Manual for PCB Spill and Fire Management

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Beginning in 1987, Environmental Protection, Conservation and Protection-Ontario Region sponsored a consultant's study that dealt with the management of PCBs involved in spills and fires. The study was intended to develop resource material on equipment, techniques, clean up guidelines/standards, and other related information that would be of assistance to those individuals who might have to deal with such incidents. The attached report entitled **"Manual for PCB Spill and Fire Management"** is the result of this study.

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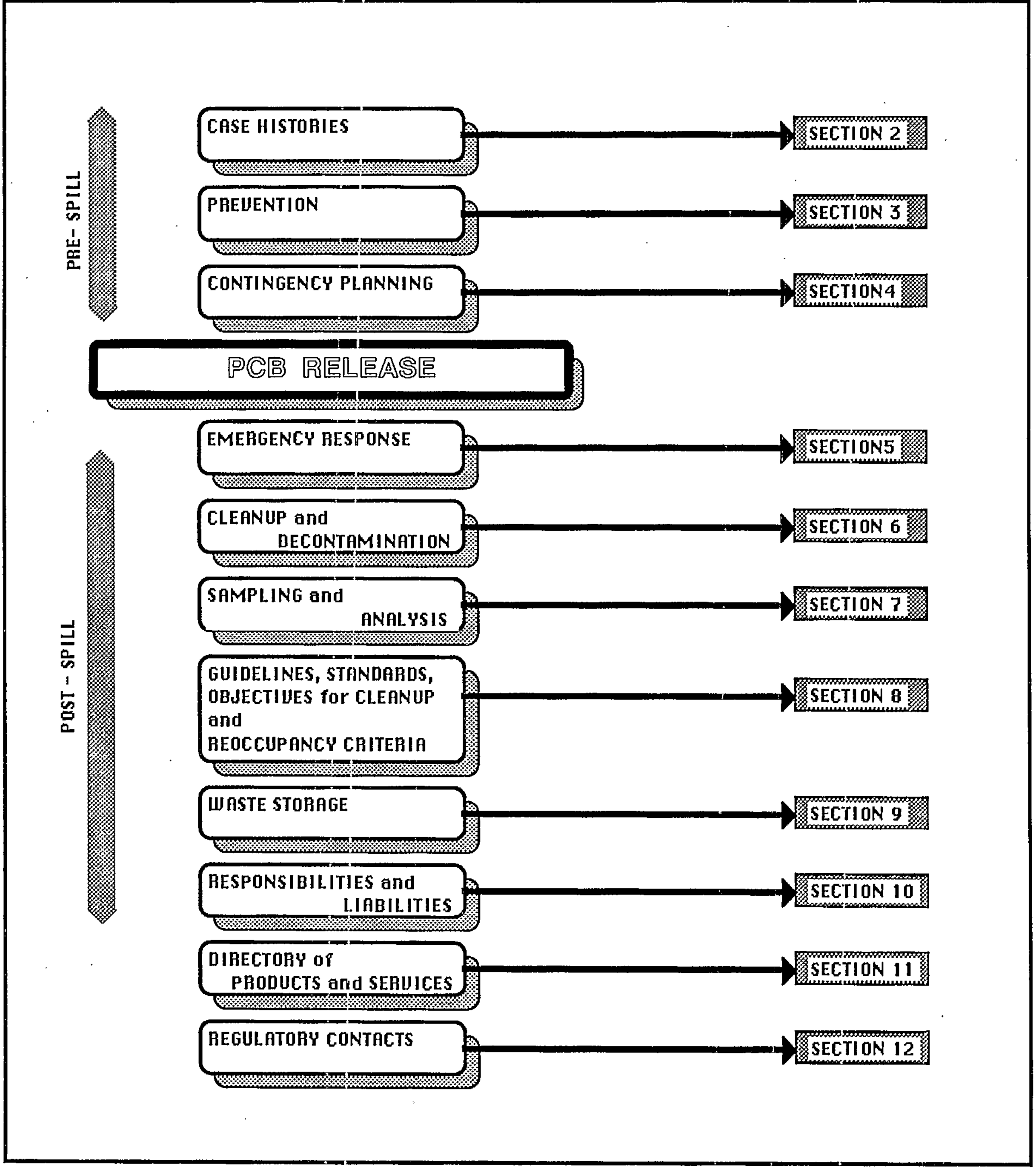
FIGURE 1

ORGANIZATION of the MANUAL



1.0 PURPOSE

1.1 Background

Polychlorinated biphenyls (PCBs) have been used commercially since the late 1920's. Although they were used in a variety of applications, the primary use was in electrical apparatus such as transformers and capacitors. Spills, pressurized releases, and fires involving PCBs are uncommon occurrences, but have occasionally resulted in the widespread contamination of buildings, plant sites and the environment. When they have occurred, these events have often required extensive and costly cleanup operations (depending on the amount of PCBs involved and the extent of contaminant migration). In some instances, highly toxic polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs) have been produced; specifically when PCBs were exposed to high temperatures. This has increased the human health and environmental concerns associated with PCB accidents.

Much practical information has been gained from past events involving PCB equipment in terms of preventative measures, facility management, and effective PCB release control and cleanup techniques. This manual summarizes such information.

1.2 Utilization of the Manual

The PCB Spill and Fire Management Manual is directed at owners and managers of PCB-containing equipment, government agency personnel, fire fighters, other first responders, and cleanup contractors. It will provide these personnel with practical measures to prevent the release of PCBs and a practical guide for dealing with these events when they do occur. The information should prepare facility personnel to respond to smaller PCB release events as well as provide guidelines for response to larger incidents where outside contractors and government agencies are required.

The information is presented as depicted in Figure 1, and is cross-referenced to facilitate utilization of the information for both non-emergency (pre-release) and emergency (post-release) situations.

PCB equipment varies in size from small capacitors containing millilitres of PCBs to large transformers containing thousands of litres. PCB concentrations can vary from a few ppm to high per cent (for example, transformer askarels are typically 70% in trichlorobenzene). In addition, the applications for use vary. Therefore it should be recognized that the circumstances surrounding PCB installations and PCB release events will be unique. To this end the Manual is intended to be a guide with optional strategies detailed for a variety of conditions. This approach should allow for the flexibility and interpretation needed to deal with conditions specific to any one situation.

The Manual includes measures that can be implemented to prevent and/or minimize the consequences of accidental release and countermeasures comprising efficient response and control procedures. Adherence to the procedures outlined in the manual will reduce the likelihood of PCB spills, pressurized releases, and fires, and will assist in responding to PCB accident. These measures should provide a means for ensuring that actions are conducted in compliance with federal and provincial regulations.

It is recommended that facility owners and managers have a person identified in their organization who is responsible for the PCB material on-site and is prepared to use the guide to respond to the particular situations at their facilities.

1.3 Support Documents

To ensure a comprehensive understanding of proper PCB management, it is recommended that copies of the following Environment Canada publications be obtained from Regional Environmental Protection Offices]:

- Handbook on PCBs in Electrical Equipment
- Manual for the Management of Wastes Containing Polychlorinated Biphenyls(PCB)
- Fires in Electrical Equipment Containing PCBs: Recommendations to Prevent Contamination by PCDF's
- Identification of Fluorescent Lamp Ballasts Containing PCBs
- Question and Answer Guide Concerning Polychlorinated Biphenyls (PCBs)
- Environmental Contaminants Act and Supporting Regulations
- Summary of Environmental Criteria for Polychlorinated Biphenyls (PCBs)
- National Inventory of Fluids Containing Polychlorinated Biphenyls (PCBs)

Additional information may also be available from Provincial Ministries of the Environment and the Canadian Council of Resource and Environment Ministers.

