropiately resistant plastic covering should be used for bench top protection.

11) All work with concentrated acids or other materials with harmful fumes should be done under a properly working chemical hood.

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12) Do not store solutions in volumetric flasks. Transfer all solutions that are to be kept, into proper reagent storage bottles.

13) Do not put highly alkaline solutions, such as hydroxide or carbonate, in glass bottles. Such solutions should not be used with any container or apparatus that has a ground glass stopper or joint because these solutions cause the joints to freeze.

14) Do not use low actinic (red) bottles or brown bottles for storage of miscellaneous solutions. These containers should be reserved for those solutions requiring the special properties of these types of glass.

15) Do not use plastic, numbered bottles for any purpose other than sample collection or storage.

16) Do not mark on the plastic, numbered bottles. If any additional labeling is necessary for special applications, such notations should be made on removable labeling tape (masking tape or other tape that is not removable, is not acceptable).

17) Be especially careful with special glassware and glass apparatus. Equipment broken will be repaired at the expense of the user.

18) When using generally laboratory glassware, do not assume that is has been cleaned in a manner that is suitable for your use.

19) Place your name on every item that you put in the cold room, refrigerator, freezer, oven, furnaces, etc. Log all samples, solutions, etc., on the sheet provided by the freezer or refrigerator. Every sample bottle or other container must be readily identifiable and traceable back to the person who placed it in there. Do not leave items in these storage areas any longer than is necessary.

20) All gas cylinders must be clamped to a table or wall. When empty,

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20 (cont.)) they should be marked "empty" and returned immediately.

21) Do not leave items on the floor unless absolutely necessary. If you must do this, place them against the wall or in a place where an individual is least likely to trip over them.

22) Do not use a vacuum pump unless it has a suitable trap in the vacuum line.

23) Use old (rather than new) tygon tubing if it is available and acceptable for your use. If possible, use the less expensive rubber tubing. Use the heavy, vacuum line tubing with the vacuum pump.

24) Do not use chemicals that belong to another research project or the department without prior permission of the student or staff member responsible for the project. You cannot assume that any chemials that you borrow from another is not contaminated for your purposes. Be careful not to contaminate any chemicals that you use. To avoid contamination problems, never dip directly into a bottle of chemical or pipet directly out of a stock solution of reagent. Always transfer a suitable amount to another container and do your percise measurement from that aliquot; discard unused portion in a proper manner for the chemical- DO NOT RETURN IT TO THE ORIGINAL CONTAINER. Keep the cover on the bottles of the reagents and solutions at all times exept when actually transfering chemical from the bottle. Parafilm is not meant to be a permanent covering material; find an appropiate cover for the container being used.

25) Each research assistant, employee, or other individual doing work in the laboratory is to maintain his/her own supply of beakers, common apparatus, glassware, chemicals, etc. for the project or exercise. Do not borrow items from your fellow students or staff without permission.

26) The distilled water system in the laboratory is prone to problems which result in impure water being produced. The conductivity of the water is monitored and recorded by the laboratory chemist. Before you use the distilled water, you should check it to determine if it meets the quality requirements for your particular use. Never assume that it is of adequate quality.

27) Be certain that you do not deplete the supply of distilled water. When the reservoir is reduced to about 1/4 of its capacity, see to it that the system is started again to fill the reservoir. If you are unfamiliar with the operation of the still or other water treatment system, ask the laboratory chemist to demonstrate it to you so that you understand how to operate it. Do not leave the still running unattended.

28) When placing an order for laboratory items, be certain that the correct item is requested. Vendors frequently charge penalties for items that are returned because of errors in ordering.

29) Do not mouth pipet any solution or water sample. Always use an aspirator bulb.

30) All electrical equipment must be grounded. Avoid the use of electrical equipment while you are standing on a wet floor. If the use of an extension cord is unavoidable, be certain that you use one of adequate current-carrying capacity, that is grounded, and that it is securely out of the way (e.g., not lying on the floor or near a hot plate, etc.).

31) Never connect a gas cylinder regulator that has been used for any gas other than O_2 , to an O_2 cylinder. Do not purchase gas cylinder valve adaptors which could be used to fit an oil-pumped gas regulator,

31 (cont.)) such as for nitrogen or air, to a cylinder of explosive gas, such as oxygen, nitrous oxide, or hydrogen. Adapters of this type are NOT ALLOWED in the environmental engineering laboratory.

