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16. Abstract (Limit: 200 words)

Polychlorinated biphenyls (BCP's) have been widely used as fire-resistant, dielectric coolants in electrical equipment used in mining applications including transformers, capacitors, electric motors, and electromagnets. In addition, PCB's have been used in hydraulic and heat transfer fluids and are present in many oil-filled transformers. The Environmental Protection Agency (EPA) recently banned the manufacture of PCB's and equipment using PCB's and imposed strict requirements on the continued use and disposal of existing PCB equipment. This manual discusses the EPA requirements, suggests ways to decrease the risks resulting from continued use of PCB equipment, and surveys the non-PCB equipment that is available as replacements for the PCB electrical equipment presently used in mines.

17. Document Analysis a. Descriptors

Mining equipment
- Polychlorinated biphenyls
- PCB's
- Transformers
- Capacitors
- Power systems
- Regulations

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group 08I

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(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

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1.0 INTRODUCTION

The U.S. Environmental Protection Agency recently banned the manufacture of new equipment containing Polychlorinated Biphenyls (PCBs) and established stringent requirements on the continued use and disposal of existing equipment containing PCBs. These regulations apply to all PCBs in the United States, Puerto Rico, Virgin Islands, and U.S. Pacific territories. All PCBs are regulated, including those in use in equipment in surface and underground mines.

PCBs have been the basis for fire resistant askarel liquids used in transformers and capacitors and have been used in various other applications in the mining industry. This manual addresses two issues: (1) how to comply with the EPA regulations and (2) how to select replacements for equipment that contains PCBs.

This manual is not complete: It is assumed that you have a copy of the EPA regulations on PCBs. If not, get a free copy from EPA by calling toll free (800) 424-9065 (in Washington, D.C., 554-1404) and asking for a reprint of the PCB Ban Regulation, May 31, 1979 Federal Register and for a list of the approved PCB Disposal Facilities. If you want more background information on the regulation, ask for a free copy of the EPA Support Document to the PCB Ban Regulation at the same phone number. (The mail address is: Office of Industry Assistance, Office of Toxic Substances TS-799, U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460.)

Other available information: This report does not go into much detail about the health and environmental effects of PCBs or the chemicals now being used as substitutes for PCBs. The following reports cover these technical areas; the NIOSH Criteria Document is particularly recommended for its discussion of health issues if you are going to service PCB equipment or clean up PCB spills.

> "Criteria for a Recommended Standard...Occupational Exposure to Polychlorinated Biphenyls (PCBs)." DHEW (NIOSH) Publication No. 77-225, September 1977. Order from: Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $4.00 plus postage.

> "Assessment of the Use of Selected Replacement Fluids for PCBs in Electrical Equipment." Report No. EPA 560/6-77-008, March 1979. Order from National Technical Information Service, Springfield, Virginia 22161. Report No. NTIS-PB-296 377.

"Polychlorinated Biphenyls and the Environment." 1972. Order from National Technical Information Service, Springfield, Virginia 22161. Report No. NTIS COM-72-10419. This is a thorough discussion of the properties and uses of PCBs.

"PCBs in the United States: Industrial Use and Environmental Distribution." 1976. Order from National Technical Information Service, Springfield, Virginia 22161. Report No. NTIS PB 252-012.

1.1 Background

Polychlorinated biphenyls (PCBs) are a class of chemicals that have been used since 1930 as the basis for non-flammable dielectric liquids in electrical equipment such as transformers and capacitors and as a component of some heat resistant heat transfer and hydraulic fluids. PCBs were manufactured in the United States from 1930 through 1977 primarily by Monsanto Industrial Chemicals Co. which marketed various mixtures of PCBs under the trade name Aroclor. Mixtures of PCBs and other chemicals were marketed by Monsanto and by other companies under a variety of trademarks for different applications as described later in this report. PCBs have also been manufactured in Europe and in Japan as listed in Table 1.1-1.

TABLE 1.1-1
Manufacturers and Trade Names of PCBs

Manufacturer	Country	Trade Name
Bayer	Germany	Clophen
Caffaro	Italy	Fenclor
Caffaro	Italy	DK
Caffaro	Italy	Inclor
Chemko	Czechoslovakia	
Geneva Industries	US	
Kanegafuchi	Japan	Kennechlor
Monsanto	UK and US	Aroclor
Monsanto	UK and Japan	Santotherm FR
Monsanto	UK and Europe	Pyroclor
Prodelec	France	Phenoclor
Prodelec	France	Pyralene
Sovol	USSR	

PCBs were identified as a serious and wide-spread environmental pollutant in 1968, leading Monsanto to voluntarily limit the sales of PCBs to "totally enclosed" capacitor and transformer applications after 1972. Limitations on the presence of PCBs in food were established by the U.S. Food and Drug Administration in 1973. In 1977 the EPA banned the discharge of PCBs in the water effluents from PCB manufacturers, capacitor manufacturers, and transformer manufacturers. A review of the uses and environmental distribution of PCBs in 1975 indicated that over one half of the 1.5 billion pounds of PCBs that had ever been manufactured in the U.S. were still in use in electrical equipment and that only about ten percent of the total PCBs had entered the environment. Even this relatively low environmental load of PCBs was sufficient to cause the PCB concentration in some freshwater fish to exceed the limits set by the FDA. The resulting ban on the sale of contaminated fish essentially ended commercial fishing in the Hudson River, in much of the Great Lakes, and in a number of other freshwater lakes and rivers.

The environmental and health problems associated with exposure to PCBs result from the same properties that make these chemicals useful in industrial and electrical applications: PCBs are very stable chemically, are soluble in organic solvents, and are almost insoluble in water. PCBs that are released to the environment do not degrade, but accumulate preferentially in the fat of micro-organisms and bioaccumulate in the food chain. As a result, the concentration of PCBs in fish may be one million times higher than in the water that the fish lives in. Compounds such as PCBs that are insoluble in water are excreted by birds and mammals by being converted to water-soluble compounds by powerful enzymes in the liver. High concentrations of chemicals in the body will cause the liver to increase the production of these enzymes. Unfortunately, PCBs are immune to attack by the enzymes and so are not excreted, but build up in the body causing the liver to increase production of the enzymes. These enzymes are not specific to PCBs, and increased enzyme levels will react with various hormones, causing the hormones to be excreted and reducing their concentration. A number of sex hormones are particularly sensitive to attack by increased levels of enzymes activated by PCBs, and the resulting decreased levels of these hormones cause decreased shell thickness in bird eggs and reproductive problems in mammals. PCBs do not appear to be a direct cause of cancer, but the enzyme changes caused by exposure to PCBs may make the body more susceptible to the effects of low levels of direct carcinogens found in cigarette smoke and in other man-made environmental pollutants. Ingestion of relatively large quantities of PCBs (on the order of one gram) can cause liver damage, skin problems, and other acute health effects.

In 1976, the U.S. Congress passed the Toxic Substances Control Act which gave the Environmental Protection Agency wide authority to control the production and use of chemicals in the United States. Section 6(e) of this act mandated a complete ban on the manufacture, processing, distribution in commerce, and use of PCBs and required the EPA to establish requirements for the marking and disposal of PCBs in use (See Figure 1.1-1). The act also allowed the EPA

Figure 1.1-1

Section 6(e), Toxic Substances Control Act

(e) POLYCHLORINATED BIPHENYLS.—(1) Within six months after the effective date of this Act the Administrator shall promulgate rules to— Rules.

(A) prescribe methods for the disposal of polychlorinated biphenyls, and

(B) require polychlorinated biphenyls to be marked with clear and adequate warnings, and instructions with respect to their processing, distribution in commerce, use, or disposal or with respect to any combination of such activities.

Requirements prescribed by rules under this paragraph shall be consistent with the requirements of paragraphs (2) and (3).

(2)(A) Except as provided under subparagraph (B), effective one year after the effective date of this Act no person may manufacture, process, or distribute in commerce or use any polychlorinated biphenyl in any manner other than in a totally enclosed manner.

(B) The Administrator may by rule authorize the manufacture, processing, distribution in commerce or use (or any combination of such activities) of any polychlorinated biphenyl in a manner other than in a totally enclosed manner if the Administrator finds that such manufacture, processing, distribution in commerce, or use (or combination of such activities) will not present an unreasonable risk of injury to health or the environment.

(C) For the purposes of this paragraph, the term "totally enclosed manner" means any manner which will ensure that any exposure of human beings or the environment to a polychlorinated biphenyl will be insignificant as determined by the Administrator by rule. "Totally enclosed manner."

(3)(A) Except as provided in subparagraphs (B) and (C)—

(i) no person may manufacture any polychlorinated biphenyl after two years after the effective date of this Act, and

(ii) no person may process or distribute in commerce any polychlorinated biphenyl after two and one-half years after such date.

(B) Any person may petition the Administrator for an exemption from the requirements of subparagraph (A), and the Administrator may grant by rule such an exemption if the Administrator finds that— Petition for exemption.

(i) an unreasonable risk of injury to health or environment would not result, and

(ii) good faith efforts have been made to develop a chemical substance which does not present an unreasonable risk of injury to health or the environment and which may be substituted for such polychlorinated biphenyl.

An exemption granted under this subparagraph shall be subject to such terms and conditions as the Administrator may prescribe and shall be in effect for such period (but not more than one year from the date it is granted) as the Administrator may prescribe. Terms and conditions.

(C) Subparagraph (A) shall not apply to the distribution in commerce of any polychlorinated biphenyl if such polychlorinated biphenyl was sold for purposes other than resale before two and one half years after the date of enactment of this Act.

(4) Any rule under paragraph (1), (2)(B), or (3)(B) shall be promulgated in accordance with paragraphs (2), (3), and (4) of subsection (c).

(5) This subsection does not limit the authority of the Administrator, under any other provision of this Act or any other Federal law, to take action respecting any polychlorinated biphenyl.

to authorize the continued use of PCBs after July 1, 1979, if the agency found that such use did not present an undue risk to human health or the environment. The EPA promulgated the required Disposal and Marking Regulations for PCBs on February 17, 1978, and on May 31, 1979, promulgated the PCB Ban Regulations which authorize certain continued uses of PCBs and specify the conditions that must be met by those who continue to use PCBs.

1.2 PCBs Used in the U.S. Mining Industry

The EPA regulations on the marking, processing, use, and disposal of PCBs will affect the following equipment and activities in the mining industry:

Askarel transformers: marking, maintenance, disposal, spill cleanup, recordkeeping, storage for disposal

Oil filled transformers: disposal of oil

Capacitors: marking, disposal, spill cleanup, recordkeeping, storage for disposal

Electric motors (PCB filled as used on Joy Manufacturing built model CU43 and 9CM continuous miners and 14BU10 loaders): continued use, maintenance, disposal, spill cleanup

Separator electromagnets (PCB filled): marking, maintenance, disposal, spill cleanup

Hydraulic and heat transfer systems (that ever contained a PCB based fluid): marking, maintenance, use, disposal, spill cleanup

Waste oil: disposal, use

Transportation of any PCBs or PCB equipment

Storage of any PCBs or PCB equipment

Recordkeeping: required if you have any PCB transformers, more than 99.4 lb of PCBs in containers, or more than 49 large PCB capacitors.

The general requirements that apply to all PCB equipment and material contaminated with PCBs are discussed in Chapter 2. The specific requirements that apply to each of the major types of PCB equipment are discussed in the following chapters.

2.0 GENERAL REQUIREMENTS

It was the intent of Congress to ban the use of PCBs and thereby prevent the entry of PCBs into the environment. If you continue to use PCBs in those applications authorized by the EPA, you will have to meet the requirements specified by the regulations. EPA has the authority to enforce these requirements by performing compliance inspections wherever PCBs are used, including in mines. Violations of the regulations can result in fines of up to $25,000 per violation per day. Willful violation of the regulations can result in additional criminal action against the responsible people, with a possible penalty of a $25,000 fine and one year in jail.

EPA is serious about keeping PCBs out of the environment. If you decide to continue to use or handle PCBs or PCB equipment after July 1, 1979, under the authorizations granted by the EPA, you will be expected to comply with the following general requirements and the specific requirements discussed in the following chapters that apply to specific kinds of PCB equipment.

2.1 Recordkeeping (40CFR 761.45)

Special recordkeeping requirements are specified in Annex VI of the PCB regulations. You are required to maintain these perpetual PCB inventory records for each facility that has in use or in storage:

45 kilograms (99.4 lb) of PCBs or PCB contaminated material in containers.

One or more PCB transformers.

50 or more PCB large (3 lb liquid) capacitors.

In addition, an annual report must be prepared by July 1 of each year, summarizing the changes in PCB use during the previous year. EPA will use these records when they perform compliance inspections, and will consider the lack of records or discrepancies in the records as evidence of lack of intent to comply with the regulations. The records will have to be kept until five years after the last PCBs have been removed from the facility.

The EPA regulations are very specific as to the kinds of information that must be kept. Any capacitor that contains three pounds of PCBs must be considered to be a "large capacitor" for purposes of labeling, disposal, and recordkeeping To estimate the weight of PCBs in a capacitor, assume that 20% of the volume of the can is filled with PCBs weighing 11.4 pounds per gallon:

$$\text{Capacitor can volume (in}^3\text{)} \times .01 = \text{lb PCBs}$$

A "large capacitor" would be any capacitor having a total volume exceeding 300 cubic inches.

2.2 Marking (40CFR 761.20)

The EPA requires that special 6" square yellow labels (described in Annex V of the regulations) be applied to practically everything that has more than 50 ppm PCBs except small capacitors (less than 3 lb PCBs) and oil filled transformers (below 500 ppm PCBs). Labels must be applied to equipment that contains PCBs including transformers, large capacitors operating above 2000 volts, contaminated hydraulic and heat transfer systems, electromagnets, electric motors, cans and drums used to store PCBs and contaminated material, storage areas, and trucks carrying PCB transformers or more than 45 kg (99.4 pounds) of PCBs or PCB contaminated material. The only exception to applying the label directly to the item applies to large capacitors mounted on the top of a power pole or behind a fence at a substation; a single label may be applied to the pole or fence if records are adequate to identify which of the capacitors contain PCBs. Large PCB capacitors operating below 2000 volts do not have to have a label until they are removed from service, but it would be a good idea to label them now to identify them as PCB items. It is advisable to keep ten or twenty extra labels on hand to be applied to drums used to store used transformer oil, cleaned up spill material, contaminated rags, etc.

Pressure sensitive labels meeting EPA requirements may be purchased from a number of companies including:*

Label Master
6001 North Clark Street
Chicago, Illinois 60660
phone: (312) 973-5100

W. H. Brady Co.
727 West Glendale Avenue
Milwaukee, Wisconsin 53209
phone: (414) 332-8100

2.3 Containers for PCBs (40 CFR 761.42)

Containers used to store liquid PCBs must comply with one of the following requirements:

1) 49 CFR 178.80 - specification 5 without removable head

2) 49 CFR 178.82 - specification 5B without removable head

3) 49 CFR 178.116 - specification 17E

Any container which meets the requirements described in these specifications will be marked with DOT-5-, DOT-5B-, or DOT-17E-. There may be additional markings but they do not affect the suitability of the containers.

*This list is for reference only, and does not imply endorsement by the Bureau of Mines or the Environmental Protection Agency.

If liquid PCBs are to be stored in containers larger than permitted in the above specifications, the following requirements must be met:

1) The containers must be designed, constructed, and operated in compliance with Occupational Safety and Health Standards, 29 CFR 1910.106. The specification for flammable and combustible liquids may be obtained from the Government Printing Office (202-783-3238). It is included in Section 1910 of Title 29 of the Code of Federal Regulations.

2) Either a) the container shall be kept in a storage area that meets the requirements described in Section 2.4 or b) a Spill Prevention, Control, and Countermeasures Plan (SPCC) as described in 40 CFR 112 must be prepared and implemented. (Amendment of SPCC plans by the Regional Administrator, 40 CFR 112.4, does not apply.)

Any container used to store rags, contaminated soil, or other non-liquid PCBs must comply with one of the following:

a) 49 CFR 178.80 - specification 5

b) 49 CFR 178.82 - specification 5B

c) 49 CFR 178.115 - specification 17C

d) Any container larger than the 55-gallon size given in the above specifications shall provide as much protection against leaking and be of the same strength and durability as the containers described.

Containers that meet either a, b, or c above will be labeled either DOT-5-, DOT-5B-, or DOT-17C.

With the exception of the specification from the Occupational Safety and Health Standards, all of the above specifications are included in Title 49 of the Code of Federal Regulations - Transportation (parts 100-199). This document may be ordered from the U.S. Government Printing Office, Washington, D.C. 20402 (telephone 202-783-3238). The cost is $8.25 plus postage.

2.4 Storage (40 CFR 761.42)

The basic requirement is that PCBs be stored in special storage areas in buildings that are located above the 100-year flood water elevation and that the storage areas be diked and have impervious floors with no drains. PCBs put into storage before January 1, 1983, must be removed and disposed of by January 1, 1984. PCBs put into storage after January 1, 1983, may not remain in storage for more than one year. The items in storage must be checked every 30 days to ensure that they are not leaking PCBs.

Temporary storage outside the special storage areas is allowed for certain non-leaking equipment and containers for a period of 30 days. Non-leaking large capacitors and drained askarel transformers may be stored adjacent to the special storage area until January 1, 1983. The regulations also specify the types of drums and tanks that can be used to store PCB liquids and contaminated solids.

The storage requirements are complicated and probably expensive. Most of the problems can be avoided if you dispose of any PCBs within thirty days after they are removed from service. However, there are no incinerators presently approved for PCB liquids, so askarel removed from transformers and other contaminated liquids will have to be stored in compliance with these regulations until EPA approves an incineration facility.

2.5 Spill Cleanup (40CFR 761.10(d))

EPA regulations require that all material contaminated with PCBs in concentrations above 50 parts per million by weight (e.g., one pound of PCBs in ten tons of dirt or other material) be picked up, drumed, and disposed of in specially approved facilities. This is potentially the most expensive provision of the regulations. The cost of cleaning up PCB spills onto dirt or major machinery can be high. The cost of cleaning up a PCB spill that has entered the water can be horrendous. The potential cost of spill cleanup will justify work performed now to limit the extent of PCB spills and may justify replacing PCB equipment if there is much risk of PCBs entering water from failed equipment.

Immediate response to PCB spills should be based on three major principles:

1) Minimize human exposure to PCBs: disconnect the power from electrical equipment to stop the boil-off of PCBs; provide workers with protective gloves and clothing and, if necessary, breathing apparatus.

2) Prevent PCBs from entering water: soak up spilled PCBs with straw, rags, sawdust, dirt, or anything else that is available; throw up temporary dikes to minimize the spread of spilled liquid.

3) After the spill is under control, contact experts to decide on cleanup and disposal procedures. The PCB labels that are required on all PCB equipment give the toll-free phone number of the U.S. Coast Guard National Response Center. Personnel at this number will give the names and telephone numbers of EPA personnel at the appropriate regional office who in turn will be able to give guidance in the cleanup procedure. In the event of a major spill into water, the Coast Guard will send personnel to supervise and aid in assessment and cleanup.

You might want to consider distributing a short emergency response guide within your own organization to mine superintendents, maintenance supervisors, electrical foremen, etc. A suggested outline is included in Appendix A.

Other Information:

Emergency response: U.S. Coast Guard National Response Center: (800) 424-8802.

Supplementary information on cleanup procedures and federal requirements: EPA Control Action Division in Washington, D.C.: (202) 755-8033.

Information on foam plastic and concrete emergency dikes: EPA publication EPA-R2-73-185, "Control of Hazardous Chemical Spills by Physical Barriers." Order from National Technical Information Service, Springfield, Virginia 22161. Publication No. NTIS-PB-221 493/03A.

Protective clothing availability: "A Survey of Personnel Protective Equipment and Respiratory Apparatus for Use by Coast Guard Personnel in Response to Discharges of Hazardous Chemicals." Order from National Technical Information Service, Springfield, Virginia 22161. Publication No. NTIS-ADA-010-110.

Other Regulations: PCB spills into water are also regulated under the Clean Water Act. Rules proposed by the EPA under this act in the February 16, 1979 Federal Register list 299 regulated hazardous materials, including PCBs. Under these rules, any spill of PCBs in excess of ten pounds constitutes a "discharge" if the spill threatens to reach "the waters of the United States." Waters of the United States do not, at this time, include groundwaters, so spills of PCBs in dry areas such as in some western states do not constitute discharges as far as the Clean Water Act is concerned unless there is a chance the discharged fluid can find its way to a stream, river, swamp, or other body of surface water. The proposed regulations require that any discharge of more than ten pounds of PCBs into water must be reported within 24 hours to the United States Government in accordance with procedures specified by the Department of Transportation in 33 CFR 153.203. (The proposed regulations also specify separate fines for spills of PCBs into the water.)