TABLE 2.1

PCB SPILL CASE HISTORIES

Company [Location]	Date	Equipment Type	Spill Cause	Spill Volume	Level of contamination: Soil	Surface	Water	Air	Cleanup Technique	Cost	Remarks	Ref.
Canadian Cellulose Pulp Mill, Port Edward, B.C.	1/77	Transformer	-corrosion of fins -poor maintenance	800 L	up to 75,000 ppm (sediments)	Not specified	Not specified	Not specified	- removal of building wall - absorption of surface liquid - excavation of soil - in situ containment of sediments with bleached hog fuel and rock	> $ 200,000 -Ongoing monitoring for PCB migration from containment area	-Charges laid under the Fisheries Act - Could have been avoided with proper maintenance and containment	41
Pierce Packing Company, Billings, Montana	6/79	Transformer [out-of-service spare]	-accidental rupture [forklift collision]	530 to 760 L	1,000 ppm (Product contamination)	Not specified	Not specified	< 4μ/cu.m.	-Complete recall of all contaminated product	$100 million -Ongoing litigation by suppliers and feed users	-Could have been avoided with proper containment and transformer isolation	22
Toronto International Airport	4/77	Transformer	-failure - poorly maintained containment	800 to 2300 L	Sediment 2135 - 10,639 ppm	400 - 48,710 ppm	Not specified	.18 - 50 μg/cu.m.	-storm drain dyked -standing liquid on concrete collected -sand spread over contamination then scraped up and contained -asphalt and concrete surface washed with ethylene glycol -sand and glycol repeated -top 1" asphalt removed -concrete sealed with epoxy	> $ 100,000	- could have been avoided with proper containment and sealing and transformer isolation	60

2.0 CASE HISTORIES - PCB SPILLS, PRESSURIZED RELEASES and FIRES

Accidents in Canada and the United States involving PCB-containing equipment have resulted in significant environmental and human health concerns as well as staggering clean up costs. Data for representative incidents are reviewed in this section according to three categories:

- Spills
- Pressurized releases
- Fires

Generally, this information suggests that the implementation of proper prevention and contingency planning measures would have either eliminated or minimized the consequences of these events. (Note that releases occurring either during transport or over time have been excluded from study.)

2.1 Spills

Spills are releases of PCB liquid that result when a breach in the container integrity occurs such as a cracked weld, corroded surface, or a rupture as a result of an accidental impact. Spill volumes may vary from a few milliliters to thousands of liters. Usually the temperature and pressure in such incidents do not exceed the standard equipment operating parameters. The PCB is released through gravitational flow.

The case histories presented in Table 2.1 indicate that poor maintenance and prevention have been significant factors in PCB-containing equipment failure and subsequent release. In addition, the lack of containment resulted in wide spread contamination and therefore much higher cleanup costs.

TABLE 2.2

PCB PRESSURIZED RELEASE CASE HISTORIES

Company [Location]	Date	Equipment Type	Release Cause	PCB Volume	Level of contamination: Surface	Level of contamination: Air	Level of contamination: Water	Cleanup duration	Surface cleanup	Cost	Remarks	Ref.
New Mexico State Highway Office Building Santa Fe, New Mexico	6/85	Transformer	Pressurized release through safety valve after electrical malfunction Release time- 65 minutes	Some portion of 927 L	PCB: 190 - 280,000 µg/100 cm2 TCDF*: 0.41 µg/100 cm2 TCDD*: non-detectable (0.19 µg/100 cm2 PCDD)	PCB: 0.73 - 41.94 µg/m3 TCDF*: 0.9 - 56.2 pg/m3 TCDD*: non-detectable (7.1 - 21.0 pg/m3 PCDD)	PCB: 870,000 µg/g TCDF*: 1.6 µg/g TCDD*: non-detectable	1 year	• physical removal of contaminated material • physical and mechanical decontamination using detergent and solvent washes • use of specialized equipment for decontamination of HVAC ductwork	$13 million	-extent of contamination could have been avoided with transformer isolation and ventilation control	13 (4-18)
B.C. Metal Fabrication Shop	3/87	Capacitor	Electrical malfunction, internal pressure build-up	2.9 L	PCB: high (not spec.) TCDF*: NO ANALYSIS TCDD*: NO ANALYSIS	PCB: non-detectable TCDF*: NO ANALYSIS TCDD*: NO ANALYSIS	PCB: Not applic. TCDF*: Not applic. TCDD*: Not applic.	2 months	• varsol wash of other electrical equipment and floor with cloth rags • contaminated concrete removal	N/A	- shielding capacitor could have prevented extent of contamination migration	pers. comm.
Canadian Forest Products, Howe Sound Pulp Division, Port Mellon, B.C.	81/03/30	Exterior Lighting Ballast Capacitor	Explosion after electrical failure	37.5 mL	PCB: 0.3-980 µg/100 cm2 TCDF*: NO ANALYSIS TCDD*: NO ANALYSIS	PCB: 5.2 - 15 µg/m3 TCDF*: NO ANALYSIS TCDD*: NO ANALYSIS	PCB: TCDF*: NO ANALYSIS TCDD*: NO ANALYSIS	7 days	• vacuum • isopropyl alcohol wash with cloth rags	N/A	- capacitor isolation could have prevented contamination migration	55

* TCDD=tetrachlorinated dibenzofuran, TCDD=tetrachlorinated dibenzo-p-dioxin; PCDD=polychlorinated dibenzofuran, PCDD=polychlorinated dibenzo-p-dioxin

2.2 Pressurized Releases

Case histories of pressurized releases from PCB-containing equipment are presented in Table 2.2. A pressurized release differs from a spill in that there is an increase in temperature and internal pressure above normal operating conditions of the equipment and can result in a release of PCB in a fine mist or liquid form. Unlike a fire situation, the temperature increase occurs without combustion. In a transformer, the release may take place through the pressure relief valve or a rupture at the weakest point of the casing. In capacitors the release usually takes place at the weld seam. In some cases the release can be explosive (referred to as catastrophic), resulting in widespread contamination.

A review of case histories has demonstrated the potential for the formation of PCDFs (furans) and PCDDs (dioxins) from pressurized releases from transformers even though visible combustion did not occur (13). The increase in temperature due to the transformer malfunction was sufficient to form the furan, dioxin by-products but without the formation of soot.

Pressurized releases from capacitors have also resulted in widespread PCB contamination. The potential for the formation of furans or dioxin as a result of increased temperature inside the capacitor requires further study. Although there are no analytical data available linking furan or dioxin formation to pressurized releases from PCB capacitors, the possibility of this occurring cannot be discounted. It would be advisable to analyze for these compounds if such an event occurred.

The incident at the New Mexico State Highway Building emphasizes the necessity of effective maintenance and prevention. The extent of contamination could have been minimized if the transformer had been fitted with an automatic shutdown mechanism (triggered by preset maximum pressure and temperature). The problem could have been further reduced by controlling the air flow patterns through venting dampers linked to temperature and pressure gauges.

PCB FIRE CASE HISTORIES

Company [Location]	Date	Equipment Type	Fire Cause	PCB Volume	Level of contamination: Surface**	Level of contamination: Air	Level of contamination: Water	Cleanup duration	Surface cleanup	Cost	Remarks	Ref.
IREQ Quebec Hydro	11/84	Mixed PCB /M.O Capacitor Bank	• Circuit overload, Explosion • Duration 6 hours	670 L		PCB [1242]		Office 3 months Large hall 6 months Annex 11 months	• Hi-efficiency vac • Hi-press. water jet • Low-press water jet + solvent • Manual cloth wipe with solvent • Freon TF® • Surface removal • Extinguishing and cleaning water filtration	$ 15 Million	• could have been avoided by not mixing PCB and mineral oil capacitors	53
					2500 µg/g	-	1250 ppb					
						TCDF						
					0.6 µg/g	N/A	-					
						TCDD						
					0.1 µg/g	N/A	-					
State Office Bldg [Binghampton N.Y.]	2/81	PCB transformer	•Arcing ignited insulation • Duration 1.5 hours	681 L		PCB		Ongoing	• High efficiency vacuum • Water & detergent • Chemical decon-tamination • Air filtration • Cleaning water filtration • Complete removal of material for disposal	$38 Million Ongoing lawsuits by some persons exposed to smoke > $ 1 Billion	• contaminant migration could have been avoided with ventillation controls	13,17 54-187
					1995 µg/m2 (200,000 µg/g)	1.48 µg/m3 80 µg/m3	N/A					
						TCDF						
					2163 µg/g 12 µg/g	21 ppm	N/A					
						TCDD						
					20 µg/g 0.6 µg/g	0.3 ppm	N/A					
One Market Plaza, San Francisco, California	5/83	PCB transformer	•Unknown cause of failure • Duration 8 hours	189 L		PCB		Ongoing	• High efficiency vacuum • Water & detergent • Solvent • High pressure freon • Surface removal • Application of sealant	$ 21 Million	• interior contamination could have been avoided through different placement of exterior air intake	13,17
					86,000 µg/g	12-1500µg/g	N/A					
						TCDF						
					6.3-15.6 µg/g	N/A	N/A					
						TCDD						
					0.059 µg/g	N/A	N/A					