32) Any thing poured down the sink should be accompanied by adequate volumes of water. All laboratory users MUST follow NJIT procedures for the disposal of solid and liquid wastes. These are outlined in the August 27, 1984 memorandum from the Department Safety Committee which is posted in the laboratory. If you have any questions about the proper disposal of a particular material, consult the laboratory chemist.

33) Report all accidents in writing as soon as possible to the Civil and Environmental Engineering office.

34) Horseplay in the laboratory is grounds for dismissal from the laboratory.

SPECIAL CONDITIONS FOR THE USE OF HAZARDOUS MATERIALS

1) Know the location of the nearest fire extinguisher, fire blanket, safety shower, and eye wash.

2) When you use a chemical, become familiar with its hazards, toxicity and antidote. BE CERTAIN that the antidote is readily available. For toxicity information, consult Elkins's, The Chemistry of Industrial Toxicology, the Chemical Rubber Company's (CRC), Handbook of Laboratory Safety, the ACS, Laboratory Safety Handbook, or Christensen's, Toxic Substances published by HEW.

3) If your are using radioactive compounds:

    a) Read and follow NJIT regulations

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3 (cont.)) b) Wear film badges

c) Do not pipet any radioactive solution by mouth

d) Keep record of amount of radioactive material disposed of

4) If you are working with exceptionally hazardous materials (e.g., parathion), be certain that someone else is in the area and that he/she knows what to do in an emergency. Do not work alone at night or weekends with this type of chemical.

5) Leave laboratory hoods on at all times to provide ventillation in the laboratory.

6) Avoid breathing fumes from organic solvents. Also avoid skin contact. Many solvents are more toxic than generally though.

7) Mercury metal should only be used in a well-ventillated area. Its vapor pressure is such that it can easily exceed maximum permissible concentration. If you are using mercury, have readily available a mercury spill clean-up kit or ready to spread sulfur on areas of any mercury spill.

8) When distilling explosive mixtures or compounds at reduced pressures, use safety shield.

9) Be especially careful when using perchloric acid, chlorine gas, and ethers. Boiling mixtures of concentrated perchloric acids and traces of organic matter can lead to violent explosions. Chlorine is especially poisonous. Check all ethers for peroxices, as peroxides cause ethers to explode spontaneously or ignite.

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INSTRUMENTATION

1) In order to avoid conflict in the use of an instrument, a sign-up notebook is provided for each instrument. Please sign serveral days in advance for any instrument that you wish to use. Priority for use is given to those who have signed up first. Include in your time reservation, all time needed for instrument preparation, warm-up, etc. Maintenance charges will be shared in proportion to the use made of the equipment.

2) Instruments can be damaged by improper use. Do not use an instrument unless you have read and understand the instruction manual throughly. These manuals can be found in the laboratory office. If possible, have a student who is familiar with the use of the instrument, or the laboratory chemist demonstrate its use to you after you have read the manual. You will need to make arrangements in advance for having the laboratory chemist provide a demonstration. The user will be charged for damage to the instruments.

3) If you are responsible for adding a new piece of equiment to the laboratory, you should prepare a maintenance schedule for it according to its instruction manual. The schedual should set the frequency of such operations as oiling motors, replacing batteries, cleaning, etc. A maintenance card is to be prepared from this list and provided to the laboratory chemist. As long as there is a laboratory chemist, he/she will take charge of having the required maintenance performed. Otherwise, it is the user's responsibility and the maintenance card and instructions should be left at the instrument. In addition, the student or staff member using the instrument should compile a list of items that should be on hand for emergency repairs or that tend to go out. Items such as extra fuses, batteries, gaskets, electrodes, lamps,

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3 (cont.)) belts should be on hand; as one is used, another should be ordered immediately.

4) If the apparatus requires the use of running water, and the water must be left running, the user will be responsible for any damage that may be incurred because of water leakage to the floor below, etc. Leave the name and telephone number of an individual who may be contacted in the event of problems with the functioning of the apparatus left unattended.

5) After using an instrument, be sure to clean up the area around the instrument. Do not leave any glassware or other items on the bench around the instrument. The user is responsible for cleaning any and all glassware, etc. that he/she uses, and putting it away in its proper location. Always be certain to turn off the instrument and/or apparauts before leaving at night.