2.6 Decontamination (40 CFR 761.43)

The EPA regulations authorize decontamination of containers, such as steel drums that have been in contact with PCBs by triple rinsing with clean solvent. The volume of solvent used for each rinse must be at least ten percent of the volume of the container. Movable equipment used in storage areas may be decontaminated by swabbing surfaces that have been in contact with PCBs with a suitable solvent. This same procedure could probably be used to decontaminate other machinery such as drag lines contaminated with PCBs.

The preferred solvents for cleaning up PCBs are kerosene and light fuel oil. The workers should be issued protective gloves and other necessary protective clothing as may be required by the conditions. Protective breathing apparatus may be necessary in some instances. Used solvents and other contaminated materials must be stored in containers (as described in Section 2.3) that have been marked as discussed in Section 2.2. This contaminated material must be stored as specified in Section 2.4 and disposed of in approved facilities as discussed in Section 2.8.

Contaminated gloves and other protective clothing should be discarded into the drums with the other PCB contaminated solid material. Any PCBs that get onto workers' skin should be removed using waterless hand cleaner and paper towels, the paper towels then being disposed of as required for PCBs.

2.7 Transportation (40CFR 761.42, 761.20(b))

PCBs are not considered a hazardous material under the regulations of the U.S. Department of Transportation. Therefore, no special type of vehicle or placarding is required. However, EPA is planning to promulgate a comprehensive manifesting system for hazardous chemicals under the authority of the Resource Conservation and Recovery Act. PCBs will be covered under these requirements.

Containers used to hold PCBs and contaminated material must meet the requirements specified by the EPA and discussed in Section 2.3. Vehicles used to transport PCBs (including common carrier trucks and railroad cars) are required to have a PCB label applied to the outside of the vehicle if they are carrying PCB containers that contain (1) more than 45 kg (99.4 lb) of liquid having more than 50 parts per million on PCBs or (2) one or more PCB transformers.

It is not required that askarel transformers be drained before they are transported. However, the cooling fins on transformers are fragile, and most of the PCB spills that have resulted in major expensive cleanup efforts have been caused by damage to askarel transformers during transportation. If an askarel transformer is drained before it is moved, there will be a greater chance of damaging the coils; on the other hand, the cost of cleaning up a spill from a transformer after a truck accident or a loading mishap can be extremely high.

2.8 Disposal (40 CFR 761.10)

Special disposal requirements apply to all PCB equipment and to all materials contaminated with more than 50 parts per million PCBs except for small capacitors that contain less than three pounds of PCBs. These small capacitors may be disposed of in muncipal landfills in which the organic wastes are expected to adsorb and immobilize the PCBs after the capacitor casing rusts through. Solid spill materials contaminated with more than 50 parts per million PCBs must be disposed of in an approved PCB landfill or special PCB incinerator. Disposal requirements for PCB equipment are discussed in the following chapters.

You cannot contract away your responsibility for proper disposal of PCBs. If there is ever a problem and the PCBs are traced to you, it is still your responsibility. The EPA regulations establish special and stringent requirements for chemical waste landfills and incinerators used to dispose of PCBs. A list of approved facilities is available from the EPA Office of Industry Assistance by calling toll free (800) 424-9065 or in Washington, D.C. 554-1404. Contact the disposal facility for prices and special instructions before sending PCBs.

The EPA had not approved any incinerators for commercial disposal of PCBs as of the time this report was written (August, 1979), so all materials required to be disposed of by incineration must be stored in accordance with the regulations until EPA approves an incinerator.

3.0 ASKAREL TRANSFORMERS

The term askarel is defined by the 1978 National Electrical Code as "a generic term for a group of nonflammable synthetic chlorinated hydrocarbons used as electrical insulating media. Askarels of various compositional types are used. Under arcing conditions the gases produced, while consisting predominantly of noncombustible hydrogen chloride, can include varying amounts of combustible gases depending upon the askarel type." In fact, all of the types of askarel sold prior to 1979 contained from 60% to 100% PCBs, the balance of the mixture usually being trichlorobenzene. The unique advantages of PCB based askarel used as a coolant liquid in transformers have been its chemical inertness and nonflammability.

Approximately two percent of the pad mounted transformers in use in the United States contain PCB based askarel coolant liquid. Askarel transformers have been used where fires might endanger human life and property. PCBs have the advantage of nonflammability, in contrast to mineral oil, the other major liquid coolant used in transformers. Gaseous coolants are also nonflammable but gas cooled (dry type) transformers have certain disadvantages when compared to liquid cooled transformers. Dry type transformers are generally more expensive than the liquid cooled units, and they usually have increased operating noise levels and a lower capacity to withstand temporary overheating caused by surges of power in the electrical circuit. Alternative liquid coolants are available but none have all the advantages of PCBs.

3.1 The Uses of Askarel Transformers in Mining

The advantages of askarel transformers in mining are the same as in any application: askarel fluids are nonflammable. Askarel transformers are, of course, no longer being produced, but the ones that are in service will be permitted to remain in service for their operational lifetimes, which in many instances could be 30 to 40 years or maybe longer. As will be pointed out below, none of the alternatives to askarels are direct replacements for askarel cooled transformers. Transformers cooled with gases, for instance, present very little fire hazard, but they are voltage limited because of the inherent characteristics of gases, and gases simply do not have the heat capacity of liquids. Liquid cooled transformers are therefore better where transformers are likely to be occasionally run at a higher than design loading. The alternative "high fire-point transformer liquids" are all more expensive than askarel and do not have the same fire resistance. Oil cooled transformers, the mainstay of the transformer industry, are the least costly of all transformers available, but in applications requiring fire safety, they must be installed in fire resistant vaults which can cost several times as much as the basic transformer.

Askarel filled transformers are used in all phases of mining: underground, in surface installations, and on-board large mobile surface machinery. Transformers used in mining range in size from 10 to 8,500 kVA and contain up to 3,415 gallons of askarel.

3.1.1 Machine Mounted

The major manufacturers of large surface mining equipment installed askarel transformers on a small portion of their equipment. This was generally done at the request of the company purchasing the machinery, though Page Engineering used askarel transformers on all of their walking draglines.

Bucyrus-Erie used to provide askarel transformers on electrically powered draglines, loading shovels, and blast-hole drills. Usually the customer was being required by its insurance carrier to use a non-flammable transformer fluid. Askarel transformers, when requested, were mounted inside the machinery in steel rooms that had originally been designed for oil transformers. These rooms usually had an opening in the floor that would duct the transformer fluid to the ground to reduce the fire hazard in the event of a transformer rupture; the rooms also contained openings to provide adequate ventilation. These transformers were 100-250 kVA single-phase units. It is estimated that askarel transformers were installed on 5-6 machines out of roughly 400 that were built by Bucyrus-Erie over the past 15 years.[1] Bucyrus-Erie quit supplying askarel transformers around the first part of 1977 and currently use only mineral oil transformers, but they are investigating the use of silicone filled units.

Marion Power Shovels also supplied askarel transformers in the 100 kVA range on their shovels and draglines at customer request. Askarel filled transformers were mounted on only a small percentage of the 1,000 electrically powered machines that Marion has built. As in the case of Bucyrus-Erie, askarel filled transformers were mounted inside the machine in the fire resistant rooms that had been designed to meet specifications for oil filled transformers. Marion quit supplying askarel filled transformers during 1975.[2]

In contrast with the preceding two companies, Page Engineering, supported by its insurance company, used askarel filled transformers on all of the walking draglines they built before 1977. Each dragline contains a bank of three single-phase transformers in the 100-333 kVA range.[3] These transformers are

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1 Telephone conversation with Dick Matusak, Bucyrus-Erie, 8/5/77.

2 Telephone conversation with Joseph Ivy, Marion Power Shovels, 8/8/77.

3 Telephone conversation with Frank Oslakovic, Page Engineering Co., 8/10/77.

mounted in cages on steel platforms about 8 feet above the main deck of the dragline. A major rupture of one of these transformers would result in PCBs leaking onto the ground underneath the dragline. An estimated 25 of these machines have been built over the past 10 years.

In addition to the above equipment, an undetermined number of blast-hole drills built by Robbins Drill Division of Joy Manufacturing used three single-phase askarel filled transformers.

Equipment that uses askarel transformers is used by a relatively small number of mines. In some cases, the mining company was required by its insurance carrier to order askarel transformers; thus most or all of the equipment at these particular mines will contain askarel transformers. In addition, it is not unusual for a company to order its large equipment from a single supplier. If the supplier were Page, all the draglines at that mine would have askarel transformers on board.

3.1.2 Underground

According to information obtained from Electric Service Co., a transformer service company, from comments that were made during a telephone survey of load center manufacturers and from information obtained during the mine visits, there are few askarel filled transformers in use underground in coal mines. All load centers used dry type transformers that have been designed to withstand the environment in the mines. When questioned about potential difficulties with dust or dampness in the mines, manufacturers replied that these conditions do not cause major problems. The few askarel transformers that are in use in underground coal mines are gradually being taken out and replaced with dry type transformers.

The relative scarcity of askarel transformers in underground coal mines is not duplicated in underground metal/non-metal mines, where the use of askarel transformers is widespread. During visits to three underground mines, askarel transformers were found in numerous locations in the underground distribution system, covering all applications from main underground substations to small units on lighting circuits. The mountings for these transformers ranged from concrete pads level with a damp mine floor to diked, elevated concrete pads. At two of the mines visited, a major askarel leak would easily find its way into the mine water. This water was being pumped to the surface where it was being used in ore processing operations and was subsequently impounded. A major askarel leak in these cases could cause widespread contamination and would be extremely costly to clean up.

Failure of an askarel transformer accompanied by an internal electrical arc can vaporize a considerable quantity of PCBs which will then be released through the pressure relief valve. The National Electrical Code requires that askarel transformers located in buildings be vented to the outside because of the potential health problems that could result from worker exposure to high concentrations of PCB vapors. No such venting is possible with those askarel transformers used underground, the mines presumably accepting the increased risk of toxicity as a tradeoff for reduced flammability.

The extent of askarel transformer use varies from mine to mine. At one mine only the main underground substations used askarel transformers, the remaining transformers were either oil filled or dry type. At a second mine all of the underground transformers were askarel filled as a matter of company policy.

3.1.3 Surface

The use of askarel transformers at the surface facilities of underground mines, both coal and metal/non-metal, and at the ore processing facilities at strip mines is also common. Askarel transformers are used any place where such use is required by the National Electrical Code, generally any indoor location where the transformer is not mounted in a fire-resistant enclosure. The transformers which were observed ranged in size from 50 kVA single-phase units, which contained roughly 40 gallons of askarel and fed an auxiliary power circuit, to 8,500 kVA three-phase units which contained 3,415 gallons of askarel and served an electrolytic zinc plant. The only environmental problem associated with the present siting of these transformers is that in most cases a major askarel leak would almost certainly find its way through numerous floor drains into the water system of the surface facility.

3.1.4 Number of Askarel Transformers Used in U.S. Mines

The information given in the tables below refers specifically to askarel transformers. Throughout this chapter, reference will be made to both askarel transformers and to PCB transformers. The terms are not synonymous. "Askarel transformers" contain askarel, while "PCB transformers" includes askarel transformers plus any other type of transformer that for whatever reason (usually inadvertent contamination) contains more than 500 parts per million (0.05 percent) of PCBs. This distinction and the problems it imposes are discussed in greater detail further on in this chapter.

The 2 percent of all transformers cooled with askarels amount to between 135,000 and 140,000 transformers nationwide. The estimate of the number of askarel transformers in service in mines was based on data gathered in 20 mine visits. Table 3.1.4-1 summarizes the results of visits in terms of stationary transformers, machine mounted transformers, and surface and underground transformers.

Overall estimates of the number of askarel transformers in use by the various portions of the mining industry have been based on these data and other information obtained over the period of this study. These numbers are shown in Table 3.1.4-2. For the coal industry, the estimates were made by directly extrapolating the number of transformers at the mines surveyed, based on the

Table 3.1.4-1 Summary of Askarel Transformer Data Gathered During Visits to Mines

Mine	Production (10^6 tons ore/yr)	Number of Askarel Transformers	
		Machine Mounted	Total
Surface Metal/ Non-Metal			
1	2.8	6	6
2	31.4	0	44
3	20.0	0	65
Underground Metal/ Non-Metal		Underground	Total
1	NA	NA	24
2	1.6	12	15
3	NA	(Nearly all)	NA
Surface Coal		Machine Mounted	Total
1 (2 mines)	7.7	15	15
2 (2 mines)	10.2	0	1
3	3.3	NA	NA
Underground Coal		Underground	Total
1 (29 mines)	8.1	0	3
2 (8 mines)	3.2	0	0
3 (3 mines)	1.7	0	6
4 (3 mines)	1.6	0	0
5 (4 mines)	new	0	12
6 (2 mines)	4.0	0	2
7 (2 mines)	1.9	1	1
8, 9, 10, 11	These 4 companies are still surveying their equipment.		

tonnage produced at those mines compared to the tonnage produced by the entire industry. For the metal/non-metal industry, the extrapolation was done based on a comparison of the electrical consumption of the entire industry. The estimate of the number of transformers includes all mining, crushing, grinding washing, drying, and beneficiation operations for each segment of the mining industry. It is likely that these estimates constitute an upper bound on the number of askarel transformers actually in service because visits were made to those mines known to be using askarel transformers.

Table 3.1.4-2 Extrapolated Estimates of Numbers of Askarel Transformers in Various Mining Segments

Industry Segment		Number of Askarel Transformers
Surface Metal/Non-Metal		1,600
Underground Metal/Non-Metal		1,300
Surface Coal		400
Underground Coal		100
	Total	3,400

3.2 How to Identify an Askarel Filled Transformer

The following methods can be used to determine whether or not a transformer is cooled by askarel (PCB):

(a) Nameplate data - Most transformers will have intact nameplates containing details on the size of the unit and the weight and volume (usually in pounds and gallons) of the coolant. In almost all cases where askarel coolants are used, the nameplate will contain the manufacturer's trade name for askarel. The following trade names for transformer askarel are the ones most likely to be encountered:

Manufacturers**	Trade Name
Allis-Chalmers	Chlorextol
American Corp.	Asbestol
Electro Engineering Works	
Envirotech Buell	

Manufacturers**	Trade Name
ESCO Mfg. Co.	Askarel*
Ferranti-Packard Ltd.	Askarel*
General Electric	Pyranol
H. K. Porter	
Helena Corp.	
Hevi-Duty Electric	Askarel*
ITE Circuit Breaker Co.	Non-Flammable Liquid
Kuhlman Electric	Saf-T-Kuhl
Maloney Electric	
Niagara Transformer Corp.	Askarel*, EEC-18
Power Zone Transformer	EEC-18
R. C. Uptegraff	
Research-Cottrell	Askarel*
Standard Transformer Corp.	
Van Tran Electric	
Wagner Electric	No-Flamol
Westinghouse	Inerteen
?	Nepolin
?	Dykanol

*Generic name used for non-flammable insulating liquids in transformers and capacitors.

**This list is not necessarily complete. PCBs have been used since 1929, and many companies have gone out of business.

(b) If the nameplate does not show one of the above trade names for askarel and if it is not plainly written on the nameplate that the unit is oil cooled, then a determination can be made on the basis of the fluid density by dividing the weight of the cooling fluid by the number of gallons. Fluids weighing less than 8 lb/gal are definitely oil, and those weighing between 11 and 12.5 lb/gal are definitely askarel. Fluids of intermediate density should be chemically tested unless the manufacturer of the unit can identify the coolant.

(c) If no nameplate data are available (sometimes nameplates become lost or obscured over the years and cannot be read) then a sample of fluid should be withdrawn and tested to establish its density. A simple test consists of using a small amount of water into which a single drop of the fluid in question can be dropped. The amount of water needed should be kept very small because if the fluid does turn out to be askarel, the test water will have to be disposed of in the approved manner. The test is this: If the drop of fluid sinks in the water, it is askarel; if it doesn't, it isn't.

(d) In many instances where transformers are listed as containing oil, they may in fact contain small, but significant, amounts of PCB. This small content of PCB is the result of the past common practice of topping off oil filled transformers (after samples have been withdrawn for testing of electrical properties) with spare askarel fluid instead of with transformer oil (mineral oil). There is no easy way to test such PCB-contaminated oil; a small sample must be extracted and properly packed and sent to a testing laboratory equipped to measure the PCB content of the fluid. If the oil is found to contain more than 500 ppm PCB, the transformer will have to be treated as if it is an askarel transformer in order to be in full compliance with Federal regulations.

Oil filled transformers may be assumed to be "PCB contaminated transformers" unless it is known that the oil contains more than 500 ppm PCBs. Requirements for "PCB contaminated transformers" are discussed in Chapter 4.

3.3 EPA Requirements for PCB (Askarel) Transformers

Definition: PCB transformers are those liquid filled transformers in which the liquid contains more than 500 ppm PCBs. (Note: PCB transformers mounted on railroad locomotives and multiple unit electric commuter cars are covered by different requirements.)

Manufacture, import, and sale of new PCB transformers: Banned

Use: Continued use of non-leaking PCB transformers is authorized indefinitely.

Diking: Not required, but you are responsible for cleaning up all spilled PCBs (see Section 3.4.3).

Marking: A large (6" square) label must be applied to each PCB askarel transformer (see Section 2.2).

Recordkeeping: The central PCB records must contain the identity and location of each PCB askarel transformer; the weight of PCBs contained in each unit; the date each transformer is removed from service, placed into storage, and shipped for disposal; the storage location and disposal location for each transformer removed from service; and the name and address of the purchaser of each PCB transformer that is resold.

Resale of used non-leaking PCB transformers by user: Authorized.

Servicing: Authorized provided the coils are not removed and there is no change in ownership of any PCBs.*

*Unless the seller of PCBs has applied to the EPA for an exemption from the ban on "distribution in commerce" of PCBs and EPA has granted the exemption. Change of ownership for purposes of approved disposal is allowed.

Rebuilding: Banned (coils may not be removed from the tank).

Retrofilling (substitution of other liquid for PCBs): Authorized if there is no change of ownership of PCBs.* The transformer must still be considered a PCB transformer as long as the concentration of PCBs in the liquid is above 500 parts per million by weight (one pound PCBs in 2000 pounds of liquid). A retrofilled transformer may no longer meet the definition of an askarel transformer established by the National Electrical Code and may therefore have different code restrictions on its use.

Processing of used PCB askarel for reuse: Authorized provided that there is no change in ownership of the liquid.*

Sale of new or reclaimed PCB askarel: Banned.*

Storage of new or reclaimed askarel: Must be in special storage areas meeting the EPA requirements (see Section 2.4).

Disposal: Drain liquid PCB askarel into approved containers (see Section 2.3). Fill transformer with kerosene or fuel oil, allow to stand for at least 18 hours, and drain into approved containers. Seal up drained transformer and dispose of in an approved chemical waste landfill. Dispose of liquids in an approved chemical waste incinerator (at present, store until an approved incinerator becomes available). Storage beyond 30 days to be in special storage area (see Section 2.4).

Scrap recovery of failed PCB transformers: Banned.

Spill cleanup: All material contaminated with more than 50 parts per million PCBs must be picked up and disposed of in facilities approved by the EPA.

3.4 Precautions for Continued Use

In section 3.1.4 it was pointed out that there are about 3400 PCB askarel transformers presently in use in the U.S. mining industry. The EPA regulations will allow these transformers to remain in service until they fail provided the special PCB label is applied to each unit and the required records are kept. However, the EPA regulations require special disposal of any material that is contaminated by PCBs spilled or vented from any transformer, whether caused by accidental damage to the transformer or electrical failure of the unit. The resulting cleanup costs can be very high if large quantities of soil are contaminated or, particularly, if PCBs enter any sewer, stream, or other water. In addition to the costs incurred in cleaning up spilled PCBs, the owner of a failed transformer may be subject to stiff fines for improper disposal of PCBs if it is not possible to recover all of the lost fluid.

*Unless the seller of PCBs has applied to the EPA for an exemption from the ban on "distribution in commerce" of PCBs and EPA has granted the exemption. Change of ownership for purposes of approved disposal is allowed.

The risk of large uncontrolled PCB spills can be minimized by analyzing the possible risks associated with each PCB askarel transformer and by taking steps to contain the uncontrolled spread and loss of PCBs from the unit. This section describes a number of methods that can be used to secure transformers against spills, including:

- Dikes
- Berms
- Curbs
- Plugging of water drains
- Transformer retrofilling
- Transformer relocation
- Fences and vehicle barriers
- Emergency foam packs
- Special problem transformers

3.4.1 The Significance of Water

When PCBs leak into the environment from transformers or from any source, the already widespread PCB pollution problem becomes aggravated. Recovery or cleanup of spilled PCBs is usually expensive, partly because the disposal costs are high and partly because special effort must sometimes be expended, as in cases where PCBs spill into water.

When PCBs spill onto land (i.e., onto soil or dirt) the cleanup procedure consists primarily of removing the contaminated soil and disposing of it in an EPA-approved chemical waste landfill. This can be expensive. The amount of soil that has been removed following spills has been tens of thousands of barrels, which, after transport and burial costs, can easily run to costs of more than $100,000.