* TCDD=tetrachlorinated dibenzofuran, TCDD=tetrachlorinated dibenzo-p-dioxin; PCDD=polychlorinated dibenzofuran, PCDD=polychlorinated dibenzo-p-dioxin
** mass contaminant/mass soot or mass contaminant/surface area, as reported

TABLE 2.3

2.3 Fires

Selected case histories of fires involving PCBs are presented in Table 2.3. Causes include an overloaded circuit leading to an explosion and arcing igniting insulating materials. It is important to note that the PCB-containing equipment may not be the cause of the fire but may be involved in a fire resulting from another source. PCBs or PCB-contaminated materials exposed to fire [600-900° C] produce a black, carbonaceous soot. PCBs, and PCDFs and PCDDs (formed from the decomposition of PCBs by fire) have been identified in the soot from fires involving PCB. In addition, case histories have shown that exposing PCBs to fire results in the formation of significant quantities of HCl (hydrogen chloride gas). When exposed to water or conditions of high humidity the HCl forms hydrochloric acid which is very corrosive and can cause severe health problems as well as extensive property damage.

The toxic soot and smoke can be distributed throughout a large area resulting in widespread contamination and the necessity for extensive clean-up operations.The cleanup costs (15 - 38 million dollars) are extremely high and are indicative of the widespread contamination that can result from such events. The discovery of widespread contamination by PCBs, PCDFs and PCDDs in pressurized release and fire events has resulted in increased concern for the safety of plant personnel and fire fighters.

The installation of appropriate fire extinguishing systems, overload and fire alarm systems, ventilation control, and segregation from combustible materials including non-PCB electrical apparatus could have reduced the magnitude of the fire events.

3.0 PREVENTION of PCB SPILLS, PRESSURIZED RELEASES, and FIRES

3.1 Background

This section describes the types of equipment that contain PCBs and details the preventive measures that can be implemented to rapidly and inexpensively reduce the probability of spills, pressurized release, and fires involving PCB equipment. These measures will also minimize the consequences of a PCB release by reducing the extent of contaminant migration and therefore reduce cleanup costs in the event a release occurs. The case history review demonstrates the significant environmental impacts and economic liabilities that have resulted from PCB spills, pressurized releases and fires, and emphasizes the need for proactive company policies in managing PCB equipment.

PCBs were used in a variety of applications. Historical information developed by the US E.P.A. indicates that most PCB-containing fluids were used in electrical apparatus: 25% in transformers, 50% in capacitors. The remainder of PCBs were used in consumer goods, hydraulic and heat exchange fluids, and specialized equipment such as vacuum diffuser pumps. Therefore, PCB fluids will most often be found in the electrical apparatus used to support power requirements. The distribution of PCBs in Canada by industry category is listed in the National Inventory of Fluids Containing Polychlorinated Biphenyls (PCBs) (referenced in Section 1).

In addition to equipment designed to use PCBs, a significant number of mineral oil transformers have varying degrees of PCB contamination. This may have occurred through "topping up" mineral oil transformers with PCB fluids (during maintenance and servicing) or through retrofilling PCB transformers with mineral oil. However, the main cause was contamination at the time of manufacture. The same companies that manufactured PCB transformers also manufactured mineral oil transformers. The filling process involved the use of common piping from bulk source tanks of PCB and mineral oil. The residual PCBs in the common piping caused the contamination of some mineral oil transformers with varying levels of PCB.

It is important that the distinction be made between equipment designed to use PCB and equipment that was not designed to use PCB but which inadvertently received some level of PCB contamination. This distinction is important because the physical characteristics, management techniques, and treatment options are different for mineral oil versus PCBs. For example:

- FLAMMABILITY
  - ◊ mineral oil is extremely flammable,
  - ◊ PCBs are not flammable unless supported by another source of combustion.
- DENSITY
  - ◊ mineral oil floats on water,
  - ◊ PCBs sink.
- CHEMICAL TREATMENT
  - ◊ mineral oil with PCB contamination levels less than 7000 parts per million (ppm)can be decontaminated using commercially-available chemical treatment services,
  - ◊ high-concentration PCB fluids cannot be economically destroyed with chemical treatment.

Although the PCB contamination levels in mineral oil are generally below 500 ppm, mineral oils contaminated with PCBs at levels of 50 ppm or greater must be considered as PCB materials and are therefore regulated under the federal Canadian Environmental Protection Act and some provincial regulations.

Mineral oil transformers should be tested for potential PCB contamination during routine maintenance. Easy to use, and relatively inexpensive colorimetric tests are available commercially and allow the qualitative identification of concentrations greater than 50 ppm. Quantitative results require analysis of the mineral oil at a commercial laboratory and are more expensive. Companies supplying colorimetric test kits and commercial labs offering PCB analysis are listed in Section 11.

Mineral oil transformers found to have PCB contamination levels of 50 ppm or greater require the same preventative measures as those recommended for PCB transformers; as required, allowances should be made for the differing physical characteristics of PCB and mineral oil coolant fluids.

3.2 Identification of PCB Equipment

The initial step in a preventive program is to ascertain whether or not there is PCB-containing equipment located on-site. Guidelines for the identification of PCB equipment and labelling are outlined in the Handbook on PCBs in Electrical Equipment available from Environment Canada. The following sections describe the types of electrical apparatus or specialty equipment that use PCBs, and indicate where they are likely to be located.

Transformers

A transformer is an electrical apparatus used to raise or lower electrical voltage. A transformer consists of a core and a coil immersed in an electrically-insulating [dielectric] fluid. (Note: dry type transformers are not of concern as they use air as the cooling medium and therefore do not contain PCBs). PCB transformers contain coolant fluids known generically as askarels. (Askarels are synthetic dielectric materials that evolve only non-explosive gases when decomposed by an electric arc). Askarels contain PCB fluids and trichlorobenzene in an approximate ratio of 70% to 30%, respectively. The volume of askarels in PCB transformers ranges from 40 litres to 6000 litres. Approximately 10% of the fluid is impregnated in the transformer core and windings and 90% is free liquid. Typical transformers and their uses are described in Table 3.1

Capacitors

A capacitor is an electrical apparatus used to provide more precise control of electrical power by improving the electrical system power factor. A capacitor has the net effect of reducing the load on power system components such as transformers, cables and generators. The physical size of capacitors ranges from extremely small units [such as those used in transmitter circuitry and fluorescent ballasts containing a few millilitres of liquid] to larger units (approximately 500 cm x 300 cm x 10 cm) containing 5 to 10 litres of liquid. The PCB is impregnated into the paper/metal core of the capacitor, which contains very little free liquid. Virtually all capacitors manufactured prior to 1978 contain 100% PCBs. Typical PCB capacitors and their uses are described in Table 3.2.