6) Any instrument malfunction should be reported immediately to the laboratory chemist or the laboratory director.

Breif Bibliography

Bender, Manfred, "Fume hoods, open canopy type-their ability to capture pollutants in various environments," American Industrial Hygiene Journal 40(2): 118-126 (1979)

Bishop, E.C., W. Popendorf, D. Hanson, and J. Prausnitz, "Predicting relative vapor ratios for organic solvent mixtures," American Industrial Hygiene Association Journal 43(9): 656-660 (1982)

Brief, S. Richard , J. Lynch, T. Bernath, and R.A. Scala, "Benzene in workplace," American Industrial Hygiene Association Journal 41(9): 616-623 (1980)

Caplan, J. Knowlton, and G.W. Knutson, "A performance test for laboratory fume hoods," Amer. Ind. Hyg. Assoc. J. 43(10):722-736 (1982)

Caplan, J. Knowlton, and G.W. Knutson, "Influence of room air on laboratory hoods," American Industrial Hygiene Association Journal: 738-746 43(10) (1982)

Cheremisinoff, N. Paul, *Management of Hazardous Occupational Environments*. Pennsylvania: Technomic Publishing Co., 1984 pp.25-34, 61-81, 165-180

CRC Handbook of Laboratory Safety, R.C. Weast and G.L. Tuve (eds.), Cleveland, Ohio: The Chemical Rubber Company, 1971

First, W. Melvin, "Engineering Control of Occupational Health Hazards," American Industrial Hygiene Association Journal 44(9): 621-626 (1983)

Green, E. Michael and A. Turk, *Safety In Working With Chemicals*. New York: Macmillan Publishing Co., Inc., 1978, pp. 11-13, 59-120.

Halitsky, James, "Atmospheric dilution of fume hood exhaust gases," American Industrial Hygiene Association Journal 43(3): 185-189 (1982)

Hazards in the Chemical Laboratory, G.D. Muir ed., Great Britian: Alden Press, Oxford, 1977

Jentzch, D., and D.A. Fraser, "A laboratory evaluation of long term detector tubes: Benzene, Toluene, Trichloroethylene," American Industrial Hygiene Journal 42(11): 810-822 (1981)

Lautenberger, J. William, E.V. Kring, and J.A. Morello, "A new personal badge monitor for organic vapors," American Industrial Hygiene Journal 41(10):737-747 (1980)

Mastromatteo, Earnest, "On the concept of threshold," American Industrial Hygiene Journal 42(11):763-769 (1981)

Brief Bibliography

Nelson, O.G., B.Y. Lum, G.J. Carlson, C.M. Wong and J.S. Johnson, "Glove permeation by organic solvents," American Industrial Hygiene Association Journal 42(2):217-225 (1981)

NIOSH/OSHA Pocket Guide to Chemical Hazards. U.S. Department of Health and Human Services, and U.S. Department of Labor (OSHA). Washington, D.C.: U.S. Goverment Printing Office, 1978.

OSHA Safety and Health Standards (29 CFR 1910), General Industry. Washington, D.C.: U.S. Department of Labor, OSHA2206, U.S. Govt. Printing office (Revised July 1, 1984).

Peck, C. Robert, "Validation of a method to determine a protection factor for laboratory hoods," American Industrial Hygiene Association Journal 43(8):596-601 (1982)

Stampfer, F.J., "Respriator canister evaluation for nine selected organic vapors," American Industrial Hygiene Association Journal 43(5):319-327 (1982)

Safe Handling of Chemical Carcinogens, Mutagens, Teratogens and Highly Toxic Substances. Douglas B. Walters (ed.), Michigan, Ann Arbor Press, 1980 vols. I and II.

Toxic and Hazardous Industrial Chemicals Safety Manual for Handling and Disposal with Toxicity and Hazard Data. Japan, The International Technical Information Institute, 1981.

Threshold Limit Values. Committee of American Conference of Government Industrial Hygienists, Cincinnati, OH 1980

Weeks, W.R. and M.J. McLeod, "Permeation of protective garment material by liquid benzene and by tritiated water," American Industrial Hygiene Journal 43(3): 201-211 (1982).

Guide for safety in the Chemical Laboratory. Manufacturing Chemists Association. New York: Van Nostrand Reinhold Company, 1972.

Occupations Exposure Guide. Wisconsin: J.J. Keller and Associates, 1984

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