Spills into water, however, are vastly more complex and therefore more expensive. Even spills into non-flowing lakes or swamps, as opposed to rivers or streams, result in extreme cleanup costs because of the dredging operations that are invariably necessary and because of the greater volume of waste material (e.g., earth and sediment) that must be handled, packaged, shipped and buried. In rivers where the moving water can both aggravate the cleanup operation as well as spread the PCBs that are stirred up from the bottom sediments during the dredging operations, cleanup costs can be high and at the same time, substantial environmental pollution can still result. In one instance in Washington State, an askarel transformer containing about 250 gallons of fluid was accidentally dropped on a dock and leaked into a river. After all the cleanup operations, it was calculated that only about 70 percent of the askarel was recovered, and the cost was close to half a million dollars.

Cleanup of spills that occur on land can be especially costly if the spill threatens to contaminate groundwater that is used for drinking. Vast amounts of soil may have to be removed to approved chemical waste landfill facilities, and costly tests must be performed to ensure that the contamination has been contained.

Thus the presence of water near a leaking transformer is an important consideration in deciding how to best manage a PCB askarel transformer.

3.4.2 Decision Guide

In general, the objective in the securing of PCB transformers is to ensure that any large leak of fluid will be contained within a specified area away from access to water of any kind (including sewage water and drainage systems that connect to either sewage systems or to any type of water body including groundwater). It is expected that in most instances (at least 3 out of 4 times) it will be feasible to either build a dike around the transformer and switch gear assembly or to effectively dike the entrance ways to the shelter or rooms that contain the units.

In all instances, the inspector or engineer who makes the decision on how to deal best with a given transformer should be on the lookout for all possible methods by which fluid can escape into the environment. For outdoor transformers, sheltered or unsheltered, the proximity of soil and access to water by way of floor drains, ditches or whatever method should be noticed and taken into consideration in establishing both the priority and the type of confinement for a given transformer. For indoor and underground transformers, drains should be pinpointed and should be plugged and sealed. Otherwise, efforts should be taken to ensure that spilled fluid will be restricted from access to the water.

For all transformers, spill confinement measures should include assurance that transformer mounting pads are not cracked or broken, that adjacent walls that may become part of a proposed spill-confinement system (especially walls made of porous materials such as cinderblock) are well sealed near the floor, that the interface between the walls and floor (this is called the wall/floor interface) is sealed, that there are no holes in the floor such as conduit access holes through which fluid can drain, and that there are sufficient barriers and/or fences to protect the unit from damage from vehicles (automobiles and lift-type trucks) and from damage by people who may be moving or working in the area.

It is not felt that it will be necessary to use the following decision guide in order to effectively analyze <u>all</u> transformer settings for spill potential and optimum spill confinement measures. It is likely that whoever uses this guide will, by doing so, quickly learn to see the points that need to be considered without having to refer to the guide.

DECISION GUIDE QUESTIONS AND CONSIDERATIONS

1. If the PCB askarel is located on the surface inside a building or outside, is there any way that fluid leaked from the unit could find its way to either a water drain (such as a sewer or a gutter leading to a sewer) or directly to water (for instance, by running downhill and into a stream or swamp or river)?

   If so, such units should be given priority in spill prevention measures. If not, the unit should still be secured against leaks, though the urgency is not as great as that of units located with access to water.

2. If the transformer is located below ground, or even simply below grade, in a location from which groundwater must be continually pumped, is there any way that fluid leaked from the unit could find its way into the water?

   Since groundwater is usually pumped out of mines, PCB contamination could easily be spread to larger volumes of water and soil, and if the water is used in ore processing, it could also contaminate the ore and processing plant. Transformers in such situations should be given priority in spill prevention measures.

3. In some instances PCB transformers are located in rooms or in alcoves that appear to be secure against the loss of fluids to either water or soil; if this is the case, are there curbs or diking either around the transformers or across the entrace ways to the transformer rooms so that the units are completely secure against uncontrolled loss of fluid?

4. In cases where transformers are situated in rooms with porous cinderblock walls, are those walls sealed with either grout type sealers or with a heavy type of paint that is not soluble in chlorinated hydrocarbon solvents such as PCB and trichlorobenzene?

5. If the transformer is otherwise secured against leaks, is the mounting pad or the floor of the transformer room free of cracks? Cracks that look like they would not prevent the loss of fluid should be grouted and painted with solvent resistant paint which will serve the dual purpose of sealing smaller cracks not grouted and of sealing the pad against water absorption which in cold places can cause freeze fracturing of the concrete.

6. Is the transformer in a location where vehicular traffic might be a hazard? For instance, is it located near to a driveway or next to a parking lot? If so, a vehicle barrier might be useful, especially if the unit is located where a body of water might be threatened by a loss of fluid.

7. Is the transformer located near machinery which might throw projectiles with sufficient energy to damage the unit? Is the transformer located in a place where fork-lift vehicles might accidently run into it or snag the heat exchanger or some other part? If so, fences or vehicle barriers might be necessary to provide protection, unless it is reasonably feasible to either relocate the transformer to a safer place or to replace it with a non-PCB transformer.

8. Is the unit mounted on unwelded steel plates (as might be the case if the unit is platform mounted), mounted on a second story, mounted in a mobile machine, or mounted on some other type of surface that might be extremely difficult to seal against fluid loss? Such a unit should be replaced with a non-PCB unit of similar fire-resistant characteristics. If replacement is not feasible, a catchbasin might be installed under the unit or the unit could be temporarily removed while the mounting surface is sealed. If the transformer does not present an immediate threat to water or to personnel and would not pose any great difficulties in a cleanup should a spill occur, then no securing measures need be taken.

9. If the unit is pad mounted, is there room for installation of a dike on the edge of the mounting pad? If not, and if some kind of spill protection is needed, either the pad could be extended and a curb installed as part of the extension or a berm of asphalt, concrete, or clay could be built around the unit.

10. If the unit is mounted near to a wall that will be part of the spill containment barrier, is the wall of non-porous material such as concrete or sealed cinderblock and is the wall/floor interface tight against fluid loss?

11. If the transformer is in a special room, alcove, or vault, is this area used as storage space, for example, for brooms and other building maintenance materials? If so, and if there is no other better storage place for the stored materials, it might be best to put a dike around the transformer itself rather than to secure the room as a whole to prevent additional cleanup expense from contaminating extra material.

12. If the transformer is in a special room, alcove, or vault, are there also drains in the room that cannot be sealed and removed from service because they are needed to remove water from other systems sharing the room with the transformer (e.g., an air-conditioning system)? If so, the transformer rather than the whole room will have to be diked against the possibility of a fluid leak.

13. If the room is used for non-transformer-related activities, is the unit sufficiently protected against the potential for mechanical damage?

14. If the unit is located outside and is already adequately diked against the possibility of fluid loss, is there an allowance for the removal of rain-water by a properly designed water-only drainage system? The design of a water-only drainage system that can be built from existing plumbing hardware is included in this section of this report.

15. Is the unit old or does it appear to be old? If so, this may be a consideration in whether or not to replace the unit. There are commercial transformer service companies that are experienced in the testing of transformers to find out whether or not they are in condition to continue in service.

16. Is there any evidence of an active leak from the transformer? If so, and if it is due to corrosion or a broken or cracked weldment, the unit should probably be replaced. Otherwise, arrangements should be made to repair the unit, especially if it is located near water or a path to water and if there are no immediate plans to secure the unit against fluid loss. (Note: approximately 10% of pad mounted askarel transformers show some evidence of leaking.)

17. If the unit has to be replaced, is its setting suitable for the installation of an oil filled transformer? That is, does the setting satisfy the NEC requirements for the installation of oil filled transformers (indoor or outdoor)? If not, the new transformer will either have to be of a fire-safe design or an oil filled transformer will have to be installed in a different location.

3.4.3 Dikes

A dike is the most effective, esthetically appealing technique for containing a potential spill. It is also among the least costly of spill prevention measures, especially when compared to the alternatives of retrofilling and relocation discussed below.

A suggested steel dike system shown in Figures 3.4.3-1 through 3.4.3-4 consists of steel angles (measuring 3.5" by 6") that are bolted to the periphery of the mounting pad. The seal between the dike and the pad consists of a gasket of 3/8" thick closed cell neoprene foam rubber. The corners of the dike are bolted together by means of 2" by 2" steel angles.

An alternative to this steel dike system is a concrete curb-type dike. However, the concrete dike may be more costly to install and, since it would have to be at least 5 inches wide to be sufficiently durable, would require more room on the periphery of a transformer pad than the steel dike. In cases where the mounting pad is small, this can be an important consideration. Also, the curb-type dike would slightly inhibit the accessibility of the transformer for maintenance operation, more so than the steel dike.

Dikes can be installed in both indoor and outdoor locations. In outdoor locations, however, especially in parts of the country where rainfall is excessive, provision must be made for water drainage in order to minimize the corrosion hazard to the transformer-related switch gear and casings. A water-only drainage valve, along with the parts specifications, is shown in Figure 3.4.3-5. It will permit the passage of three gallons of water per hour (when submerged three inches deep), but will close if the level of askarel approaches the level of the drain opening.

Curb-type dikes can most easily be installed in those instances where the mounting pad must be enlarged because of insufficient room even for the steel dike. Figure 3.4.3-6 shows the typical requirements for the enlargement of a mounting pad and the installation of a curb dike.

3.4.4 Berms

A berm is simply a mound of earth or asphalt surrounding an outdoor transformer. A berm, especially an earthen one, would take up much more room than a steel dike, and if porous enough to allow the drainage of rainwater, would also be too porous to give maximum protection against high cleanup costs in the event of a PCB spill. On the other hand, it would be difficult to install an effective water-only drainage system in a berm if the berm were adequately waterproofed with a lining of bentonite or some other impermeable clay.

Asphalt berms constructed on asphalt or concrete surfaces that surround a given transformer mounting might be a low cost alternative to dikes, but they can restrict accessibility of the transformer and are not as esthetically appealing as a dike.

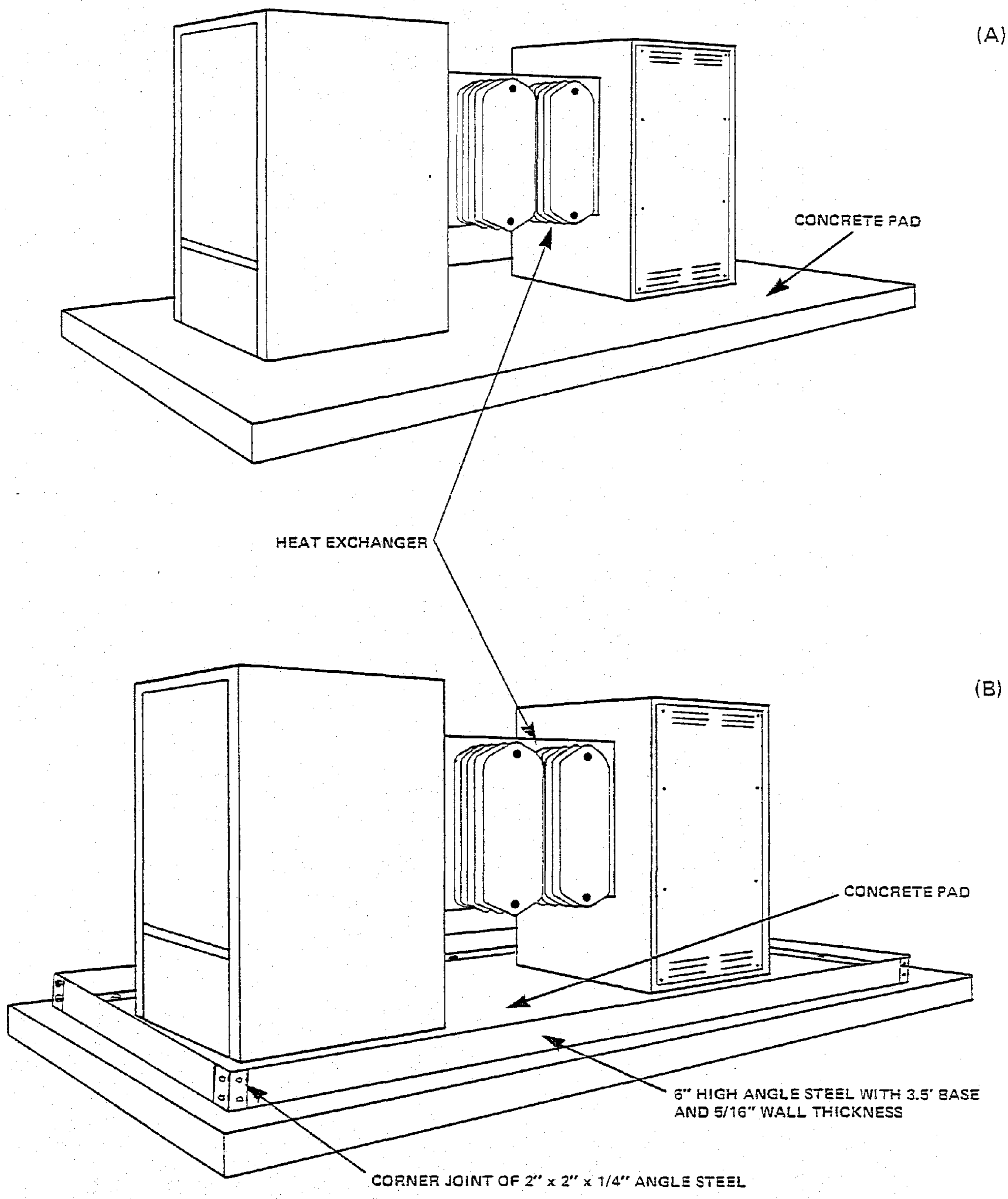


Figure 3.4.3-1 - (a) Typical Transformer and Switch Gear on Concrete Mounting Pad
(b) Same Transformer with Steel Dike Installed

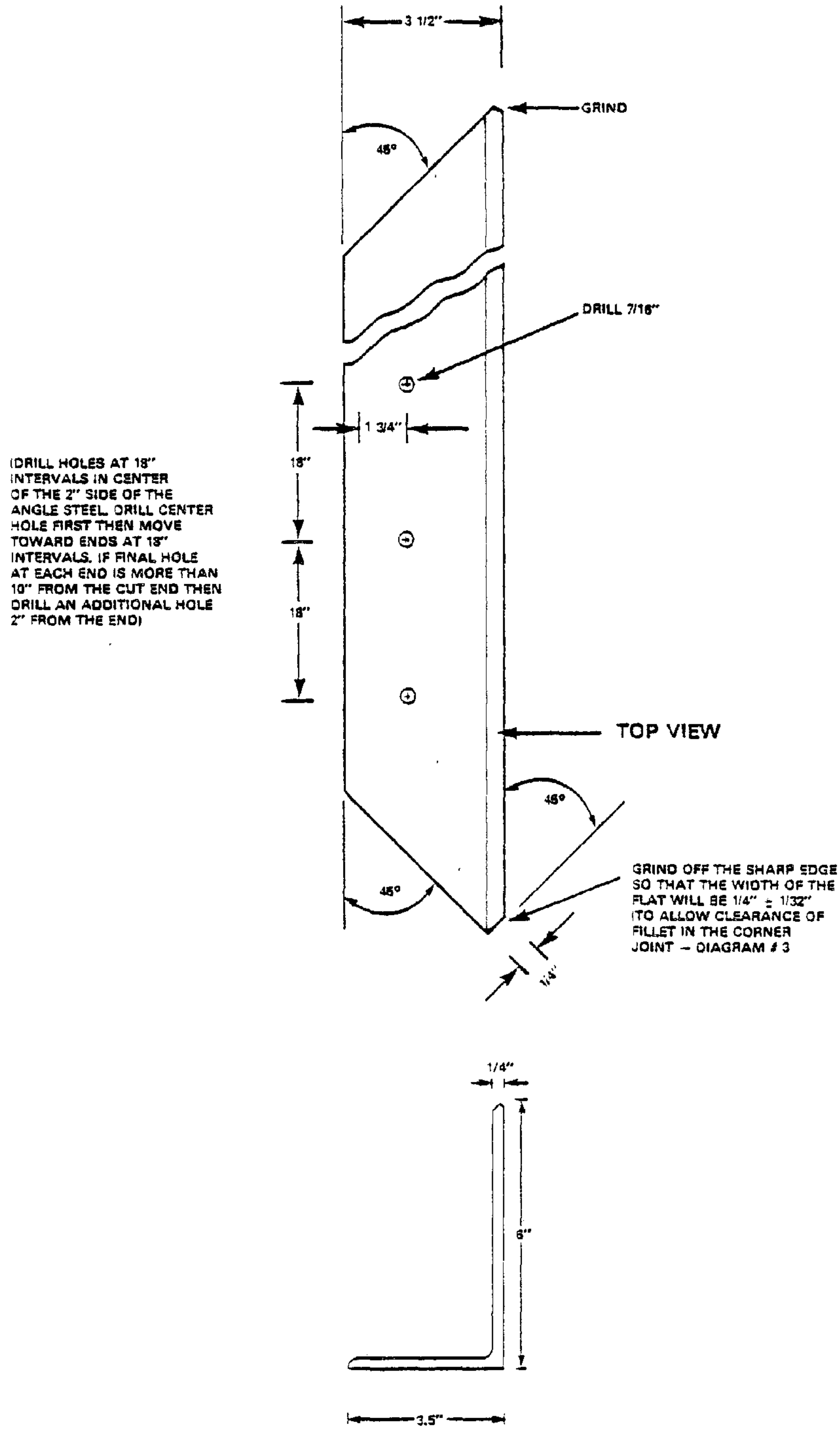


Figure 3.4.3-2 - Shop preparation of 6" x 3.5" angle-steel dike edge, including mitre-cut and ground ends and holes to be drilled.