TABLE 3.1

TYPICAL PCB TRANSFORMERS

TYPE		DESCRIPTION
1	**Large Power Transformers**	• Liquid immersed core and coil • Capacity ratings range greater than 10,000 kVA ◊ conventional transformers and auto transformers ◊ primary and secondary unit substation transformer
2	**Small Power Transformers**	• Liquid immersed core and coil • Capacity rating range from 501 to 10,000 kVA ◊ conventional transformers and auto transformers ◊ secondary unit substation transformers and single unit substations ◊ primary unit substation transformers
3	**Distribution Transformers**	• Liquid immersed core and coil • Capacity range from 500 kVA and smaller ◊ overhead - top of office buildings, schools, hotels, highly populated structures where fire safety was an important consideration ◊ pad mounted - installed on concrete pad outside the area they serve and are usually in less populated areas ◊ sub-surface - installed underground in building basements, vaults, and subways
4	**Network Transformers**	• Special arrangement of transformers to disribute electrical load to form a network system ◊ grid type secondary network system - common in high density load locations eg. metropolitan areas - prevents service interuption to the system by passing load to other grid components sources in the event of a component failure ◊ spot network system - two or more transformers linked to provide service reliability and operating flexibility in downtown, high density areas - may be used in outlying areas for large commercial services
5	**Instrument and Special Purpose Transformers**	Transformers designed for specific functions • reactors • grounding transformers • mobile unit substations • furnace transformers • ground fault neutralizers • integral single circuit unit substation • rectifiers • locomotive transformers • mobile transformers

TABLE 3.2

TYPICAL PCB CAPACITORS		
TYPE		DESCRIPTION
1	High Voltage Power Capacitors	• Designed for 4800 to 13,800 volt service • Generally AC units • Used to improve power factor of circuit directly at load or utility station
2	Low Voltage Power Capacitors	• Installed in industrial plants at the power demand site • Power rates encourage power factor correction at site • Eliminates need for electrical utility to transmit both power producing current and magnetizing current all the way from the generator to the plant site • Designed for 230 to 530 volt service
3	Lighting Capacitors	• Improves efficiency of lighting system • Used in flourescent or mercury vapor lamps to bring system powerfactor up to 90 to 95 %
4	Air Conditioning Capacitors	• Installed on starter motor of air conditioning unit • Provides phase differential for start winding to deliver good starting torque
5	Industrial Electronics Capacitors	• Catch-all category • Includes motor run applications such as pumps, compressors, and fans • Includes specialized applications such as radio transmission equipment, electronic circuitry

Other Equipment

PCB was also used in other equipment including, electro-magnets, heat exchange units, hydraulic systems and vacuum diffusion pumps. This equipment has specialized uses and would not be found in the vast majority of facilities. Companies and institutions with research facilities may, for example, have heat exchangers or vacuum diffusion pumps, although this equipment is not common. If a facility has this type of equipment the suppliers or manufacturers should be contacted to ascertain whether PCBs were used in the equipment.

3.3 Preventive Measures

The preventive measures implemented are dependent on the type, amount, and location of the PCB equipment at a facility. One obvious and effective solution is the complete phase out and replacement of all PCB-containing equipment. For facilities with a small amount this can be done without an untoward economic burden, although there is still the problem of long-term, on-site storage, pending a disposal option. Economic and operational factors become more important to large holders of PCB-containing equipment for whom phase out may not be practical.

There are a number of other preventive measures that can be implemented to minimize the hazard posed by the continued use of PCB-containing equipment. Each facility must be assessed with respect to the specific conditions regarding the type of equipment, number of units, volumes and the potential risk posed by the equipment. For example food and feed facilities or commercial buildings with regular public access that utilize PCB-containing equipment could have greater degrees of risk posed by PCBs than industrial facilities such as foundries or pulp mills. This is not to suggest that industrial facilities do not have to ensure that preventive measures should be implemented. However, the overall risk posed may be less.

The preventive measures considered should include electrical protection, pressure relief devices, fire suppression systems, fault detection and alarm circuits, increased preventive maintenance, enclosure isolation, and equipment relocation. The degree and complexity of the measures implemented should be related to facility type, amount of PCB-containing equipment and location.

TABLE 3.3 A outlines the initial steps that should be undertaken at all facilities with PCBs. These general tasks will assist in the definition of the overall situation for each facility and provide the basis for the implementation of specific preventive measures.

The preventive measures that can be implemented for specific equipment types are outlined in: TABLE 3.3B: Transformers, TABLE 3.3C: Capacitors, TABLE 3.3D: Other Equipment

TABLE 3.3 A

GENERAL PREVENTIVE MEASURES - ALL PCB CONTAINING EQUIPMENT

TASK	ACTION
	TRANSFORMERS, CAPACITORS, and OTHER PCB-CONTAINING EQUIPMENT
IDENTIFY	• See Chapter 2 - Handbook on PCBs in Electrical Equipment • If in doubt, assistance is available from: (1) equipment supplier or manufacturer (2) the Regional Office of Environmental Protection (Address in Section 11)
LOCATE	• Identify and record the specific location of all PCB equipment on site • Identify whether equipment is in use or in storage
LABEL	• Label equipment in service and in storage with serialized PCB labels available from Environmental Protection Regional Offices • Label rooms containing PCB equipment at eye level and 2 feet from floor (in case of fire) • Label stored drums of PCB material (apply non-serialized labels to the drum exterior; the exterior labels should indicate the items of contained equipment and the corresponding serialized PCB label numbers)
EQUIPMENT DESCRIPTION (Note: The volume, serial number, and date of manufacture is not always available from capacitor nameplate.)	• Note and record particulars of each piece of equipment including: ◊ Manufacturer ◊ Proprietary fluid name ◊ Volume ◊ Serial number ◊ Date of manufacture ◊ kV rating ◊ EP label number
CONDITION	• Record equipment description • Equipment in poor condition (eg. leaking, weeping, bulging, corroded) should be repaired or replaced immediately
INVENTORY	• Prepare hard copy inventory of all equipment listing all the information from the above points • Update inventory as status of equipment changes
NOTIFY	• Provide copies of inventory to Environmental Protection Regional Office, Provincial Environment Ministry, and local Fire Departments • Notify above authorities of changes in inventory status
CONTINGENCY PLAN	• Prepare contingency plans as outlined in Section 4
EMERGENCY RESPONSE	• Prepare emergency response procedures as outlined in Section 5

PREVENTIVE MEASURES - PCB TRANSFORMERS	
TASK	**ACTION**
	TRANSFORMERS
MAINTENANCE PROGRAM	• See Chapter 3 - Handbook on PCBs in Electrical Equipment • Inspect gauges to ensure optimum operating conditions • test the dielectric strength of transformers on a regular basis • Keep transformers clean and painted to prevent corrosion and to detect leaks easily
CONTAIN	• See Chapter 6 - Handbook on PCBs in Electrical Equipment for containment descriptions and compatible materials • Install containment designed to hold 125% of the transformer fluid volume • Concrete floor and dyking should be sealed with 2 component amine cured epoxy paint (eg. Plastite 7122 ®, Flakeline 660, Valspar 78 TC) • Metal drip trays should be of continuous weld and sealed as above with epoxy • The containment should not impair cooling ventilation and should allow for easy maintenance • If construction of a containment system is not possible without impairing operation or inspection seal the entire room for emergency containment • Ensure outdoor locations (PCB & Mineral Oil transformers) are covered to prevent accumulation of precipitation
ISOLATE	• Ensure that vault area is kept clear and is not used for any other purpose (eg. storage) to avoid physical damage • If transformer is not located in a vault ensure that it is isolated from other facility operations and high traffic areas • Seal floor cracks and isolate and plug drains • Do not mix electrical equipment containing mineral oil with PCB equipment • Ensure that there are no flammable materials in vault or in proximity to the transformer
VENTILATION	• Provide means of controlling air flow patterns into and out of vault or area where transformer is located • Air flow from the vault or transformer area should be controlled with automatic smoke dampers or filters in the event of a fire or pressurized release
SECONDARY POWER SHUT OFF	• Install secondary power shut off outside transformer vault or transformer area to allow de-energizing of the transformer without having to enter the vault
ALARMS	• See Chapter 3 - Handbook on PCBs in Electrical Equipment • Alarms include tank pressure, smoke detectors, temperature, electrical fault,and fluid level
FIRE EXTINGUISHING SYSTEM	• Install PCB compatible fire extinguishing system (eg. Halon, CO2) • Have portable fire extinguishing system for back-up • Avoid using water extinguishing system

TABLE 3.3 B

PREVENTIVE MEASURES - CAPACITORS

TABLE 3.3 C

TASK	ACTION
	CAPACITORS
MAINTENANCE PROGRAM	• See Chapter 3 - Handbook on PCBs in Electrical Equipment • Inspect regularly to assess condition (eg. rusting, bulging, overheating) • Keep capacitors clean and painted to prevent corrosion and detect leaks easily
CONTAIN	• See Chapter 6 - Handbook on PCBs in Electrical Equipment for containment descriptions and compatible materials • Install metal drip tray with 5 cm lip under individual units or banks - low enough to visually inspect for leaks • Install metal splash wall • Metal drip trays should be of continuous weld and sealed with epoxy • The containment should not impair cooling ventilation and should allow for easy maintenance • Seal floor cracks - isolate and plug drains
ISOLATE	• Ensure that capacitor area is kept clear and is not used for any other purpose (eg. storage) • If capacitor is not located in a vault ensure that it is isolated from other facility operations and high traffic areas • Do not mix capacitors containing mineral oil (or other flammable insulating fluids) with PCB capacitors • Ensure that there are no flammable materials in vault or in proximity to the capacitors
VENTILATION	• Provide means of controlling air flow patterns into and out of vault or area where capacitor is located • Air flow from the vault or capacitor area should be equipped with automatic shut off controls in the event of a fire or pressurized release
POWER SHUTOFF	• See Chapter 3 - Handbook on PCBs in Electrical Equipment • Check whether capacitors are equipped with fusing to de-energize capacitor in the event of a failure
ALARMS	• Install smoke detector in capacitor area
FIRE EXTINGUISHING SYSTEM	• Install PCB compatible fire extinguishing system (eg. Halon, CO2) • Have portable fire extinguishing system for back-up • Avoid using water extinguishing system

PREVENTIVE MEASURES - OTHER PCB EQUIPMENT	
TYPE	**ACTION**
OTHER PCB EQUIPMENT	
FLUORESCENT AND MERCURY LAMP BALLASTS	• See Reference 10: "Identification of Fluorescent Lamp Ballasts Containing PCBs" • Identify manufacturer & serial number • If serial number is not visible or if the manufacturer is not listed in the above report ascertain the age of the ballast; if the ballast was installed prior to 1978 assume it contains PCB • Inspect ballasts for weeping or leakage of asphaltic sealing compound • Store ballasts removed from service as per the recommendations in Chapter 5 of Reference 10, "Identification of Fluorescent Lamp Ballasts Containing PCBs" and Appendix B of the Manual for the Management of Wastes Containing Polychlorinated Biphenyls (PCBs)
ELECTRICAL COMPONENT CAPACITORS (eg. from Radio Transmitters)	• If equipment manufactured prior to 1978 assume it contains PCB capacitors • Store ballasts removed from service as per the recommendations in Chapter 7 of "Identification of Fluorescent Lamp Ballasts Containing PCBs" and Appendix B of the Manual for the Management of Wastes Containing Polychlorinated Biphenyls (PCBs)
LARGER APPARATUS (eg. Rectifiers, Heat Exchangers, Vacuum Diffuser Pumps, Hydraulic Equipment)	• Adapt preventative measures outlined for transformers

TABLE 3.3 D

4.0 CONTINGENCY PLANNING

A contingency plan consists of a well thought out sequence of procedures to enable safe and effective response to an emergency situation. At a minimum, the procedures should be stated in a document which is directly relevant to an individual facility where an emergency response may be required. The document should be available to all workers at the facility, and ideally would be supplemented by worker education programs (eg. seminars, video training packages, discussions at worker safety meetings).

It is recommended that a detailed contingency plan be prepared for individual facilities where PCB-containing equipment is located to ensure that response to spills and fires would be safe and effective. The information presented in this section outlines the major aspects relating to contingency planning and will facilitate the implementation of the Emergency Response Procedures described in Section 5. The level of detail required should be put into perspective with regard to the amount and type of PCB material at the facility.

4.1 General Requirements

A contingency plan for facilities with PCB-containing equipment should:

1. Describe the purpose of the plan with reference to potential environmental and worker health consequences
2. Address the following phases of response:
   - ◊ discovery, alerting, and notification;
   - ◊ definition of evacuation procedures;
   - ◊ evaluation and initiation of action;
   - ◊ containment and countermeasures;
   - ◊ cleanup, mitigation and storage;
   - ◊ documentation, cost accounting, legal procedures and public relations

3. Clearly assign duties and roles to responsible personnel and clearly define the structure of the emergency response organization. The actual number and type of personnel involved will depend upon the size and potential impact of a release event (ie. a spill, pressurized release, or fire).
4. Specify procedures for rehearsing, auditing, and updating the plan on a scheduled basis.
5. Co-ordinate with other site contingency plans and procedures, if appropriate.
6. Be submitted to appropriate jurisdictional authorities for review (ie Environmental Protection, the Provincial Environment Ministry and the Local Fire Department).

TABLE 4.1

SUGGESTED COMPONENTS OF A PCB EMERGENCY KIT
1 INSTRUCTION SHEET, INCLUDING EMERGENCY CONTACT NUMBERS AND IDENTIFICATION OF CONTINGENCY PLANS
1 STANDARD OPEN-HEAD DRUM (45 IMP. GALLON/200 LITRE) OR 85 IMP. GALLON RECOVERY DRUM [MAY BE USED TO HOLD EQUIPMENT]
ADDITIONAL DRUMS AS REQUIRED TO CONTAIN SPILLED MATERIAL WHICH IS RECOVERED
4 PAIRS OF NEOPRENE VITON GLOVES
2 RESPIRATORS AND ORGANIC CHEMICAL CARTRIDGES
2 APRONS (IMPERMEABLE AND CHEMICAL RESISTANT)
2 PAIRS NEOPRENE BOOT COVERS
2 IMPERMEABLE SUITS (COVERALLS)
1 DUSTPAN
1 SHOP BRUSH
1 SQUARE-POINT "D" HANDLE SHOVEL
1 DOZEN POLYETHYLENE BAGS WITH TIES
1 50-CENTIMETER PUSHBROOM, SYNTHETIC FIBERS
4 LITRES LIQUID DETERGENT
2 SELF-CONTAINED OR AIR-SUPPLIED BREATHING APPARATUS (AND/OR IDENTIFY LOCATIONS OF THE NEAREST AVAILABLE UNITS)
50 KILOGRAMS OF SORBENT MATERIAL, INCLUDING HIGH-CAPACITY SORBENT
1 STAINLESS STEEL SPRAYER
1 BUNG WRENCH
1 DRUM SPIGOT
1 35 MILLIMETER INCH OPEN END WRENCH
1 MANUAL DRUM PUMP
10 METERS X 15 MILLIMETER TYGON TUBING
5 BLANK LABELS AND PCB LABELS
1 FIRST AID KIT (AND IDENTIFY LOCATIONS OF OTHER UNITS)
2 PACKAGES OF SORBENT PAPER TOWELS OR RAGS
1 PLASTIC DRIP PAN
1 POLYETHLYENE TARPAULIN
NOTE: The indicated items are for guidance only. Specific kits should reflect site-specific conditions and requirements, including provisions for protecting personnel and the spill site from adverse weather

4.2 Specific Requirements

4.2.1 Implementation Capability

In addition to achieving the general requirements outlined in Section 4.1, a contingency plan should include provisions which will effectively assure implementation of response

1. Ensure regularly scheduled inspections of PCB-filled equipment and PCB storage areas as outlined in Section 3.3.
2. Prearrange all response capability needed for the estimated worst-case release.
3. Prearrange for use of the best available cleanup and containment equipment. A facility with PCB-containing equipment should maintain or have ready access to a PCB spill response kit as described in Table 4.1.
4. Describe location, capability and limitations of fire fighting cleanup and containment equipment.
5. Ensure that all areas containing PCBs are properly labelled and that the labels would be visible to emergency response personnel (eg. fire fighters).
6. Ensure that the location of the primary load breaker switch is known so that rapid power disconnect is possible by authorized personnel.
7. Identify detailed response options and strategies.
8. Provide for training programs and regular practice sessions.
9. Identify communication requirements with police, fire departments and regulatory agencies.
10. Detail how communications will be maintained among all parties during response operations.
11. Address human safety issues.
12. Assign selected personnel to respond to public and media calls.
13. Provide for sampling and data collection for all possible contaminated material.
14. Allow for regular review of the plan.
15. Identify contractors, specialists, and laboratories whose services may be required.