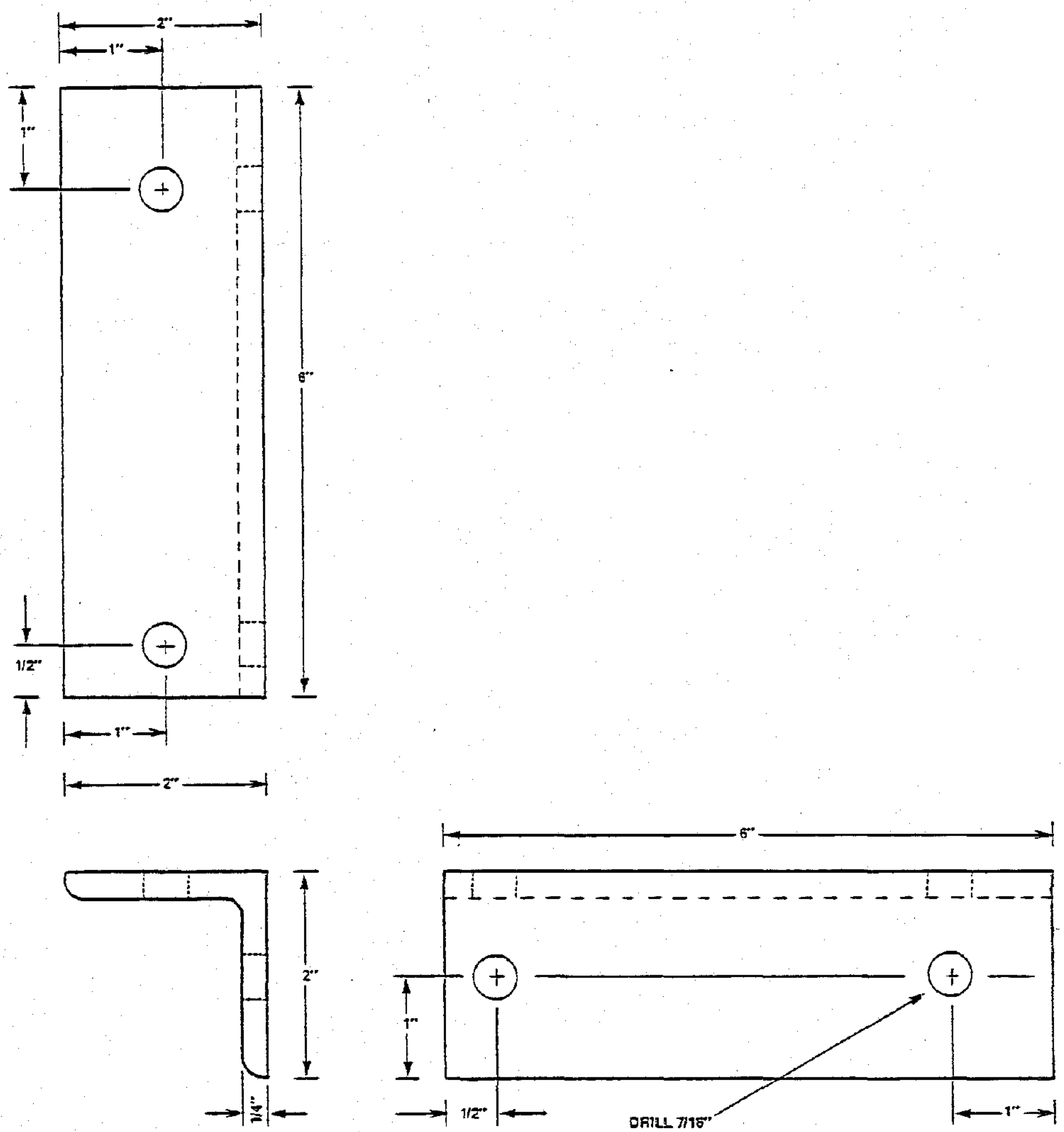


Figure 3.4.3-3 Corner joints - 2" x 2" steel angle
Cut and drill as shown

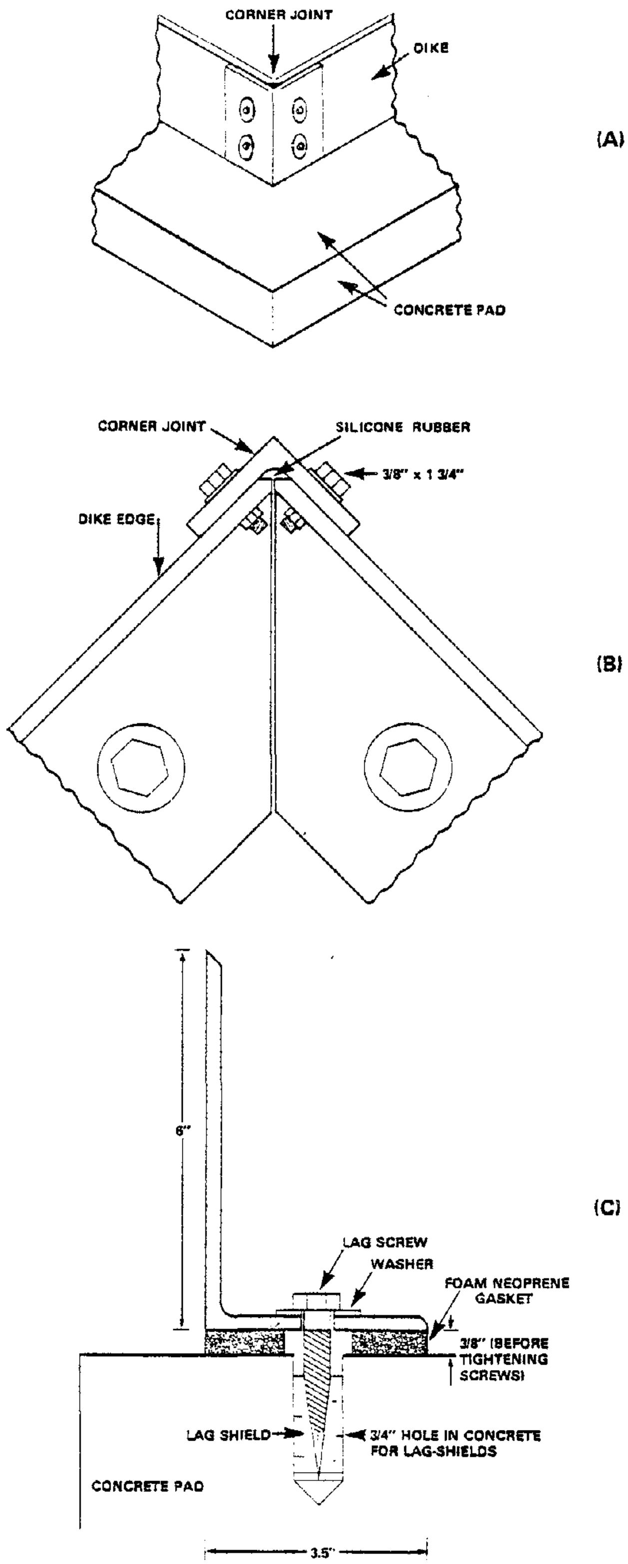


Figure 3.4.3-4 - (a) View of corner joint.
(b) Top view detail of corner joint.
(c) Selection through dike.

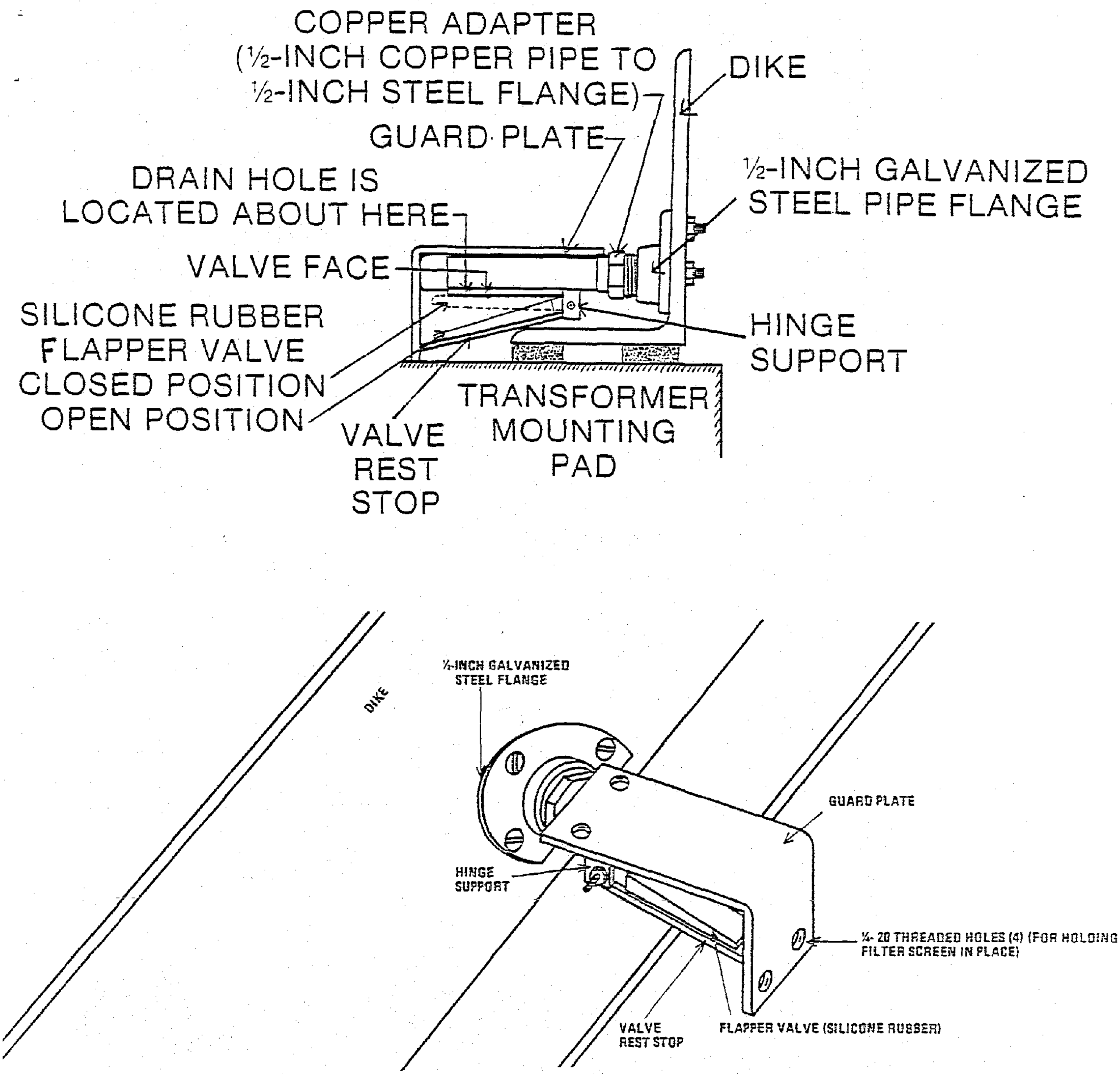


Figure 3.4.3-5 - Side view and pictorial view from top of the water-only drainage system. Filter screen is not shown. See Appendix B for details.

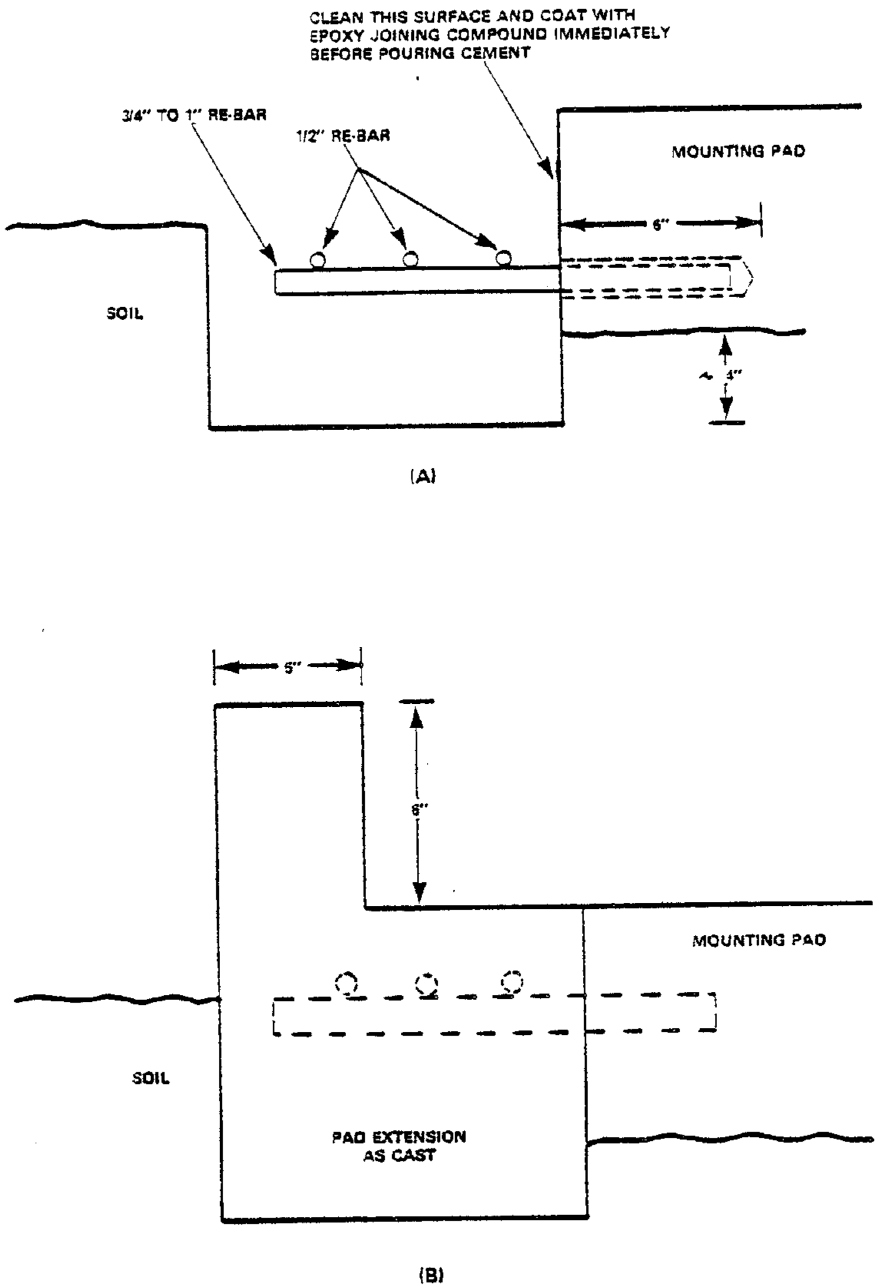


Figure 3.4.3-6 - Schematic diagram of basic parts and dimensions of an extended mounting pad. (a) Excavation and re-bar location; (b) Cross-section of extended pad.

In cases where there is a moderate problem of water accessibility to a potentially leaking transformer, and where the transformer is in a location where vehicular damage is a possibility, such as near a parking lot or street or driveway, a berm could provide both security against leaks and protection from vehicles.

3.4.5 Fences and Vehicle Barriers

It is probable that a small number of PCB transformers will be found in locations where the threat of damage from moving vehicles should be taken into consideration (for instance, in locations where fork-lift type vehicles are commonly used, either indoors or outdoors, and next to parking lots and close to driveways).

In some cases, chain-link fences will provide adequate protection against light weight freight vehicles, but usually when vehicle damage to transformers is possible, heavier protection such as that depicted schematically in Figure 3.4.5-1 is advisable. The simple pipe-type barriers can be installed with relatively little effort and cost, and in many instances, one pipe of sufficient diameter will provide adequate protection.

3.4.6 Curbs and Doorway Dikes

Transformers, PCB or otherwise, are often mounted in special transformer rooms. Whether the room is inside a larger building or is a free-standing structure, the least costly method of securing the transformers against PCB loss is often to install a dike or concrete curb at the entrances. The only cases where an entrance sill may not provide adequate protection would be where there is a drain in the room with the transformer that cannot be plugged (say, because the room is shared with an air-conditioning unit that must be provided a drain for the runoff of condensation), or where the floor or walls will not provide a tight sealing barrier against fluids. Walls of special enclosures are often made of unpainted cinderblock built onto concrete mounting pads. In this case, both the walls and the interface between the wall and floor must be sealed with a material that is only minimally soluble in chlorinated hydrocarbons (PCBs and trichlorobenzene). This can be done by grouting with cement or other inorganic material and then painting.

3.4.7 Emergency Foam Packs

Possibly the most cost effective means of spill control--but not of prevention--is with the use of emergency foam packs. These are back-mounted units capable of dispensing up to 70 cubic feet of urethane foam that can be used to form a fluid barrier very rapidly. However, there are certain disadvantages to these units, including the need to keep at least one man in training and on call in the event of a spill. Also, the urethane foam will not adhere well to wet surfaces nor will it provide a good fluid barrier when located on porous or sandy soil. On concrete or asphalt, urethane should make an

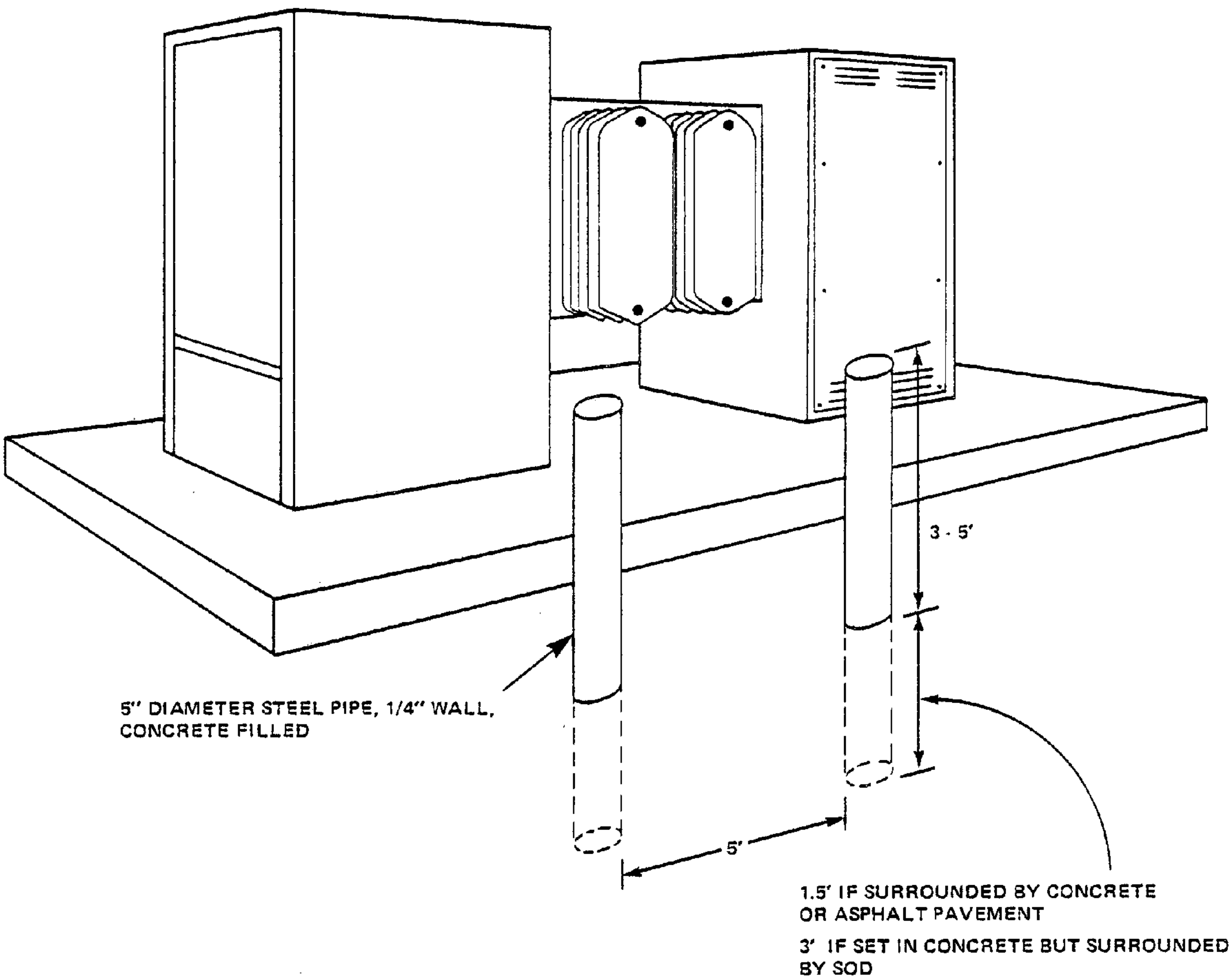


Figure 3.4.5-1 - Vehicle barrier suitable for protection of an askarel transformer located in a parking lot or next to a street. Similar barriers used for protection against fork-lift type vehicles would have to have the pipes situated closer together and could be made using 3-inch diameter pipe (concrete filled).

effective instant dike. The problems with wet surfaces have been studied, and some solutions have been found. The interested reader is referred for additional information to Control of Chemical Spill by Physical Barriers, an EPA publication dated March 1973 which has the identification number EPA-R2-73-185. (Order from National Technical Information Service, Springfield, Va. 22161. Report No. NTIS PB 221 493/0BA).

3.5 Special Problems

Instances will probably arise where no set of pre-established procedures will apply to a special-problem transformer. For instance, sometimes in order to conserve floor space, indoor mounted transformers are mounted on raised platforms 10 or 12 feet or more above the floor, often on a platform of steel plates that are not welded together to form a liquid-tight seal. This is common in draglines. In such a case, there is no way to dike and to seal the platform against fluid loss without temporarily raising the transformer and then welding the platform plates together. But the effort in temporary removal of an askarel transformer is not much less than the work required to relocate the unit either on the floor (on concrete, diked) or outside of the building. A similar effort could replace the unit with a different fire-safe transformer or with an oil filled transformer mounted outside. In other words, the amount of effort to secure a transformer against fluid loss to adjacent work areas and to the environment at large might be more than is justified by the probability of a major leak. It might be more effective in the long run, if water or vast amounts of porous soil are not threatened by a possible leak, to leave the PCB unit in service without precautions; if water is a problem, it might be best to replace the unit rather than to secure it against leaks.

Most transformers can be readily secured against fluid loss, but protection of those that are resistant to easy solutions will have to be decided by comparing cost of securing the unit against fluid loss or removing it to a better location versus the potentially high cleanup costs should a leak occur.

3.5.1 Mobile Mining Machinery

Transformers are used on electrically powered draglines, shovels, and blasthole drills to reduce the incoming high voltage to the levels required by the drive motors. In most instances, mobile mining machines have been designed to safely use oil filled transformers. However, several mining companies have asked that machines be delivered with askarel transformers, and the manufacturers have compiled.

There appears to be no general method for securing onboard askarel transformers against loss of fluid. In some instances there is sufficient room to allow the installation of transformer dikes; in some cases, however, the simple installation of a dike would not be sufficient; for instance, the mounting surfaces often consist of a floor made of steel plates that are butted up against each other without being welded or sealed. Welding of mounting surfaces under transformers would require the temporary removal of the transformer, an undertaking that would be almost as costly and time consuming as replacement of the units with non-askarel units.

Most mobile mining machinery that contains PCB transformers is used in surface applications. The loss of PCB fluid from an onboard transformer might be difficult to clean up if it runs into the complex portions of the machinery, but the loss of fluid to the ground would probably be unaggravated by the presence of water in most instances. The cleanup procedure would consist of decontaminating the machine and the containers and of disposal of earth and soil.

If anything general can be said about the precautions that can be taken with respect to askarel transformers on mining machines, it is that the individual mining companies will probably have to use some subjective measures to determine whether the cost of securing their mobile mounted askarel transformers against leaks is likely to be less than the cost of fines, penalties, and cleanup costs in the event of a transformer failure.

3.5.2 Relocation of Transformers

It has been noted in many transformer surveys, at mines as well as in other industries and operations, that not all askarel transformers are located in places where electrical codes or safety considerations require their use. In such cases, especially where a fluid loss from an askarel or PCB transformer could reach water or otherwise cause local or environmental damage, the simplest and securest solution is to replace the PCB transformer with an oil filled unit and to relocate the original transformer in a site known to be secure from leaks. It might be feasible in a small number of cases to simply exchange two transformers, location for location, and to totally eliminate any other PCB securing measures.