4.2.2 Environmental Protection and Other Liability Risks

A contingency plan must also discuss environmental protection and other liability risks. The plan should:

1. Discuss expected chemical and physical behaviour of spill materials.
2. Discuss decomposition products of PCBs exposed to elevated temperatures.
3. Identify high-risk areas and operations (eg. food storage areas, drinking water supplies).
4. Identify and priorize sensitive environments for protection from spills, smoke, fumes and fire fighting waters.
5. Detail specific actions planned for minimizing damage to resources eg. prearrange for evacuation if required.
6. Have explicit standards to define the components of and extent of effective cleanup.
7. Have provisions for responding to release events under all anticipated weather conditions.
8. Prearrange for containment of fire fighting waters if likely to be used.

5.0 EMERGENCY RESPONSE

A site-specific response procedure should be available in writing and posted in the vicinity of PCB-containing equipment. Workers at a facility should be briefed and updated with regard to the response procedures. The response actions should be taken immediately if a spill, pressurized release or fire occurs. The following provides examples of emergency response actions for spills, pressurized releases and fires. Site-specific conditions may require additional or alternative actions, depending on the seriousness of the accident (for example, considering the quantity and type of material released, location, and circumstances of release).

5.1 EXAMPLE EMERGENCY RESPONSE - SPILLS

1. Rapidly disconnect electric power if the transformer or capacitor is leaking
   - ◊ if appropriate, shut down mechanical production systems in the vicinity of the spill
2. Warn people in the immediate vicinity
   - ◊ immediately remove injured personnel from the spill area and apply appropriate first aid [including decontamination if contact has occurred]
   - ◊ do not allow unauthorized personnel to enter the area
   - ◊ provide proper protective equipment (from spill kit) for on-site personnel
   - ◊ avoid any contact with skin, eyes, clothing or shoes
   - ◊ if appropriate, ventilate area of leak or spill
3. Contain the spill
   - ◊ act promptly
   - ◊ if possible, stop the spill at source
   - ◊ block drains, culverts and ditches
   - ◊ surround spilled materials with earth, peat, sand, sawdust booms, or sorbents
   - ◊ use liquid recovery type vacuum cleaners for recovery of pools
   - ◊ cover spills to soil with plastic tarps to prevent spread of contamination in the event of rain
   - ◊ prevent unnecessary boat traffic if spill to water occurs

4. Obtain required assistance from:
    - ◊ lead company personnel (advise at earliest opportunity)
    - ◊ fire/police/contractors (as required)
5. Notify applicable government agencies (as identified in consultation with Environmental Protection and the Provincial Ministry of the Environment)
    - ◊ prompt notification (as required by federal and/or provincial legislation) is especially important for spills which have entered or may enter receiving waters
    - ◊ spills to marine waters require contact with Federal Environmental Protection
    - ◊ for all other spills, contact Provincial Emergency Program office (Notification of Provincial Agencies may be mandatory; eg. Ontario)
6. Commence recovery, cleanup, restoration action
    - ◊ recover pools by use of vacuum systems and store appropriately
    - ◊ complete cleanup as per Section 6
    - ◊ collect contaminated sorbent and store appropriately
    - ◊ carry out cleanup and disposal in consultation with provincial and federal regulatory personnel

5.2 EXAMPLE EMERGENCY RESPONSE - PRESSURIZED RELEASES

1. Rapidly disconnect electric power to the transformer or capacitor
   - ◊ if appropriate, shut down mechanical production systems in the vicinity of the release
2. Warn people in the immediate vicinity
   - ◊ remove injured personnel immediately to areas upwind of the spill and apply appropriate first aid [including decontamination if contact has occurred]
   - ◊ do not allow unauthorized personnel to enter the area
   - ◊ provide proper protective equipment (from spill kit) for on-site personnel
   - ◊ avoid any contact with skin, eyes, clothing or shoes
   - ◊ if applicable, shut down ventilation system
3. Seal area
   - ◊ act promptly
   - ◊ if possible isolate the transformer or capacitor
   - ◊ close doors and windows
   - ◊ evacuate the area
4. Contain released material
   - ◊ surround any spilled material with earth, peat, sand, sawdust booms, or commercial sorbents
   - ◊ cover contaminated soil with plastic tarp to prevent spread of contamination in the event of rain
5. Obtain required assistance from:
   - ◊ lead company personnel (advise at earliest opportunity)
   - ◊ fire/police/contractors (as required) [predetermine criteria and procedures for notifying outside agencies]
6. Notify applicable government agencies (as identified in consultation with Environmental Protection and the Provincial Ministry of the Environment)
   - ◊ prompt notification (as required by federal and/or provincial legislation) is especially important for spills which have entered or may enter receiving waters

6. Notify applicable government agencies (continued)...

   ◊ for all other releases, contact Provincial Emergency Program office (Notification of Provincial Agencies may be mandatory; eg. Ontario)

7. Commence recovery, cleanup, restoration action

   ◊ carry out cleanup and disposal in consultation with provincial and federal regulatory personnel

   ◊ recover visible residues by use of vacuum systems or sorbents and store

   ◊ complete cleanup as per Section 6

   ◊ collect contaminated sorbent and store

5.3 EXAMPLE EMERGENCY RESPONSE - FIRES

1. Cut power to the affected equipment
2. Immediately notify the fire department and rescue units and inform them of the presence of PCBs[1]. All fire fighting efforts must be carried out by personnel trained in the control of PCB fires . Facilities without trained personnel should initiate evacuation and leave the fire fighting efforts to the fire department.
3. Protect firefighters from toxic gas emissions by use of self-contained breathing apparatus (SCBA) operated in a positive-pressure mode and full protective clothing (chemical suit, chemical gloves, neoprene safety boots, safety glasses or face shield). Where possible, wear flame resistant disposable protective clothing over the usual primary protective gear. (see Table 6.4)
4. Attempt to put out the fire as quickly as possible to minimize generation of highly toxic pyrolysis products
5. Use water only to cool fire-exposed containers
6. If possible only use foam, dry chemical or carbon dioxide for extinguishing fires
7. Shut-down ventilation systems in fire area to prevent spread of contamination
8. Limit number of firefighters exposed to smoke. Consider smoke as extremely hazardous.
9. Prepare to evacuate people from areas with potential exposure to the smoke plume.
10. Provide for containment of contaminated liquid runoff.
11. Notify the Provincial emergency agency if runoff waters may have entered receiving waters. (Notification of Provincial Agencies may be mandatory in any fire situation; eg. Ontario)
12. Provide follow-up medical monitoring of on-site personnel.
13. Decontaminate fire-fighting equipment in accordance with the requirements of the involved regulatory agencies.

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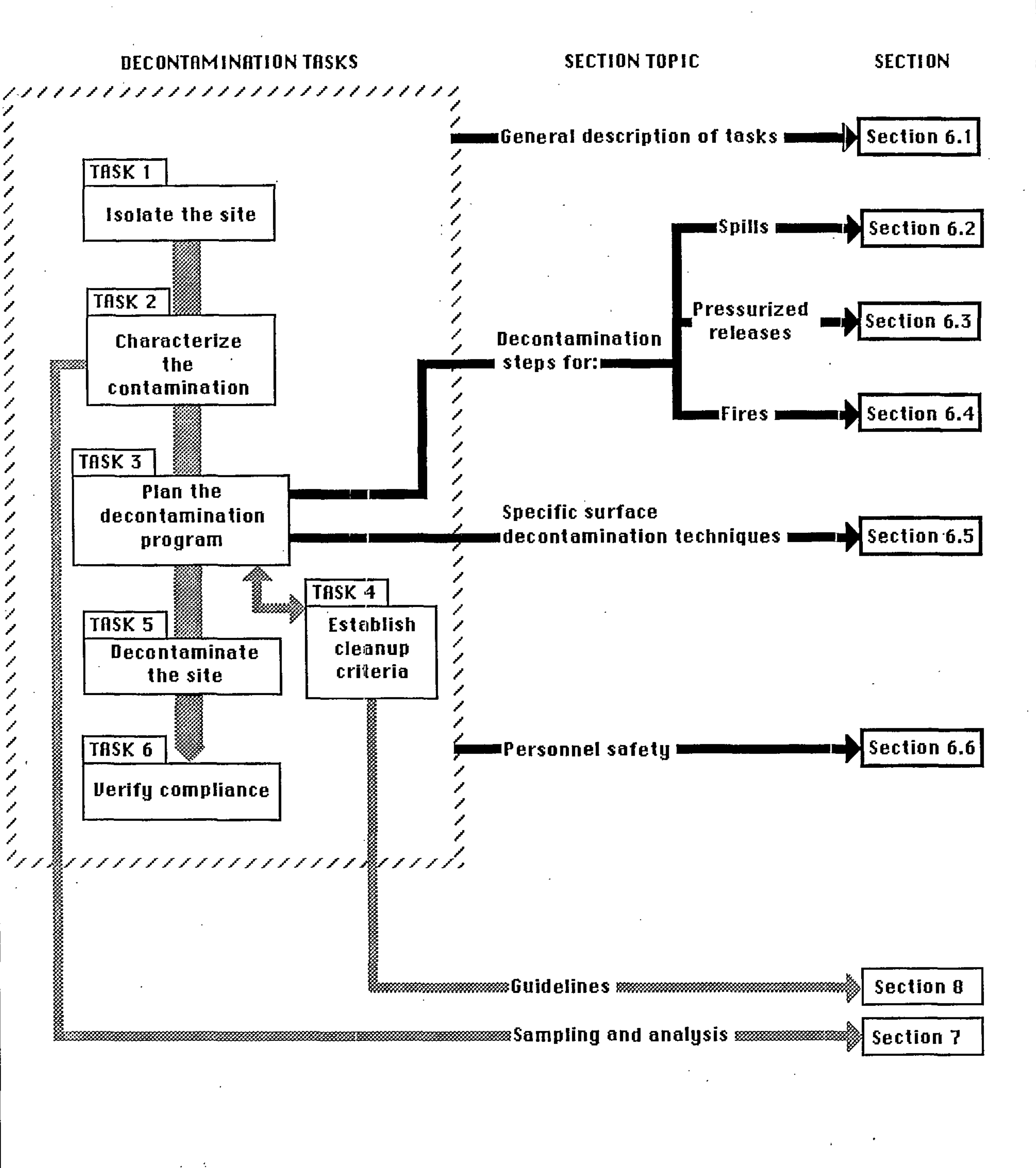
[1]NOTE: A fire officer must decide whether it is safe to attempt to fight the fire, in consideration of factors such as threat to life, safety (public and fire fighters), capability of emergency personnel and availability of safety equipment.

FIGURE 6.1

ORGANIZATION of SECTION 6: Cleanup and decontamination of PCB releases



6.0 CLEANUP and DECONTAMINATION of PCB RELEASES

This section discusses considerations which are important in:

- assessing a release of PCBs [or related decomposition products such as dioxins and furans], and
- selecting and applying techniques to safely and effectively decontaminate affected media [including ground, air, water, surfaces, structures, or equipment].

The organization of SECTION 6 and its relation to other sections are summarized in FIGURE 6.1:

Section 6.1 describes the general sequence of 6 tasks required to successfully decontaminate the site of any PCB release [including spills, pressurized releases, and fires]. The tasks identify all required actions for the cleanup from the time the release event is brought under control to the final verification of successful cleanup.

Section 6.2 suggests the specific steps of a program for decontaminating media exposed to PCB spills.

Section 6.3 suggests the specific steps of a program for decontaminating media exposed to pressurized releases of PCBs.

Section 6.4 suggests the specific steps of a program for decontaminating media exposed to fires involving PCBs.

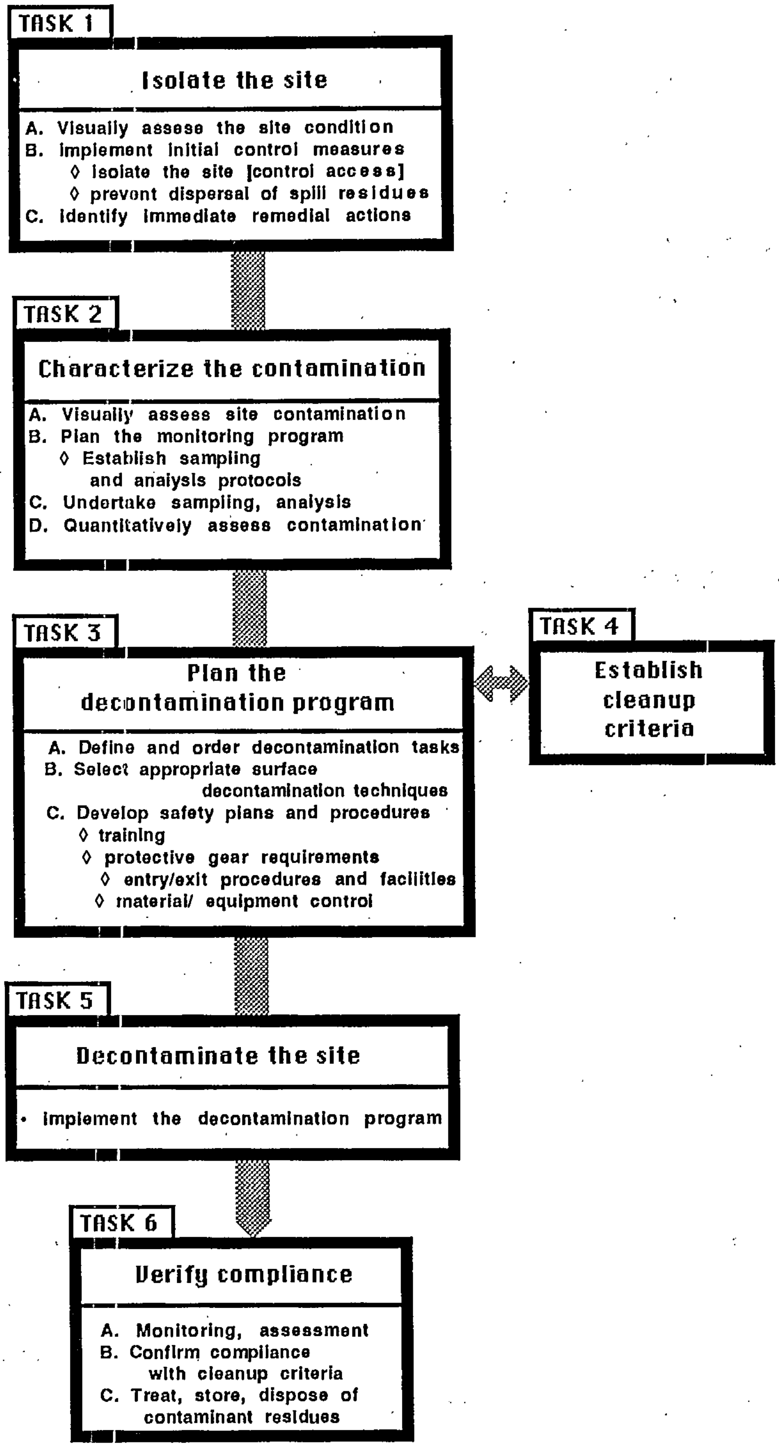
Section 6.5 identifies and describes specific techniques which have been successfully used for cleaning surfaces contaminated by PCBs and/or dioxins and furans.