3.5.3 Retrofilling

Retrofilling is the replacement of the PCB askarel fluid in a transformer with non-PCB fluid. Askarel transformers located in places where fire hazard is a consideration can be retrofilled with silicone fluid or with the new high-fire-point hydrocarbon fluids that are available. However, retrofilling is expensive and a single retrofill does not usually reduce the concentration of PCBs to below 500 ppm.

Typical commercial costs for field retrofilling of askarel transformers are $30 per gallon of capacity of the transformer and this does not include the cost for storage of the PCB fluid removed or of the solvent fluids used to flush the transformer at the time of retrofill. (PCB storage is necessary until approved PCB incineration facilities become available; cost of disposal is expected to be high because it must include the cost of shipment by an approved method; the actual cost of incineration will probably be on the order of several dollars per gallon of PCBs.) Retrofilled transformers must be marked and handled as PCB transformers unless the concentration of PCBs has been reduced to below 500 ppm. A transformer must be retrofilled at least 3 times to get the concentration of PCBs to less than 500 ppm. Successive retrofills should be at least 18 months apart.

The major advantage of retrofilling is achieved only if the concentration of PCBs is reduced to below 500 ppm by repeated replacement of the liquid. Once the concentration of PCBs has been reduced to this level, the transformer may be considered a PCB contaminated transformer, and may therefore be rebuilt if it fails (see Chapter 4). If a PCB askarel transformer is in a critical application and the time savings achieved by rebuilding rather than replacing the unit when it fails offset the cost of multiple retrofilling, this procedure might be justified. However, once the unit is filled with oil, silicone, or high fire point transformer liquid, the risk of fire is increased, and although the total amount of PCBs in the unit is decreased, the same cleanup requirements exist as for PCB filled units if the concentration of PCBs is above 50 ppm.

The technology for reducing residual PCB levels in retrofilled transformers is rapidly being developed, and the supplier of the liquid should be contacted to determine the cost and feasibility of achieving the 50 ppm level of PCBs in retrofilled transformers. The companies most active in this field are:

For hydrocarbon fluids: RTE Corporation
Fluids Division
1900 East North Street
Waukesha, Wisconsin 53186

Phone (414) 547-1251

For silicone fluids: Dow Corning Corporation
Midland, Michigan 48640

Phone (517) 496-4000

3.6 Non-PCB Replacement Transformers

New PCB askarel transformers have not been manufactured in the U.S. since 1978, and the EPA regulations prohibit the manufacture of additional new PCB units or the rebuilding of existing units. Therefore, it will be necessary to replace every existing PCB askarel transformer, either when it fails or because there is too great a risk of uncontrolled PCB spills and no adequate way to dike or protect the transformer.

There are a number of alternatives to the use of PCB askarel transformers, but each type is characterized by different tradeoffs of fire safety, overload capacity, and initial price. Most existing large non-PCB transformers are filled with transformer oil, which is a refined petroleum oil with viscosity and flammability characteristics comparable to SAE 10 motor oil. Oil cooled transformers are the least costly units available for installations where the potential fire hazard presented by the oil is not a problem. Askarel filled transformers have almost all the advantages of oil cooled transformers, plus they are the most fire safe of any kind of liquid filled transformer. (The disadvantages of askarel compared to oil, aside from the obvious ones of the recently recognized toxic and environmental hazard, are such minor considerations as the higher solvency strength of askarel on the insulation components of transformer windings, plus slightly lower dielectric strength than oil, and a tendency for the askarel to form corrosive HCl under conditions of internal arcing or even during corona discharge; the latter effect results in a more stringent maintenance program for askarel transformers than for oil transformers.)

The alternatives to askarel transformers are listed, described, and compared below. No one of the alternatives has all of the advantages of askarel transformers, all cost slightly to significantly more than askarel transformers, but none present the environmental hazard associated with PCBs. Some alternatives have special advantages possessed by neither oil nor askarel transformers. The attributes of the different types of non-PCB alternatives are given below; they are compared on an installed cost basis, and a simple decision guide is supplied at the end of this section.

3.6.1 Characteristics of Non-PCB Replacement Transformers

3.6.1.1 Oil Filled Transformers

The major disadvantage to mineral oil is its flammability. Transformer mineral oil has a flash point of 145°C, and if an arc occurs within the transformer, the breakdown products will be hydrogen and methane which are also flammable. Detailed records of such failures are maintained by the electrical industry. Fire underwriters do not approve of the use of oils and other flammable liquids for indoor applications; where oil filled transformers are not specifically prohibited as on-site replacements for askarel filled units, the National Electrical Code imposes certain restrictions upon their mode of installation.

If safety were not a consideration, there would be no reason why oil filled transformers could not be used in all applications. Askarel filled transformers cost about 1.3 times as much as oil filled units of the same capacity, and thus most users prefer the oil type where possible. The oil filled transformers are the same size as the askarel units, and they are considerably lighter in weight. In addition, mineral oil has somewhat better heat transfer characteristics than does askarel, and an electrical arc in mineral oil results in breakdown products that are non-corrosive.

Oil filled transformers can be used in these applications only if they are suitably isolated from flammable structures or if these structures are suitably safeguarded against fires. When transformers are located outside of the building or mine they service, however, the low-voltage power must be brought into the building via cables or insulated buses, incurring additional energy losses due to Joule heating in the additional low voltage transmission lines.

The National Electric Code specifies the vault requirements for oil filled transformers in indoor locations. Building a fire resistant vault can double the installed cost of the transformer.

There are apparently no federal regulations that prohibit the use of oil filled transformers in underground mines. Oil filled units are not used underground in Colorado, but this is apparently in response to a state requirement. Although some mines have removed all oil filled transformers from underground installations because of the fire hazard associated with the possible loss of hundreds of gallons of hot oil, other mines have used oil filled units underground for years with no problems. Adequate safety underground can be achieved by installing an oil filled transformer in a vault that is equipped with automatic dampers on the ventilation openings and automatic fire supression systems that would flood the vault with carbon dioxide or Halon 1301 gas in the event of a fire. An extensive discussion of the fire protection recommended for use with underground oil filled transformers is included in the report, "Improved Fire Protection for Stationary Underground Equipment," dated May 1976, which was prepared for the Bureau of Mines by Factory Mutual Research. This report is available from the National Technical Information Service, Springfield, Virginia, 22161, as report number NTIS PB 280 136/LLC.

3.6.1.2 Silicone Transformer Liquid

All liquid filled transformers have better sustained overload capacity and short term, high overload capacity than do dry type transformers. The greater heat capacity of liquids compared to air and other coolant gases used in transformers is the reason for this greater overload capability. The fire resistant alternatives to askarels are mainly silicones and high-fire-point hydrocarbons of the paraffinic variety. High-fire-point hydrocarbons are discussed in the next section.

Silicone filled transformers are filled with low viscosity polydimethyl siloxane liquid. Silicone fluids can also be used to retrofill askarel transformers. Silicone fluids are non-toxic, have low flammability (though not quite as low as PCBs), and low solvency strength (which means that transformers filled with silicone can be expected to have very low service lives). The disadvantages of silicones are: (a) even though the material is referred to as "low viscosity," silicone is more viscous than either oil or askarel, which means that silicone filled transformers must be slightly larger than transformers of equivalent power capacity filled with askarel or oil; (b) on a volume basis, silicone fluids cost about twice as much as askarel; (c) when silicone does burn, it releases clouds of amorphous silica which may create visibility problems; and (d) when used as a retrofill fluid, the poorer heat transfer characteristics of silicone relative to askarel require the derating of the transformer by about 15 percent if the unit is likely to be run continuously at close to its original rated temperature.

Silicone filled transformers are not recommended for use in underground coal mines because silicone vapors will gradually deactivate methane detectors. Silicone liquids are also powerful defoamers, so large spills of transformer silicone liquid onto ore that will be treated by floatation or into the water of a floatation plant may disrupt the operation of the process.

3.6.1.3 High-Fire-Point Transformer Liquids

High-fire-point fluids for transformers are essentially of two varieties: (1) natural, i.e., derived from natural hydrocarbon fluids by refining out everything but certain molecular species, usually the long-chain paraffinic molecules and (2) synthetic, that is, built up out of simpler molecular species into long chain paraffinic molecules. The products are roughly the same, just derived by different processes.

The 1978 edition of the National Electrical Code has a new specification for high-fire-point liquid insulated transformers which reads: "Transformers, insulated with a non-propagating liquid approved for the purpose, having a fire point not less than 300°C shall be permitted to be installed indoors or outdoors. Such transformers installed indoors and rated over 35,000 volts shall be installed in a vault."

The fire point of the synthetic hydrocarbon high-fire-point fluid is about 310°C; for the refined high-fire-point hydrocarbon it is about 312°C; and for silicone it is 360°C. Factory Mutual has not formally approved any liquids as high-fire-point transformer liquids. However, they have given tentative acceptance to a number of liquids of the classes of silicones, synthetic hydrocarbons, and paraffinic hydrocarbons. Acceptance means that Factory Mutual recommends that insurance companies insure facilities where high-fire-point liquid filled transformers containing accepted liquids are installed in accordance with the requirements of the National Electrical Code. However, the insurance company reserves the right to require additional fire protection at a later time if such a need is demonstrated by experience.

The Factory Mutual criteria for transformers filled with high-fire-point liquids will probably require (a) that transformers filled with approved less flammable liquids be installed in a diked area where the dikes' volume is sufficient to contain all the liquid and (b) that the diked area be drained to a safe location if this is feasible. In addition, any approved liquid with a fire point above 300°C could be used in transformers in flammable buildings with sprinkler systems. In buildings of non-combustible construction (non-sprinklered), the minimum allowable ceiling height over a high-fire-point transformer would be a specified function of the heat release rate of the particular liquid used in the transformer. The heat release rate used in this calculation would be measured for each liquid in a test involving a burning quiescent pool of standard size, temperature, and ignition source.

The liquids presently accepted by Factory Mutual are silicone and RTEmp paraffinic hydrocarbon (manufactured by RTE Corporation). The silicone is more costly, but it has a lower heat of combustion than RTEmp.

There are a number of questions not yet satisfactorily answered concerning the use of the high fire point transformer liquids. The most important question concerns the realism of the test conditions. It has been suggested that catastrophic arcing followed by case rupture is a relatively unusual mode of transformer failure and that a more frequent problem is prolonged minor arcing which generates flammable gases from the breakdown of transformer fluid. The flammability of unused liquids may not be a reliable indication of their relative safety under actual transformer operating conditions.

The high fire point of the paraffinic hydrocarbon fluids is a result of the relatively high molecular weight of the hydrocarbon material. The inherent disadvantage of the high molecular weight is higher viscosity and thus lower heat transfer capability than either ordinary mineral oil or askarel. The major advantages of the high-fire-point fluids are their low price relative to silicone and askarel and their inherent biodegradability.

3.6.1.4 Open Air Cooled Transformers

Transformers can be built without the use of a liquid cooling medium. One type of dry transformer which is quite successful under limited conditions is the open air cooled transformer. In this design, the required cooling is provided by air which passes through the transformer due either to thermal convection or forced fan circulation. In those sizes where air cooled transformers are available, they are about equal in price to askarel filled transformers of the same kVA rating. However, the following limitations govern the successful use of open air cooled transformers, and prevent them from being considered for many applications using askarel filled transformers.

Heat Capacity: The power drawn from a transformer usually varies over a fairly wide range. The rating of a transformer is basically governed by the power which it can handle continuously without overheating. If a liquid filled transformer is operated at overload conditions for a short period of time, the liquid will act as a heat sink, absorbing the excess heat produced in the transformer without a rapid increase in temperature. The result of this thermal inertia is that liquid filled transformers can operate at outputs of up to 200 percent of rated capacity for a period of one to two hours without being damaged.

An air cooled, dry type transformer does not have this heat sink available and is limited to operating at a maximum service rating near its continuous rating. Where the current drawn on the transformer does not vary greatly during the day, this limitation is no problem. However, in most cases the variation in load would require that a dry transformer be sized 20 percent to 30 percent greater in capacity than a liquid-filled transformer for the same application.

Dielectric Strength: The liquid coolant in a liquid-filled transformer also provides a significant level of electrical insulation between the various current-carrying components within the transformer. Air has a much lower dielectric strength, and open air cooled transformers are limited to a maximum voltage of 25 to 40 kv. The problem of electrical insulation is even more severe if the open air cooled transformer only operates intermittently. When the transformer is operating, the heat generated within the windings keeps their insulation dry and maintains a high dielectric strength. However, when the transformer is not operating, the coils cool to ambient temperatures and the insulation can absorb moisture from the air which reduces its dielectric strength. Therefore, an open air cooled transformer must be carefully dried before being put into service after each time it has been allowed to cool.

One final problem with dry air cooled transformers is due to the tendency of dust to be attracted from the air to the coils by electrostatic attraction. This dust can build up in the coils which blocks the flow of air and causes overheating, or the dust can form conductive paths which short circuit the transformer.

Dry open air cooled transformers are generally limited to dry, clean locations where the load requirements are fairly even and constant, and where the maximum voltage does not exceed 30 kV.

3.6.1.5 Sealed Gas-Filled Transformers

A dry transformer can be provided complete protection from environmental effects by sealing it in a pressure tight container and using an inert gas as the coolant. Gas filled sealed transformers have the same overload limitations as dry air cooled units, but better control of the insulating media raises the maximum achievable voltage to levels available with liquid filled units.

Several different gases have been used as the coolant in sealed gas filled transformers. The commonly used gas in the United States is hexafluoroethane (C_2F_6). Although chlorofluorocarbons are regulated by the EPA, the use of this gas in transformers will probably not be affected by the regulations. Nitrogen and sulfur hexafluoride have also been used successfully as transformer coolants in certain applications.

Because the inert gas increases in pressure when heated, a gas filled transformer must be enclosed in a heavy pressure vessel housing. The pressure vessel increases both the size and weight of the gas filled transformer compared to open air cooled units. The price of the sealed gas filled units is also considerably higher than open air cooled units. Because of the poorer heat transfer characteristics of the gas compared to liquids, the gas filled transformers are designed to operate at 150°C coil temperature rise and have insulation systems limited to 220°C. Hot spots in the coils can approach 220°C; accordingly, there is no allowance for even short-term operation at loads higher than rated capacity. Therefore, the gas filled transformers must often be specified in a larger size than the liquid filled transformers to allow for the expected heavy load peaks of power consumption.

3.6.1.6 Cast Coil Transformers

The third class of dry transformer is the cast coil type. Cast coil transformers have had their primary windings or both their primary windings and their secondary windings totally encapsulated in vacuum degassed epoxy resin. This type of construction decreases the noise level in comparison to other dry type transformers, and because of the thermal capacity of the encapsulating epoxy, the overload capacity approaches that of liquid transformers while the fire safety advantage is about the same as that of other dry transformers.

Cast coil transformers are generally more compact, lighter, and more shock resistant than either liquid cooled or the other dry type units. The exceptional thermal performance (comparable to that of liquid transformers in terms of running temperatures and overload capability) is achieved by reducing resistance losses in the coil conductors. This significantly increases manufacturing costs and initial price, but it results in decreased electrical operating costs and is a factor in the probable longer life of these units.

This technology is better developed in Europe than in the U.S. Although the cast coil transformers are among the most expensive in terms of initial cost, they are gaining increased usage where reliability, small size, and fire safety are important considerations.

3.6.2 Mining Machinery Transformers

Draglines, shovels, and blasthole drills that are electrically powered use transformers to reduce the incoming high voltage to the levels used by the drive motors. In some instances, the machinery was originally designed for oil filled transformers. When askarel transformers were specified by the buyer, they were installed in the fire-resistant vaults that had been designed for oil filled transformers. In some cases where these customer-ordered askarel units fail, they can be directly replaced with oil cooled transformers with little, if any, increase in fire hazard. In the event that an insurance carrier requires fire safety in addition to an on-board vault, there is likely to be no great difficulty in installing a silicone or high-fire-point hydrocarbon cooled transformer.

In those instances where an item of mobile machinery was actually designed with askarel transformers in mind, the installation of oil filled transformers might not be possible because of the lack of fire safety precautions, such as fire proof vaults. Gas cooled transformers might be adequate replacements for askarel transformers, except that gas cooled units are generally slightly larger in physical dimensions then comparable kVA liquid cooled units. Silicone and high-fire-point hydrocarbon transformers might satisfy most safety requirements at slightly higher cost than the original askarel units.

Several other alternatives to the use of askarel transformers on mobile machinery were observed during the mine visits. On one dragline, there were several oil filled transformers, each in a steel room with appropriate vents. Each room was equipped with a fire detection system that would set off an alarm in the operator's cabin if a fire occurred and would also activate a Halon 1301A fire suppression system. A second dragline, still under construction, had two large three-phase oil filled transformers mounted on platforms on the exterior of the machine, thereby minimizing the damage that a transformer fire could cause. A third possible alternative was under consideration for a transformer on a blasthole drill. This transformer was mounted on the rear of the machine and, in the event of a fire, could have posed a considerable threat to the operator. Mine personnel were planning to remove the transformer from the drill and mount it nearby on skids so that the transformer posed less of a hazard but could still be moved as required. Though this particular transformer was oil filled, this same procedure could be done any time an askarel transformer needed to be replaced on any type of machinery with a slight increase in electrical resistance losses.

3.6.3 Relative Costs of Non-PCB Replacement Transformers

The National Electrical Code allows only the smallest of oil cooled transformers to be used indoors without a vault. The cost of a vault can increase the installation cost of an oil filled transformer in place of an askarel unit by 90 to 133 percent of the base cost of the transformer, thereby eliminating the use of oil filled transformers for askarel units where no vault already exists. At voltages in excess of 35,000, the code requires that all types of transformers be installed in vaults if they are located in buildings. However, as far as the mining industry is concerned, it is unlikely that many transformers will be installed in indoor locations handling more than 35,000 volts. Therefore, the cost of vault construction will be considered here in connection with oil cooled transformers only.

Table 3.6.3-1 summarizes the relative basic costs and installed costs of various types of transformers. Askarel transformers are included for the sake of comparison.

3.6.4 Summary - Considerations in Choosing an Alternative to PCB Transformers

The following considerations apply to all situations in which transformers are used in mining, i.e., above ground, underground, indoor, or on mobile machines.

Table 3.6.3-1

Cost Comparisons of Oil Filled Versus Other Transformers Designs Intended for Hazardous Locations*

(1000 KVA, 15 KV Transformer)

Type	First Cost	Vault	Catch Basin	Vent	Total Installed Cost
Oil	100%	90-133%			190-233%
Askarel (1976)	140%		10%	2%	150%
High fire point hydrocarbon liquid	120%		10%**		120-130%
High fire point silicone liquid	140%		10%**		150%
Dry open coil air cooled	150-170%				150-170%
Dry gas filled	200%				200%
Dry cast coil	150-200%				150-200%

*Adapted from: Westinghouse, "Is There Another Way," Sharon, PA., p. 18, undated; and Deaken, R.F.J., and P.D. Smith (Polygon Industries Ltd.,) "Epoxy Insulation - A New Generation of Dry Type Transformers," Paper presented at the 64th Annual Meeting of the Canadian Pulp and Paper Association, Montreal, Quebec, January 31, 1978.

**Catch basin is not required by law or regulation but is required as a condition for insurance coverage by certain industrial insurers.

Oil Cooled Transformers - There are surprisingly large numbers of transformer installations, in mining and in other industries, where askarel transformers have been installed in places where the prevailing electrical code as well as common sense would have allowed the installation of oil filled transformers. If such an askarel transformer must be replaced, either because it has failed or because in its present location it is too costly or virtually impossible to secure against fluid loss (and therefore presents a potential extreme cleanup threat), the first choice to be considered is an oil filled unit. If the use of an oil filled transformer presents no particular fire hazard, and if no additional fire precautions are needed such as a vault, then the oil filled unit will be the most cost effective and the easiest replacement.

Silicone and High-Fire-Point Transformers - Because the coolant fluids in silicone and high-fire-point type transformers are of a higher viscosity than either askarel or ordinary transformer mineral oil, their heat transfer characteristics are not quite as good. Thus replacement transformers of these types are likely to be slightly larger than the askarel units they replace. They will probably not be as heavy as the equivalent askarel units, however, because of the extremely high density of the askarel coolant. Silicone and high-fire-point hydrocarbon cooled transformers find their best applications as replacements for askarel transformers in places where fire vaults for oil filled units would either be too expensive to install or would be impractical to install because of space limitation. Being liquid filled, they have the advantage of having high sustained overload capacity, the same as askarel and oil filled transformers.

Dry Type Transformers - Dry open air type transformers are usually larger than liquid cooled units because of the allowance that must be made for air movement. And assuming that the unit is used in an environment where dust is not a consideration, open air cooled transformers can operate with less maintenance than any of the liquid type transformers. Open air cooled transformers have two drawbacks as far as mining is concerned: they have only short-term overload capability because they contain no liquid to act as a heat sink, and they tend to generate much more noise than liquid filled transformers, which can be irritating to people who have to work nearby.

Sealed gas cooled transformers have all the same characteristics of open transformers, except they are totally sealed against the hazards of environmental dust and corrosive gases and fumes. Since they are sealed, their cases have to be of heavy guage construction to contain the pressure of the gas inside when the unit is operating at high temperatures. Thus they tend to be heavy as well as large in comparison to liquid units of equivalent rating. Their chief advantage is their almost total freedom from maintenance, which makes them suitable for applications where maintenance is impractical. Their disadvantages include high initial cost, high operating noise, and poor sustained overload capacity.

Cast coil transformers have advantages of both liquid and dry transformers. They require virtually no maintenance, they produce noise levels that are intermediate between liquid and other dry units, and because of their designed-in high efficiency plus the amount of material used to encase the windings, they can sustain high overloads almost as well as liquid filled transformers. Their main disadvantage is high initial cost.

4.0 PCB CONTAMINATED TRANSFORMERS

About 98% of the liquid filled transformers in use in the United States (probably including the majority of those used in mining applications) are filled with transformer oil. Analysis of oil taken from several hundred transformers owned by electrical utilities has indicated that as many as 38% of all of the oil filled transformers may be contaminated with PCBs in concentrations exceeding 50 parts per million (i.e., one tenth pound PCBs per ton of oil). The contamination of transformer oil with PCBs may have occurred either in transformer manufacturing plants where both PCBs and oil were used to fill transformers, or in routine field servicing that involved filtering the liquid by use of equipment that was used for both oil and askarel filled units. In a few cases, PCBs may have been used to top off oil filled transformers.

PCBs are completely soluble in transformer oil, and there is no easy way to determine whether low levels of PCBs are present in any particular lot of oil at concentrations above 50 parts per million. The only feasible method for analyzing for low levels of PCBs in oil involves the use of a gas chromatograph with an electron capture detector. A number of qualified analytical laboratories will perform this analysis for prices ranging from $60 to $100 per sample depending on the number of samples submitted at one time.

The EPA regulations on PCBs define "PCB contaminated transformers" as any oil filled transformer in which the oil is contaminated with PCBs in concentrations above 50 ppm, or as any oil filled transformer in which the oil has not been tested and found to contain less than 50 ppm PCBs. In other words, all oil filled transformers must be considered to be contaminated with PCBs unless tests have been performed and the oil found to not contain PCBs.

4.1 EPA Requirements for PCB Contaminated Oil Filled Transformers

Transformer oil known to be contaminated with more than 500 parts per million PCBs is classified as a PCB askarel; both the oil and the transformer that it is in are considered to be PCB askarel items and are covered by the regulations discussed in Section 3.3 of this report. Transformer oil that contains 50 to 499 ppm PCBs or that has not been tested is considered to be PCB contaminated. EPA regulations apply to the disposal or reuse of contaminated oil, but there are no regulations on the continued use, maintenance, rebuilding, or disposal of the transformers.

Transformer oil that is known by test to contain less than 50 ppm PCBs is not covered by the EPA PCB regulations.

Disposal of transformer oil from PCB contaminated transformers: by incineration in an approved PCB incinerator; by burial in an approved PCB chemical waste landfill; by burning as an auxiliary fuel in a large power boiler that meets specific operational requirements (see regulation for details).

Reuse of oil from PCB contaminated transformers: reclamation and reuse of oil is allowed by the owner of the oil.

Resale of used or reclaimed oil from PCB contaminated transformers: banned.

Storage of out-of-service PCB contaminated transformers or oil from such units: must be in a facility meeting the requirements of SPCC plan.

Spill cleanup: all material contaminated with more than 50 ppm PCBs must be picked up and disposed of as PCBs. In general, the oil spill regulations will apply and will be more stringent for low level contamination of land and water by oil.

5.0 PCB CAPACITORS

Most ac power capacitors manufactured in the U.S. between 1935 and 1977 used PCBs as a dielectric liquid. The EPA regulations banned the sale of PCB capacitors after July 1, 1979, unless the seller has obtained an exemption from the regulations from the EPA. However, non-PCB capacitors have been developed for almost all of the applications where PCB units were previously used. The liquids used to replace the PCBs in these new designs are more flammable than PCBs, but the manufacturers have developed various pressure sensitive and heat sensitive circuit breakers that prevent the capacitor from rupturing if it fails electrically.

The EPA regulations will allow existing capacitors to remain in service, but impose certain marking, recordkeeping, storage, disposal, and spill clean up requirements.

5.1 Uses of PCB Capacitors in the Mining Industry

Electronics: small PCB capacitors were used in the power circuits of some microwave ovens and television sets.

Motor Start Capacitors: used in series with the secondary windings of larger single phase motors such as those used in room air conditioners and submersible well pumps.

Ballast Capacitors: used in the ballasts of fluorescent lights and high intensity mercury arc and sodium arc lights.

Surge Capacitors: used with circuit breakers on large electric motors and on load centers.

Power Factor Capacitors: usually located in substations, although often found on distribution poles.

5.2 How to Identify PCB Capacitors

Liquid dielectric type ac capacitors are sealed metal cans with two or more terminals. The non-PCB capacitors that have been built since July 1, 1978, have all been marked "No PCBs". All other capacitors of this type must be assumed to contain PCBS unless you know, based on manufacturer's literature or label information, that a specific capacitor does not contain PCBs.

The following is a list of the manufacturers known to have produced PCB capacitors since 1971. PCB capacitors manufactured prior to 1971 may not appear on this list if the manufacturer stopped using PCBs or went out of business.

Manufacturers	Trade Name of Liquid
Aerovox	Hyvol
Axel Electronics	
Capacitor Specialists	
Cornell Dubilier	Dykanol
Electrical Utilities Corp.	Eucarel
Electromagnetic Filter Co.	
General Electric	Pyranol
Jard Corp.	Clorphen
McGraw Edison	Elemex
P. R. Mallory & Co.	Aroclor B
R. F. Interonics	
Sangamo Electric Co.	Diaclor
Sprague Electric Co.	Clorinol
Tobe Deutschmann Labs.	
Universal Manufacturing Corp.	Askarel
Westinghouse	Inerteen
York Electronics	

5.3 Requirements for PCB Capacitors

PCB capacitors may continue in use indefinitely, with no special diking provisions required. The PCB regulations define three types of PCB capacitors, and different requirements apply to each type:

Types of PCB Capacitors:

Small: Contain less than three pounds PCBs (exempted from all requirements).

Large High Voltage: Contain more than three pounds PCBs and operate at voltages above 2000 volts (basically distribution system power factor capacitors)

Large Low Voltage: Contain more than three pounds PCBs and operate at voltages below 2000 volts.

Note: In general "large" capacitors are those having a can volume greater than 300 cubic inches.

Use: No restrictions on continued use of existing PCB capacitors.

Marking:

Large High Voltage: A PCB label must be applied to each capacitor in use and in storage (see Section 2.2).

Large Low Voltage: A PCB label must be applied to each capacitor when it is removed from service. It would probably simplify the job of keeping track of the large PCB capacitors if the large low voltage capacitors in service had the label applied, but this is not required.

Small: No marking requirements.

Recordkeeping: Required, except for those facilities having fewer than 50 large capacitors and no other PCB transformers. The records for capacitors must include the following information: the total number of PCB large high voltage and low voltage capacitors in the facility; the date each large PCB capacitor is removed from service, is placed into storage for disposal, and is placed into transport for disposal; for large capacitors removed from service, the location of the initial disposal or storage facility and the name of the owner or operator of the facility; for PCB capacitors in storage in containers, the total weight of capacitors in each container. An annual report must be prepared summarizing this information as of July 1 of each year. All records must be retained for five years after the facility ceases using or storing PCBs.

Storage for Disposal: Requirements apply to storage of large PCB capacitors only. In general, capacitors must be placed in drums (see Section 2.3) and stored in special PCB storage areas (see Section 2.4). However, non-leaking large capacitors may be stored on pallets next to an approved storage area until January 1, 1983, provided that (1) the storage area has immediately available unfilled storage space that could accomodate at least ten percent of the capacitors stored outside the area (in case a capacitor should start to leak, it could be immediately moved into the storage area) and (2) the capacitors on pallets are inspected weekly.

Disposal:

Large PCB Capacitors: In an approved PCB landfill until January 1, 1980; in an approved PCB incinerator thereafter.

Small PCB Capacitors: No special disposal requirements. May be disposed of as any other trash.

Spill Cleanup: It is uncommon, but not unknown, for a capacitor to leak when it fails. Because of the high temperatures and pressures caused by an electrical arc occurring inside a capacitor, PCB vapors may be vented under pressure and spray over a considerable area. The regulations require that all material contaminated with over 50 parts per million PCBs be picked up and disposed of in an approved PCB landfill, and that contaminated surfaces of equipment be decontaminated. Rupture of a capacitor in an underground or indoors application could result in high concentrations of PCBs in the air which would present a serious health hazard to any workers in the area.

5.4 Precautions for Continued Use

Capacitors seldom rupture when they fail, and there is little likelihood that a major PCB spill will result from the failure of any PCB capacitor presently in service. Even a large power factor capacitor rated at 200 KVAR will contain only about 40 pounds of PCBs, and most of this is adsorbed in the paper or other solid dielectric material. Therefore, the maximum amount that could leak out would probably not exceed eight pounds of PCBs. In the infrequent occasion of a rupture of a capacitor, PCBs will probably be sprayed out as a fine mist. This will contaminate nearby objects and materials, and the contaminated material will have to be picked up and disposed of as PCBs.

The only significant risk that could result from continued use of PCB capacitors would be human exposure to PCB vapors if a capacitor failed in a building or underground installation. Most capacitors used in these environments are used as surge protection on distribution transformer primary terminals and on motor contactors. In most cases, system electrical safety can be improved by removing the capacitors and installing properly sized surge arrestors. This system modification is discussed in more detail in the following section.

5.5 Substitutes for PCB Capacitors

PCBs are no longer being used in capacitors, and the EPA regulations ban the sale of PCB capacitors after July 1, 1979 unless the seller has applied for and been granted an exemption from these ban requirements. Capacitors using non-PCB dielectric liquids are available for most applications. Although the replacement liquids do not have the fire resistance of PCBs, the manufacturers are improving the rupture resistance of non-PCB ballast capacitors by building thermal and pressure sensitive circuit breakers into the capacitors. Most large high voltage power factor capacitors are located out doors at substations, and there is little risk of major fire damage even if a leak should occur and the liquid burn.

The capacitors used in buildings and in underground mines on the primary terminals of distribution transformers and associated with motor contactors can present a potential fire problem if non-PCB capacitors are used. These capacitors are used to limit the rate of voltage rise, and to protect the circuit breaker from flash over resulting from chopping when a motor is disconnected. However, recent research has shown that capacitors used in these applications may actually degrade the electrical system performance.

The presence of too much load side capacitance can result in prestrike when a motor contactor is closed; the capacitor should be installed on the motor terminals rather than adjacent to the contactor as is usual practice — the inductance of the cable will help reduce the tendency of prestrike. In addition, the charging requirements of excess capacitance can trip out the ground fault detector in some cases. In most cases, improved system safety can be achieved by removing the capacitors and installing low sparkover distribution class surge arrestors that are coordinated with insulation characteristics of the associated motor and transformer. The factors that must be considered in making this system change are discussed in detail in the report "Evaluation of Mine Electrical System Safety" that is presently being prepared at Pennsylvania State University under Bureau of Mines Contract GO 155-003. This report should be completed in September, 1979, and will subsequently be made available through the National Technical Information Service, Springfield, Va. 22161.

6.0 UNDERGROUND MINING MACHINERY

6.1 Use

In the late 1960's and early 1970's, PCBs were used in some electric motors manufactured by Reliance Electric for Joy Manufacturing Co. Joy used these motors in the following applications:

CU43 continuous miners - cutting-head motors, pump motor

9CM continuous miners - cutting-head motors, pump motor

14BU10 loaders - traction motors

Liquid-filled motors were used because they were smaller and lighter than air cooled motors. A PCB mixture was chosen as the liquid because it was non-flammable, provided adequate lubrication, and possessed the best overall combination of electrical properties, chemical stability, and cost. The amount of PCBs used in each of the various kinds of motors is summarized in Table 6.1-1.

Table 6.1-1. Quantity of PCBs in Mining Machinery

Machine	Weight of Fluid per Motor		Weight of Fluid per Machine	
	(kg)	(lb)	(kg)	(lb)
CU43 Continuous Miners	20.9	46.0	62.7	138.0
9CM Continuous Miners	26.1	57.5	78.3	172.5
14BU10 Loaders	20.9	46.0	41.8	92.0

6.2 Identification

All of the CU43's, 9CM's, and 14BU10's originally sold by Joy used PCB filled motors. Some of the traction motors on the loaders have been converted to air cooling and are no longer affected by the PCB regulations. If one of the loaders was purchased used, and there is some doubt about whether the motors still contain PCBs, the air cooled motors can easily be identified because they have no fill-plug or pressure-relief valve.

Some of the continuous miner motors have been converted to silicone cooling. The shop that performed the conversion should be contacted for information about the possibility of the motors being contaminated with small amounts of PCBs. If the repair shop does not have any information, the following guides should be followed:

1) If the motor was disassembled, degreased, and rewound, there is little or no chance that any PCBs remain; thus the motor would not be covered by EPA regulations.

2) If the motor was not rewound but was only drained, flushed, and refilled with silicone, there were probably still enough PCBs trapped in the motor windings to contaminate the silicone. In this case, the motor is covered by the regulations and should still be treated as though it were filled with PCBs. The procedures and recommendations in this chapter should be followed.

6.3 EPA Requirements

All three types of equipment may be used until January 1, 1982, under the following conditions:

1) PCBs may be added to any of the motors until January 1, 1982.

2) PCB filled motors on the loaders must be rebuilt as non-PCB motors the next time the motor is rebuilt.

3) PCB filled motors on the continuous miners may not be rebuilt after January 1, 1980.

4) Any PCBs that will be used to service PCB filled motors must be stored in accordance with the requirements described in Section 2.4.

5) PCB motors must be disposed of in an approved chemical waste landfill. Disposal must take place before January 1, 1984. The regulations permit used machinery to be bought and sold.

The EPA regulations require that labels be applied to anything that contains PCBs. A description of the labels and addresses of label manufacturers are in Section 2.2. In connection with the PCB filled motors, the following things must be labeled immediately:

1) Each PCB filled motor.

2) Each mining machine that still has a PCB filled motor.

3) Each can of PCBs that is on hand for servicing or being stored for disposal.

4) Each area that is being used to store PCBs or PCB-filled motors.

The labels should be placed where they can be easily seen.

Recordkeeping: None required by the regulation.

Servicing

PCBs may be added to mining machinery motors until January 1, 1982. After this date, further use of the machinery is prohibited and any PCBs in stock must be disposed of properly.

The motors on the continuous miners may be rebuilt until January 1, 1980. After that date the machinery may still be used (until January 1, 1982); if a motor fails and no spare motor is available, the machine must be retired and the motors must be disposed of properly.

Disposal

The regulations require that the motors be drained of as much liquid as possible, and the liquid must be shipped to an incinerator that has been approved by the EPA for disposal of PCBs. The drained motor must be disposed of by burial in an approved chemical waste landfill. Information on the location of approved incinerators and landfills can be obtained from the EPA's Industry Assistance Office (800-424-9065).

The motor and the liquid must be disposed of before January 1, 1984. If the motor or the liquid will be kept for more than 30 days after the motor is removed from service, storage must be in an area which meets the requirements described in Section 2.4.

6.4 Recommended Precautions for Continued Use

The following precautions should be taken when using PCB fluids in mining machinery motors:

1) A pan filled with floor-dry, sawdust, or some other absorbent material should be placed under a motor before it is topped off.

2) Drips and spills should be avoided or promptly cleaned up when topping off a motor.

3) Motors should not be overfilled as this has, in some instances, resulted in leaks.

4) Any leaking motor or any motor which is using a greater than normal amount of fluid should be immediately removed from service until the cause of the loss of fluid is located and eliminated.

5) If a continuous miner is going to be used much past January 1, 1980, Joy Manufacturing Company should be contacted as soon as possible to make arrangements to have the motor rebuilt before the January 1, 1980 deadline on rebuilding.

6.5 Emergency Spill Response

If PCBs leak or spray out of a mining machinery motor, the procedure described in Appendix A should be followed. In addition, if the spill happens underground the following precautions should be taken:

1) If water is being sprayed on the mine face near the machine, the water should be shut off immediately.

2) If mine dewatering is being performed in the area of the spill, it should, if possible be stopped immediately. (If the dewatering system becomes contaminated with PCBs, it will have to be thoroughly cleaned or possibly sent to a chemical waste landfill.)

6.6 Non-PCB Replacement Equipment

Loaders

The traction motors on the loaders can be rebuilt as air cooled motors. Joy Manufacturing will do this for approximately $3,100 per motor. This is roughly what it would cost for rebuilding the motor for continued PCB cooled operation. The EPA regulations do not permit the motors to be used after January 1, 1982 and also do not permit Joy to perform the conversion to air-cooling after January 1, 1982. For further information on having the conversion performed, contact the nearest Joy sales representative or service facility.

Continuous Miners

There is no suitable replacement for the PCB filled motors on the continuous miners. The motors cannot be rebuilt for air cooled operation because there is not enough room in the machinery frame. Some of these motors have been refilled with a silicone fluid. The use of silicone fluid has not been approved by MSHA because silicone vapors will deactivate methane detectors, and is not recommended by Joy because the silicones will burn. Therefore, silicone fluid cannot be considered an acceptable replacement for PCBs in these motors. The only acceptable alternative is to purchase another miner before the January 1, 1982 deadline.

7.0 ELECTROMAGNETS

7.1 Use

Most separator electromagnets are filled with mineral oil, but PCBs have been used in magnets mounted in locations where there is an increased danger of fire. These PCB filled magnets have been used primarily indoors near coal crushers and over conveyors at the head of a mine, though they may be found in other locations.

7.2 Identification

There are no markings on a magnet that tell whether it is filled with mineral oil or PCBs; PCBs were simply substituted for mineral oil at the request of the purchaser. The simplest way to determine what a magnet is filled with is to check company records. If there are no records available, the serial number of the magnet should be obtained from the nameplate and the manufacturer should be contacted. There were three manufacturers who used PCBs in some of their magnets. Their addresses and telephone numbers are:

Dings Company
4780 West Electric Avenue
Milwaukee, Wisconsin 53246
(414) 672-7830

Eriez Magnets
95 Magnet Drive
Erie, Pennsylvania 16512
(814) 833-9881

Stearns Magnetics, Inc.
6001 South General Avenue
Cudahy, Wisconsin 53110
(414) 769-8000

7.3 EPA Requirements

PCB filled electromagnets are considered to be totally enclosed uses of PCBs, and are subject to the same requirements as PCB transformers except for the recordkeeping requirement.

Marking

Any electromagnet that contains PCBs or liquid contaminated with over 50 ppm PCBs must be labeled (See Section 2.2).

Recordkeeping: None required by the regulation.

Servicing

Minor servicing of PCB filled electromagnets is permitted until July 1, 1984, but rebuilding or any other type of servicing that requires removing the coil is prohibited. The following requirements must be followed when servicing a PCB filled electromagnet:

1) PCBs removed from the magnet must be either returned to the magnet, used in some other permitted application, or disposed of properly. The PCB material may not be sold.

2) Any PCBs that may be used to service or repair a PCB electromagnet must be stored in an area which meets the requirements described in Section 2.4.

Disposal

The regulations require that the PCB magnet be drained of as much liquid as possible, and the liquid must be sent to an incinerator that has been approved by the EPA for disposal of PCBs. The drained magnet must be buried in an approved chemical waste landfill. Information on approved incinerators and landfills can be obtained from the EPA Industry Assistance Office (800-424-9065).

Before the liquid is drained from the magnet, the ground or floor underneath should be covered with a sheet of plastic and a layer of floor-dry, sawdust, or other absorbent material. If the magnet does not have a drain plug, a hole should be drilled or cut in one corner of the top of the magnet and the fluid should be siphoned into a barrel or drum that meets the requirements described in Section 2.3 and that is acceptable to the incineration facility that will be receiving the fluid. Some incinerator operators may require that small drums of liquid be packed inside of larger barrels of sawdust to provide more protection against spills, so the incinerator facility should be contacted to determine its requirements. After the magnet has been thoroughly drained the siphoning hose should be placed inside the magnet case and the hole should be plugged to prevent any small amounts of PCBs that remain in the magnet from leaking out when the magnet is sent to the landfill. If any PCBs dripped onto the layer of floor-dry, the contaminated material and, if necessary, the plastic must also be sent to the landfill.

For additional information on transportation of PCBs, see Section 2.7.

7.4 Recommended Precautions for Continued Use

Precautions should be taken to reduce the possibility of spills and leaks when using a PCB filled electromagnet. These steps include:

1. Inspecting the magnet at least once a month for minor leaks, with particular attention being paid to the welds, where cracks may develop if the magnet is frequently turned on and off.

2. If the magnet is being moved, extra care should be taken to ensure that the casing is not damaged.

The EPA regulations allow continued use of PCB filled separator magnets over coal conveyors because it is assumed that any PCBs that leak out of the magnet will be destroyed when the coal is burned. However, the use of PCB magnets over coal that will be washed or otherwise subjected to water based physical cleaning processes risks a major PCB contamination incident. Washing coal that has been contaminated with spilled PCBs will result in PCB contamination of the wash water, exposure of workers to PCBs vaporized from the recycled water, and stream pollution when the water is discharged from the plant. A major spill of PCBs into the water of a coal cleaning plant, whether directly or due to contamination of the feed coal, would have to be considered an environmental disaster that would be extremely expensive, if not impossible, to clean up. The consequences of a possible PCB spill should be carefully considered when deciding whether to allow a PCB separator magnet to remain in service.

7.5 Emergency Spill Response

If a PCB filled magnet develops a leak, the spill response plan in Appendix A should be followed. In addition, the following steps should be taken:

1. The conveyor should be stopped immediately to limit the amount of coal that becomes contaminated.

2. The magnet should be removed from over the conveyor, and a pan of sawdust or floor-dry should be placed under the leak. If the magnet can not be moved, a pan should be placed on the conveyor under the leak.

3. Any visibly contaminated coal should be removed from the conveyor and placed in a drum for disposal. (See Section 2.3).

4. See Section 2.6 for decontamination procedures.

7.6 Non-PCB Electromagnets

Several alternatives to the use of PCB filled electromagnets are available. Oil filled magnets can be used if there is a location where the increased fire risk would not pose a significant threat.

The magnet manufacturers also sell silicone filled magnets for use when a fluid with fire-resistant properties is required. A silicone filled electromagnet costs 40% to 50% more than a comparable oil filled unit. The use of silicone fluids underground is not recommended because silicone vapors will deactivate methane detectors. Although the silicone fluid is non-toxic, major spills onto coal (or ore) prior to wet floatation processing may disrupt the process because silicone is a powerful anti-foaming agent.

Other high fire point hydrocarbon transformer liquids might also be considered. These have about the same fire point characteristics as silicone, but they release more heat than silicone if they do ignite. See Section 3.6.1.3 for additional discussion of these liquids.

Repeated refilling of existing PCB separator magnets with transformer oil, silicone, or high fire point transformer liquid will gradually reduce the residual levels of PCBs. If the concentration of PCBs is reduced to below 50 parts per million, the magnet would be allowed to be rebuilt or sold for scrap when it fails. (The regulations allow these alternatives for transformers continuing less than 500 ppm PCBs. Rebuilding or scrapping a magnet having PCBs present in the fluid in concentrations between 50 and 500 ppm would require the owner to apply to the EPA for an exemption based on the precedent established for transformers.)

Dry type separator magnets are also available. Eriez sells an air cooled magnet which has been approved by Underwriter's Laboratory for use in dirty, dusty environments. This type of magnet costs 20 to 25% more than a comparable oil filled unit.

8.0 HEAT TRANSFER FLUIDS

8.1 Use

Because of their fire resistance and stability, PCBs were used as the major component of several high temperature heat transfer fluids. These fluids were manufactured from 1930 through 1972 by Monsanto. From 1972 through 1974 Geneva Industries of Houston, Texas, manufactured one type of PCB based heat transfer fluid. Monsanto quit selling PCB based heat transfer fluids during 1971-1972, but it was several years before all the fluid was in the hands of the final consumer. Most purchasers of heat transfer fluids were advised by Monsanto to drain their systems and refill them with a different fluid. Recent tests on a number of heat transfer systems have found PCBs present at levels high enough to be regulated by the EPA even in systems that have been drained and flushed.

PCB based heat transfer fluids were apparently not widely used in the mining industry. Versar identified only one system that ever used a PCB based heat transfer fluid. This system was used as a part of several concentrate dryers at an ore beneficiation plant.

8.2 Identification

The trade names for the various PCB based heat transfer fluids manufactured by Monsanto are shown below. The trade name for the product sold by Geneva Industries is not known but it was sold as being equivalent to Therminol FR-1.

Trade Names for PCB Based Heat Transfer Fluids Manufactured by Monsanto

Heat Transfer Fluids
Therminol FR-O
Therminol FR-LO
Therminol FR-1
Therminol FR-2
Therminol FR-3

8.3 EPA Requirements

Use: Heat transfer systems containing fluid contaminated with more than 50 parts per million PCBs may be used until July 1, 1984, provided that:

1. Every heat transfer system that ever contained PCB based fluid must be tested by October 1, 1979, to determine the concentration of PCBs remaining in the fluid.

2. If the concentration of PCBs exceeds 50 parts per million:

- The system must be drained and refilled with fluid free of PCBs within six months. The PCB contaminated fluid must be properly stored and disposed of in an approved PCB incinerator (See Section 2).

- The testing and refilling procedure must be repeated annually until the concentration of PCBs is found to be less than 50 parts per million at least three months after the most recent replacement of fluid.

- Records of the testing and refilling must be maintained for at least five years after the concentration of PCBs is reduced to 50 ppm.

Marking

Any heat transfer system that contains a fluid with over 50 ppm of PCBs must be marked immediately. The label should be placed where it can be easily seen. Names and addresses of label printers are in Section 2.2.

Recordkeeping

All records resulting from any test conducted to determine the PCB content of the fluid in a heat transfer system must be kept for at least five years after the system is determined to have a concentration of PCBs in the fluid of less than 50 parts per million.

Servicing

Any type of servicing may be done on contaminated heat transfer systems. The only restriction is that fluid containing 50 ppm or more of PCBs may not be used to refill or top-off a system. This includes fluid that has been removed from a system during servicing.

Fluid containing over 50 ppm of PCBs may be processed in some manner to reduce the level below 50 ppm, and then the fluid may be used in a heat transfer system. This processing may be done by the owner of the system or by someone who has received authorization from the EPA to perform this type of servicing.

Any fluid removed from a system that contains any level of PCBs must either be processed or disposed of in an approved incinerator. Some land-fills may accept liquids with less than 50 ppm PCBs for disposal. Fluid contaminated with any detectable amounts of PCBs may not be used for road oiling, as an herbicide carrier, or in any other similar application.

Disposal

When a PCB contaminated (above 50 ppm PCBs in the fluid) heat transfer system is taken out of service and will no longer be used, the fluid and the system must be disposed of separately. The fluid must be sent to an approved PCB incinerator. The drained heat transfer system must then be disposed of by burial in an approved chemical waste landfill.

Once the system is drained, it must be carefully disassembled for shipment (unless it is possible to ship the system whole). Plastic and floor-dry should be placed under each joint before it is taken apart. The landfill and the shipping company should be contacted for instructions on packaging portions of the system that are too large to fit in 55 or 110 gallon drums. All containers that hold contaminated liquids and parts of the system must be labeled. If any of the material is going to be stored for more than 30 days before it is shipped to the disposal site, it must be stored in an area that meets the requirements described in Section 2.4.

Disposal of scrapped PCB heat transfer systems in a chemical waste landfill will be expensive. Present costs are about $8 per cubic foot plus transportation, and the owner of the machine also loses the scrap value of the metal. It may be cheaper to decontaminate the system using a solvent such as fuel oil, even though the contaminated solvent would require disposal in an approved incinerator.

8.4 Recommended Precautions for Continued Use

The following precautions are recommended when using a heat transfer system that is contaminated with PCBs:

1. If a major leak in the system could reach the ground or any water drain, the system should be diked.

2. Any drains or cracks in the floor near the system should be plugged or patched.

3. If there are minor leaks in the system and it is impractical or impossible to repair them, a pan of floor-dry or sawdust should be used to catch the leakage. The pans should be emptied periodically. Contaminated floor-dry and sawdust should be accumulated in a drum that meets the requirements described in Section 2.3. This drum must be marked, stored in an area that meets the requirements described in Section 2.4, and disposed of in an approved chemical waste landfill.

4. The system should be checked at least once a month for leaks.

5. When servicing is necessary, pans of floor-dry or a layer of plastic and then a layer of floor-dry should be placed under all joints that will be disassembled or that could leak as a result of being stressed while working on a different part of the system.

6. When a pump, piping, or other component of a system is removed, the ends or other openings should be plugged with rags, or the component should be supported on a rack, pallet, wooden slats, or in some other manner such that plastic or pans and floor-dry can be placed under all openings that may leak PCBs.

If the system is located in an area where it could be accidentally damaged by a forklift or because heavy equipment or items are being moved nearby, either the activity should be moved or a sturdy fence or other barrier should be erected to protect the system.

8.5 Emergency Spill Response

In the event of a leak from a heat transfer system, the spill response plan in Appendix A should be followed. In addition, the following steps should be taken:

1. The heat should be shut off.

2. Any pumps in the system should be shut off.

3. If the leak is in a high pressure portion of the system, the pressure should be relieved as rapidly as possible.

4. The system should be drained below the level of the leak as rapidly as possible.

8.6 Non-PCB Heat Transfer Fluids

When Monsanto discontinued the sale of PCB based heat transfer fluids in 1972, they made available a number of substitute fluids for high temperature, low pressure heat transfer systems. Suitable fluids are also available from a number of other manufacturers. These fluids are mostly of the chemical type of alkylated aromatics and aromatic ethers.

The non-PCB fluids have two disadvantages compared to the PCB based materials: (1) The non-PCB fluids are flammable, and (2) they will oxidize upon prolonged exposure to air at high temperatures. As a result, conversion to non-PCB fluids requires that the expansion reservoir be sealed and blanketed with an inert gas such as nitrogen to protect the fluid from oxidation. Direct fired systems must be protected against a major fire resulting from a break in the fired tubes by installing a remotely controlled steam, Halon, or carbon dioxide quench system in the combustion chamber. Information required to design specific applications is available from your insurance underwriter and from the National Fire Protection Association in Boston, Massachusetts 02210.

9.0 HYDRAULIC FLUIDS

9.1 Use:

PCBS were used as the basis of a number of fire resistant hydraulic fluids sold prior to 1972. These fluids were used primarily in die casting machines and in various hot metal equipment in steel mills. This study did not identify any use of PCB based hydraulic fluid in mining machinery or in mine-related operations. However, it is possible that PCB based fluid may have been used to some extent in the mining industry, and the EPA regulations apply to all systems that ever used PCB based fluid, including mine applications.

9.2 Identification:

The only known supplier of PCB based hydraulic fluid was Monsanto, which marketed a number of different types prior to 1972 under the following trade names:

Pydraul A-200
Pydraul AC
Pydraul AC-28
Pydraul F-9
Pydraul 135
Pydraul 150
Pydraul 230
Pydraul 280
Pydraul 312
Pydraul 540
Pydraul 540-A
Pydraul 625

9.3 EPA Requirements:

Any system that ever contained a PCB based hydraulic fluid must be tested by October 1, 1979, to determine the concentration of PCBs remaining in the system. Requirements for recordkeeping, marking, flushing and periodic testing of contaminated hydraulic systems are the same as for contaminated heat transfer systems (see Section 8.3). Disposal of drained hydraulic systems is not regulated if the liquid contains less than 1000 ppm PCBs; flushing prior to disposal is required if the fluid contains over 1000 ppm PCBs. Disposal of fluid contaminated with over 50 ppm PCBs must be in an approved PCB incinerator.

9.4 Non-PCB Hydraulic Fluids

Most systems that used PCB based fluids have been converted to fluids based on phosphate esters or to water/glycol mixtures. Performance has been satisfactory, although neither of these substitute materials has the fire resistance or oxidation resistance of PCBs.

Analysis of phosphate ester based hydraulic fluids for residual PCBs will cost more than will similar tests on hydrocarbon based fluids because the phosphate interferes with the equipment that is usually used to perform this analysis. There should be no special problems if you tell the analytical lab what type fluid is presently in the system.

10.0 WASTE OIL

Over one billion gallons of used oil per year is collected for use as road oil or is reclaimed for use as lubricating oil. The used oil that is re-refined for use as lubricating oil often contains industrial oil such as used transformer oil and hydraulic fluid that is contaminated with low levels of PCBs. As a result, much of the re-refined motor oil contains low levels of PCBs, and dissipative uses of even segregated motor oil can release PCBs into the environment.

10.1 EPA Requirements:

The use of waste oil containing any detectible levels of PCBs as road oil, insecticide carrier, or other dissipative use is forbidden. The regulations do not define the analytical method to be used to check for PCBs, but the commonly used gas chromatograph can easily detect PCBs at concentrations of one to two parts per million in used oil.

10.2 Recommendations:

The major impact of this ban on the use of PCB contaminated waste oil will be on the oiling of mining roads. Alternatives to discontinuing road oiling include the use of carefully segregated used virgin motor oil, testing each batch of oil for the presence of PCBs (at a cost of $50 to $70 per batch), the use of synthetic soil stabilization chemicals, or the use of water for dust control. A synthetic material that may perform satisfactorily is Coherex, which is manufactured by Witco Chemical Corporation. The manufacturer should be contacted for additional information and recommendations.

Proper disposal of used oil will be required to prevent the release of low levels of PCBs into the environment. Used oil may be used as a fuel or re-refined without special handling provided that the oil contains less than 50 ppm PCBs.

APPENDIX A

Outline of PCB Spill Response Guide

APPENDIX A

EMERGENCY SPILL RESPONSE GUIDE FOR

Polychlorinated Biphenyls

(PCBs, Askarel, Pyranol, Inerteen, etc.)

What are PCBs:	PCBs are a non-flammable oil used as a coolant and electrical insulating fluid in some transformers, capacitors, and separator magnets and in electric motors on certain Joy continuous miners and loaders.
Hazards:	PCBs are a toxic environmental pollutant. Do not breath vapors or get on skin. Do not allow spilled PCBs to get into drains, sewers, or other water.
First Aid:	Skin contact: wash off with waterless hand cleaner using paper towels. Store contaminated towels for special disposal.
	Eye exposure: Flush with water.
	Vapor exposure: Get medical aid.

SPILL RESPONSE

Spill from live electrical equipment: disconnect power, call chief electrician. (Phone No.)
Then try to plug leaks with rags, stick, or other material.

All spills:

Call (environmental engineer, mine superintendent, etc.)
(Phone No.)

APPENDIX A (Continued)

Protective clothing:	Use plastic gloves to prevent contact with skin. Contaminated gloves, clothing, shoes, etc., should be put into 55 gallon drum for disposal as PCBs. Tools may be decontaminated by washing with solvent; dispose of solvent, rags, etc., as PCBs.
Control spill:	Dike major spills with dirt or other material. Soak up spilled PCBs with rags, straw, or other material. Do not let PCBs run into drains or water.
Final cleaning:	Check with (mine environmental engineer) at (Phone No.) for detailed instructions.
Disposal of PCB Contaminated Material and Equipment:	Solids - load into 55 gallon drums; label with PCB label; ship to EPA approved PCB chemical waste landfill. Liquids - drain into 55 gallon drums; flush equipment with solvent such as kerosene or fuel oil to remove as much residual PCB as possible; drain solvent into drums; apply PCB label and store in secure roofed area meeting EPA requirements until an approved incineration facility becomes available for the disposal of PCBs.

APPENDIX B

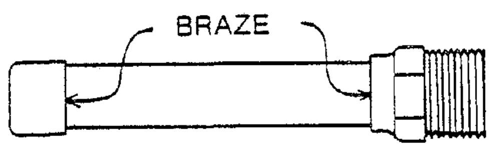
WATER-ONLY DRAINAGE SYSTEM*

The drainage system described below is designed so that water can freely flow out of the diked area, while askarel (PCB) fluid which is denser than water will cause a silicone rubber "flapper valve" to float up into a position covering the drain hole. Figure 8 shows the complete water-only drainage system in side and top views, but without the filter screen system that covers the valve and keep leaves and other particulate matter from clogging the valve.

The fabrication and installation sequences of the valve are as follows:

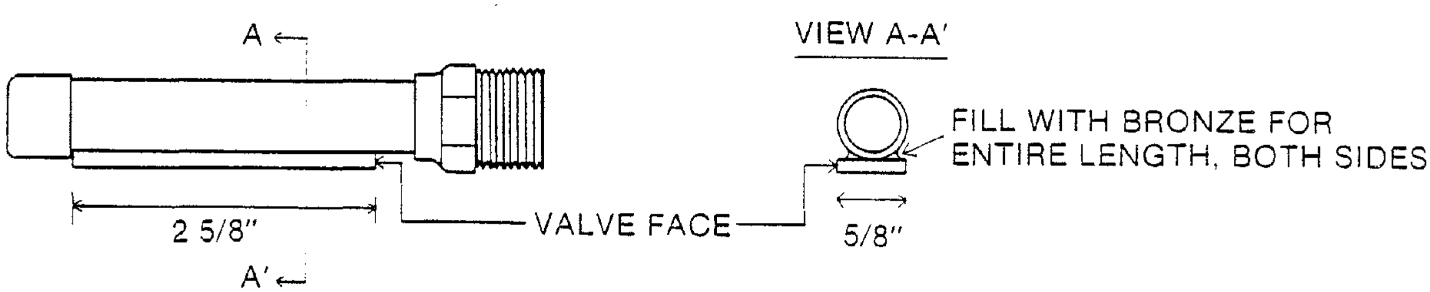
1. Cut a 4-inch-long, straight, undented section of ½-inch (ID) copper plumbing pipe.

2. Place a copper cap on one end and a copper fitting having a ½-inch male pipe thread on the other end and then braze (do not solder) the three pieces together to thoroughly seal the joints.



Brazing is necessary to allow for the additional high-temperature brazing processes that are necessary for adequate strength of the finished valve.

3. From a piece of 1/8-inch-thick copper flat stock, cut a strip that is 2 5/8 inches long and 5/8 inches wide. This will be the "valve face." Braze it onto the part above in this manner:



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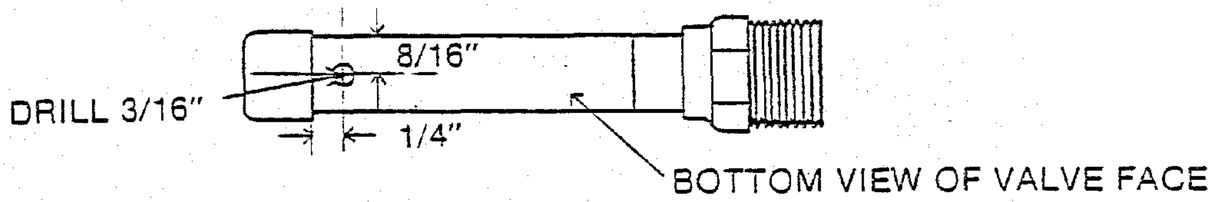
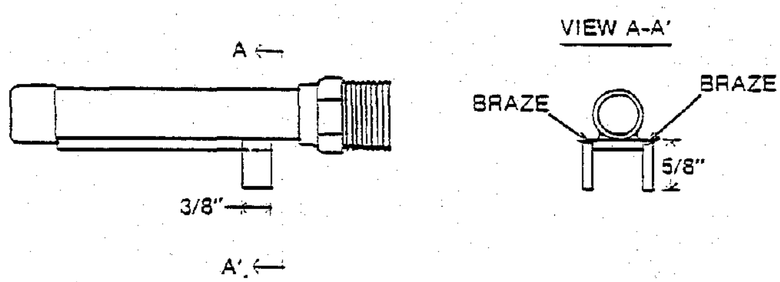
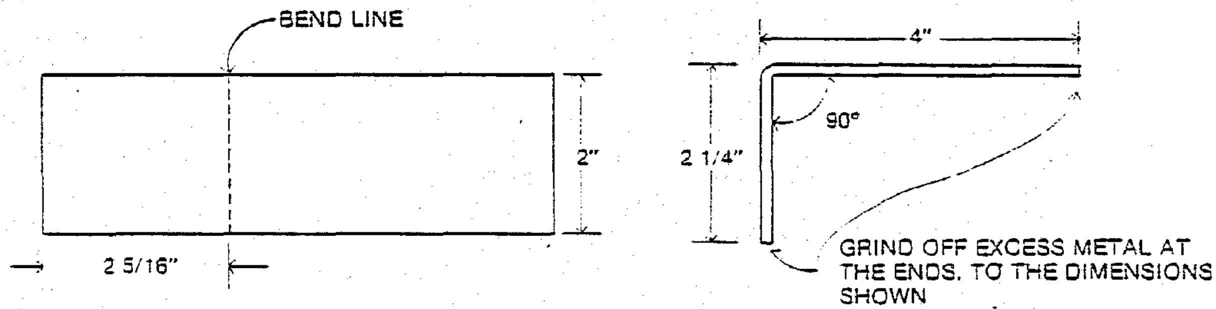
4. Drill a 3/16-inch hole as shown, and then cut away excess metal around the hole and gently grind the entire surface of the valve face on fine emery paper backed by a flat surface to remove any unevenness of the face.



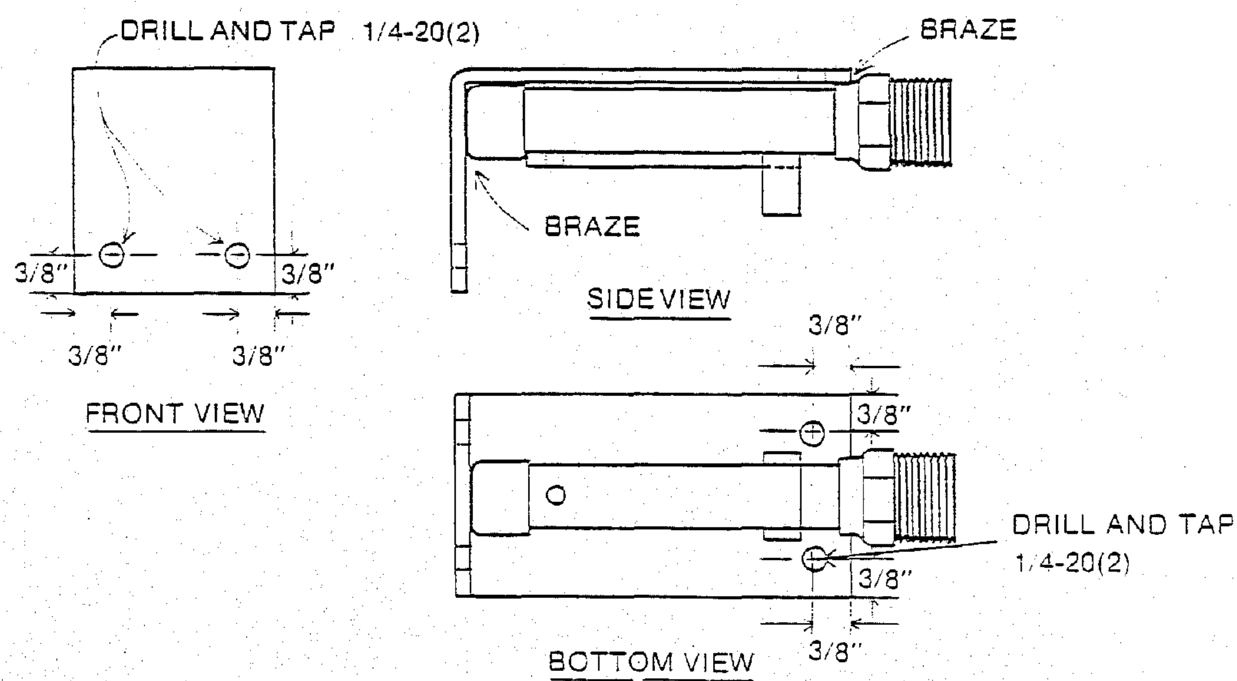
5. From 1/8-inch-thick copper flat stock, cut two pieces measuring 3/8 inch by 5/8 inch and braze them onto the valve face in the positions shown.



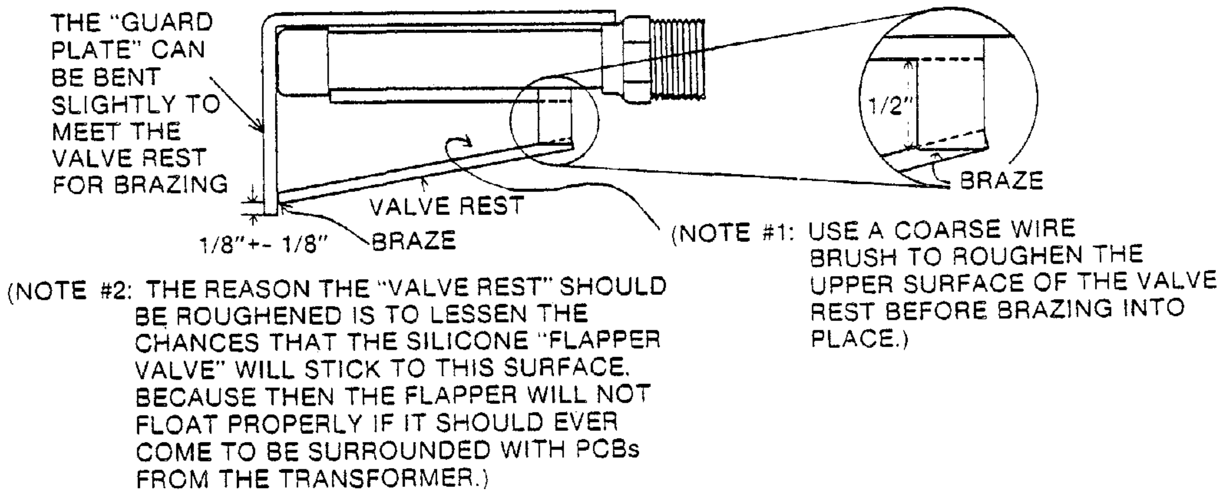
6. From 1/8-inch, flat copper stock, cut a rectangular piece measuring 2 inches by 6 3/8 inches. Bend it to this shape to make the "guard plate."



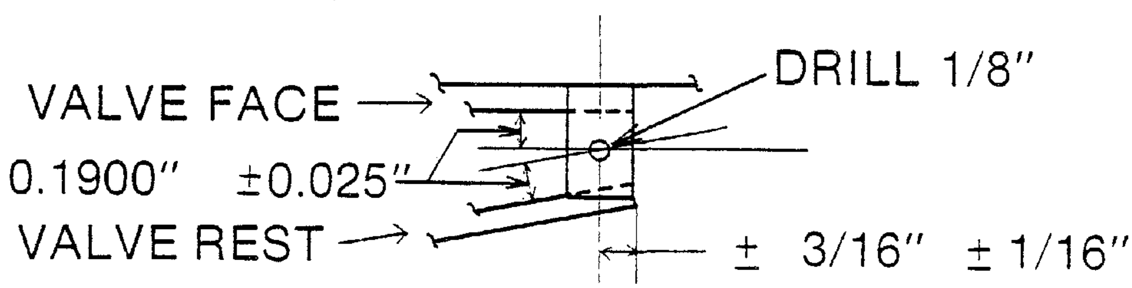
7. Braze the "guard plate" to the main body of the valve:



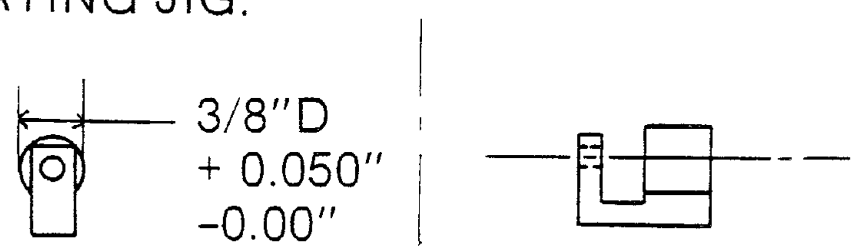
8. From 1/8-inch flat copper stock, cut a rectangular piece - the "valve rest" - measuring 5/8 inches by 3 3/8 inches, and braze it onto the valve in this position (see Note #1 in the diagram below):



9. Drill a 1/8-inch hole through each of the two (bearing supports) in the location shown below. (It might be useful to make an alignment jig to facilitate the finding of the center for this hole; a schematic of the type of jig that might be useful is shown.)



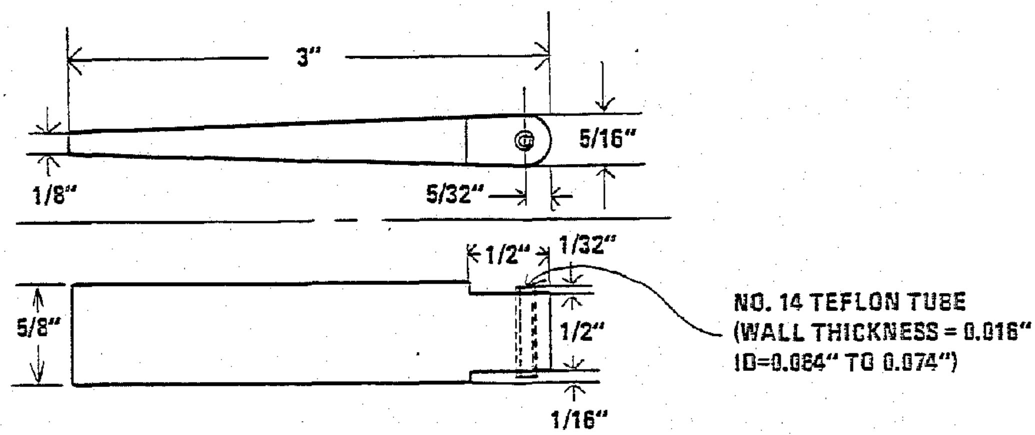
HOLE-LOCATING JIG:



10. After all the brazing processes are finished, the copper will have a coating copper oxide scale. Remove the scale with a rotary wire brush, but be careful not to mar the smooth valve face. Use fine emery paper and light finger pressure to remove scale from the valve face. If there are large irregularities on the valve face, remove them with a fine flat file or use fine emery paper backed with a solid flat surface.

11. The "flapper valve" is made of two-component silicone rubber. The best silicone rubber formulation to use is General Electric RTV 11, which has a specific gravity of 1.18. Two other RTVs, 41 and 77, could also be used, but since their specific gravities are respectively 1.31 and 1.33, they won't have the bouyancy and sealing power of the less dense RTV 11.

The flapper valve must have these dimensions:

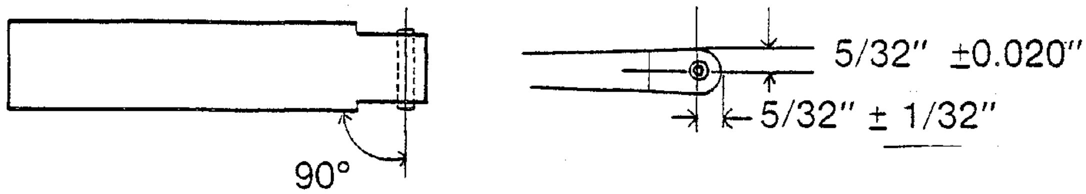


There are several ways to make these flapper valves, the two easiest probably being:

a. On a smooth flat surface, pour out a 5/8-inch-wide, or wider, strip of the uncured silicone rubber; make it at least 5/16 inch thick. Locate the teflon tube so that it is perpendicular to the strip and 5/32 inch ($\pm$ 0.020 inch) off of the flat surface. When the rubber has cured, use a razor blade to cut the flapper valve into the required dimensions. The critical dimensions and characteristics are:

(1) One surface of the flapper must be very smooth in order to seal the drain hole tightly when PCBs are present in the diked area.

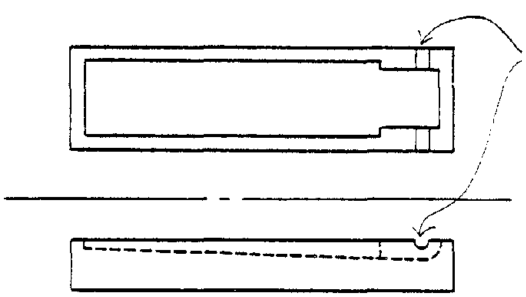
(2) The location of the teflon tube must be accurate in both alignment with the rest of the flapper and at height from the faces of the flapper



If these two conditions are not met, the flapper may bind during operation when it is supposed to float in PCBs, and/or it may not properly cover the drain hole.

b. The second method is to make a metal or plastic pattern of the flapper valve. The pattern can be used to make a reusable mold out of plastic or metal. Since the flapper valve is symmetric, the two mold halves can be identical in shape. (However, one of the mold halves should have a roughened face so that one side of the flapper valve will also be rough; the roughness will be on the side of the flapper valve that is away from the drain hole, and the purpose of the roughness is to minimize sticking of the flapper valve to the "valve rest" during the period of years that it may lay in the open position.)

Each mold half will look like this:

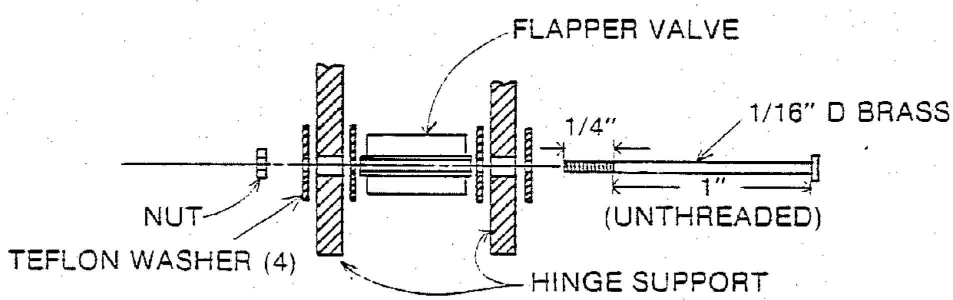


A LENGTH OF #14 TEFLON TUBE CAN BE LAID ACROSS THIS TROUGH BEFORE THE MOLD HALVES ARE CLOSED; IN ORDER TO MAKE SURE THE TUBE REMAINS STRAIGHT, CAST THE SILICONE RUBBER AROUND IT WHILE THE 1/16-INCH BRASS HINGE SCREW IS INSIDE THE TUBE.

Use parting compound on the mold halves and do so sparingly on the face that is to be smooth.

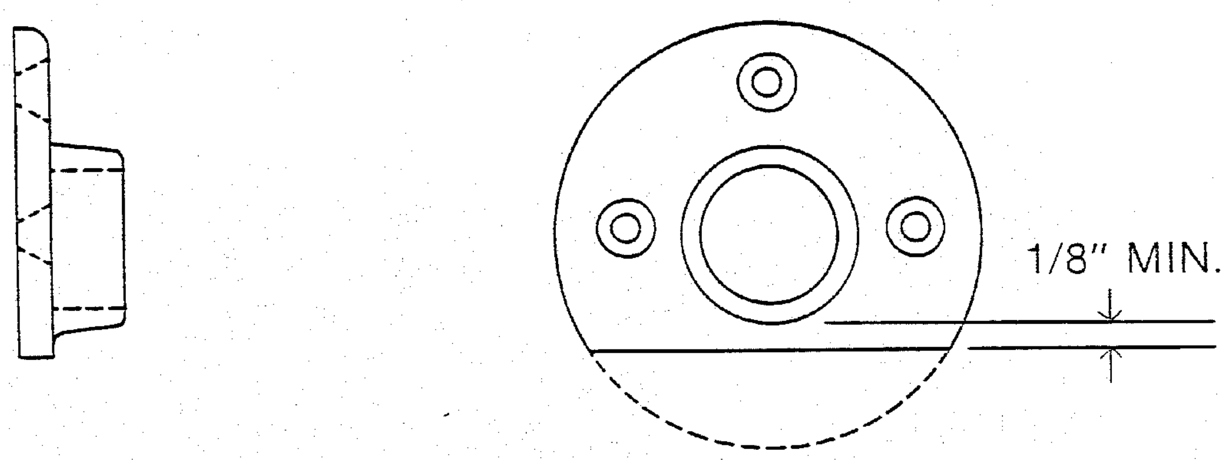
After casting, cut away the excess rubber (the flash) and (after removing the brass hinge screw) cut the teflon tube to the proper length - i.e., approximately 1/32 inch or 0.030 inch excess tubing on each side of the flapper valve.

12. The flapper is attached to the valve body by means of a brass hinge screw and four teflon washers measuring 0.020 inches in thickness and with an inside diameter of 1/16 inch and an outside diameter of 1/4 to 3/8 inch. The hinge screw must have the dimensions shown in the diagram below, and the teflon washers must be placed as shown. The nut should be run down tight against the end of the threaded portion of the hinge screw to provide adequate tightness of the nut and screw. The final assembly should allow the flapper valve lots of free play.

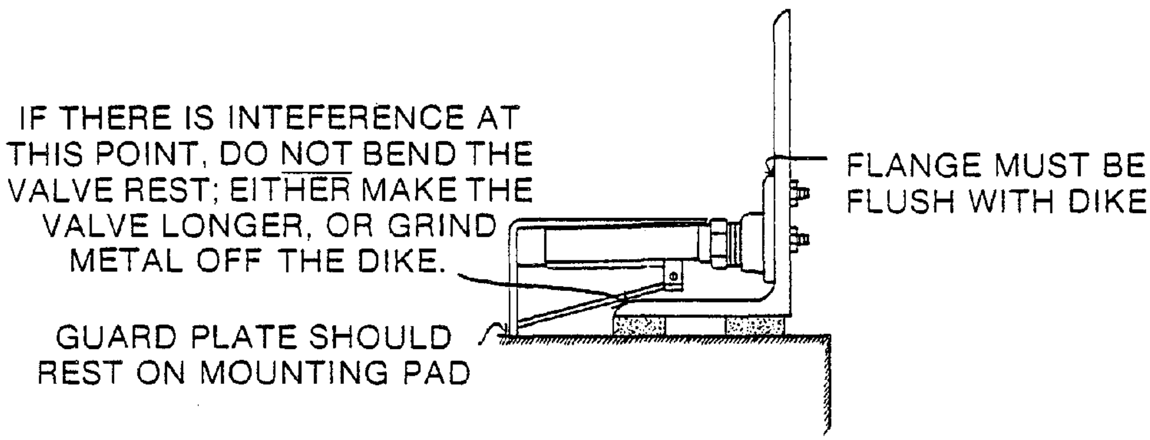


13. The filter screen is not to be attached until after the entire valve assembly is in place in the dike. Installation of the valve assembly on the dike should follow this sequence:

a. A ½-inch galvanized pipe flange should be cut in the manner shown below so that it can be fitted low on the inside of the steel dike.



b. The drain valve is screwed into the flange tightly, and then the combination of flange and valve is fitted put into position on the inside of the dike in this manner,

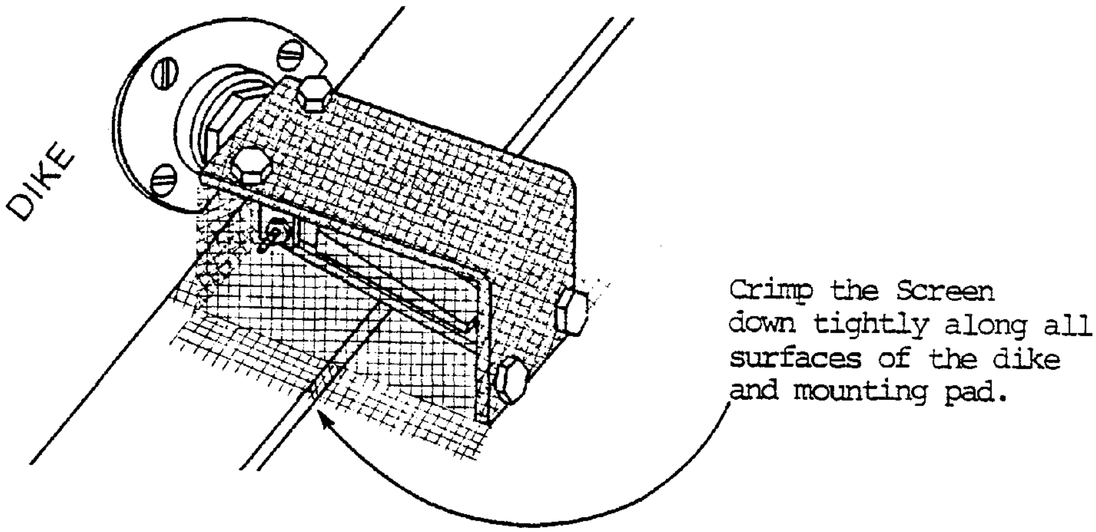


c. Remove the flange from the valve and then, after the bolt holes are drilled in the dike, locate and drill the center drain hole in the dike, using the flange to locate the position of the center hole. (Drill a hole of about 3/4 inch diameter, or at least drill a smaller hole that will be positioned so as to allow all water to drain from the valve.)

d. Screw the valve back into the flange tightly and, sealing the face of the flange with silicone rubber caulking compound or some other weather-proof sealant, screw the flange and valve assembly tightly into place on the dike.

e. Additional sealant on the tops of the flange screws and around the edge of the flange will help assure a liquid-tight seal.

f. Using brass or stainless steel screen with holes not larger than 1/16 inch on an edge, fabricate the filter screen so that it is bolted into place by the screws that mount into the "guardplate", and so that it completely covers the valve system all the way down to the concrete and to the bottom and side of the dike. The arrangement for the screen should appear something on the order of:



The hold-down screws should be ¼-20, hex-head copper, brass, or stainless steel. Washers of the same material should be used under the screws and on top of the screen in order to keep the screen from binding and wrapping up on the screws when they are tightened. Bolt holes can be made in the screen by either a punch or by piercing with an ice-pick-like tool having a shank diameter of about ¼ inch or slightly larger. It is imperative that all sides of the valve system be protected by the screen, because the movement of leaves and other particulate matter into the valve area can keep the valve from functioning properly.