Section 6.6 summarizes the procedures and equipment recommended for protecting personnel involved in the cleanup of sites contaminated by PCB releases.

All users of this section should carefully review SECTION 6.1 to identify the elements of decontamination programs which apply to their particular situation. SECTIONs 6.2 to 6.6, 7.0 and 8.0 can then be referenced [as required] for specific detail to assist in the selection and implementation of decontamination activities.

FIGURE 6.2

Tasks for the cleanup and decontamination of PCB releases



6.1 General description of site decontamination tasks

FIGURE 6.2 summarizes the general tasks for decontaminating a site which has been exposed to any release of PCBs. These tasks are:

TASK 1: Isolate the site,

TASK 2: Characterize the contamination,

TASK 3: Plan the decontamination program,

TASK 4: Establish cleanup criteria,

TASK 5: Decontaminate the release site, and

TASK 6: Verify compliance with cleanup criteria through follow up monitoring and assessment actions .

The generally applicable elements of these tasks are described in this section, followed by elaboration of considerations which depend on the specific type of release [SECTIONs 6.2 (spills), 6.3 (pressurized releases), and 6.4 (fires)].

TASK 1

Isolate the site

TASK 1A: Visual assessment

The first action following the control of any PCB release event is to isolate the site through physical and procedural controls. This action should be guided by an initial visual assessment to establish the extent of site damage and contamination and to identify any physical constraints to the cleanup activities.

TASK 1B: Implement controls

The initial measures to isolate the site should:

- prohibit site access to all but qualified and authorized personnel who
  - ◊ are trained and experienced in the assessment and cleanup of similar events and
  - ◊ are equipped with appropriate protective gear (see Section 6.1), and
- securely confine PCB residues to the structure and site and prevent further release or dispersal beyond the site by any means [including tracking by cleanup equipment and personnel].

TASK 1C: Identify immediate remedial actions

When the above-noted objectives are assured, a preliminary assessment should then identify immediate actions which will minimize cleanup costs and secondary damage from the event. For example, the decomposition of PCB fluids in fires can generate significant volumes of hydrogen chloride (HCl) and chlorine (Cl_2) gases. In the presence of moisture, hydrochloric acid is formed and can cause extensive corrosive damage to metal surfaces, electronics, and susceptible surfaces (19). This corrosive action can be minimized by dehumidifying the interior atmosphere at the fire scene or by displacing the air with an inert gas such as nitrogen. This initial action may result in substantial cleanup/salvage cost reduction.

TASK 2

Characterize the contamination

Determining the extent of contamination requires quantitative tracking of the spread of contaminants from the source by means of sampling, analysis and assessment. Contamination by spills to soils or surfaces may be reasonably confined and visually apparent. In contrast, residues from fires or pressurized releases may not be visible, and contamination at levels of serious concern can be extensively spread throughout an entire building and its exterior (for example, through ventilation systems, as noted in SECTION 3.0). Consequently, site-specific aspects must be carefully considered in determining potential mechanisms for the dispersal of toxic residues.

TASK 2A: Visual assessment

A visual assessment will generally not be sufficient to characterize contamination. However, the visual assessment is necessary to guide the planning for subsequent sampling activities. The goals of the visual assessment are:

- to identify the outermost boundaries of contamination [by identifying all possible physical routes of dispersal of contaminants], and
- to focus sampling activities in the areas of primary concern and contamination.

TASK 2B: Planning the monitoring program

The goal of the monitoring program is to provide a reasonably accurate and complete quantitative description of contamination. The program should also establish levels of background contamination of PCBs in order to assist in the development and application of reasonable cleanup criteria. The case studies in SECTION 3.0 provide general guidance in determining the scope and accuracy of sampling which may be required for different types of PCB releases.

As noted in SECTION 7.0, detection of toxic residues at a fire scene involves collection of minute quantities of contaminants [microgram quantities of PCBs and nanogram or picogram quantities of dioxins and furans][1]. The sampling, laboratory analysis and assessment of such trace quantities of substances should be planned and undertaken by personnel with an appropriate level of training and experience. SECTION 7.0 provides

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[1] A microgram is one millionth[10^{-6}] of a gram; a nanogram is one billionth [10^{-9}] of a gram; a picogram is one trillionth [10^{-12}] of a gram.

specific guidance for establishing appropriate sampling and analytical protocols for PCBs, dioxins and furans.

TASK 2C: Undertaking the monitoring program

It is recommended that monitoring programs be undertaken by or under the supervision of appropriately qualified personnel. The participation of qualified personnel will :

- ensure personnel safety,
- facilitate the efficient collection of reliable and accurate data, and
- prevent contaminant dispersal from the site.

These factors are particularly important for sites potentially contaminated by dioxin or furans. Careful planning of monitoring is crucial because dioxin and furan analysis is expensive [of the order of $1000/sample]. Furthermore, severe liabilities may be incurred if personnel are exposed to these contaminants. This liability extends to the occupants who return to the site following the cleanup.

TASK 2D: Assessing site contamination

For the reasons identified above, it is recommended that the assessment of site contamination be undertaken only by qualified personnel who are:

◊ trained and experienced in characterizing similar contamination circumstances, and

◊ qualified to assess the environmental and human health implications of the contamination.

Inaccurate assessment may result in severe financial liabilities as a result of subsequent human exposure to PCBs and/or dioxin or furan contaminants and associated real or perceived health risks.

TASK 3

Plan the decontamination program

Planning a site decontamination program is a complex task involving accurate knowledge of:

- the scope and extent of contamination,
- the associated toxic hazards of the contaminants,
- safe levels of the contaminants (as defined by cleanup criteria),
- appropriate measures for protecting site personnel,
- effective general approaches for ordering and controlling site decontamination activities,
- effective specific techniques for containing and removing contaminants from a variety of media and surfaces, and
- government legislation (at all levels) that applies to decontamination, removal, transportation, and treatment of the resulting materials.

TASK 3A: Defining and ordering decontamination tasks

The overall decontamination program entails:

- the selection of specific decontamination techniques, and
- the application of these techniques in a safe and efficient manner.

The decontamination program must provide an organized process in which the extent and degree of contamination are systematically reduced. The program should:

- establish controls to contain and prevent dispersal of existing contamination, and
- order decontamination activities from areas of high to low contamination.

TABLE 6.1 lists the major factors which will influence decision-making in planning the cleanup program for a given PCB release. The specific circumstances of the release will dictate the nature and extent of contamination and each occurrence should be assessed as a unique situation, giving careful consideration to all of the factors identified in TABLE 6.1. It is recommended that a comparative assessment of these factors be used to evaluate options to decontaminate and to remove/dispose of contaminated media. If decontamination is appropriate, the evaluation will assist in identifying and selecting the most suitable techniques for the specific situation. As a starting point for planning,

Table 6.1

Factors to be considered in planning PCB release decontamination programs	
Factor	**Specific considerations**
Event type	• A major influence on the nature and extent of contamination. ◊ PCB SPILLS principally contaminate soils, surfaces or water. ◊ PRESSURIZED RELEASES and FIRES may vaporize PCBs at elevated temperatures and form highly toxic PCDFs (furans)and/or PCDDs (dioxins). These contaminants can be spread through ventilation systems and may contaminate the air and surfaces throughout a facility.
Material released	• The composition and form of releases depend on the type and history of the equipment, and the nature of the event. • SPILLS release askarel, PCB, or PCB-contaminated mineral oil. PCBs subjected to high temperatures may contain trace contamination of furans or dioxins. • PRESSURIZED RELEASES may include: ◊ liquids [directly, through rupture of transformers] ◊ mists, aerosols, or vapors of the contained fluid ◊ contaminated particulates. ◊ HCl and/or furans, or dioxins [if arcing or high temperatures are involved] • FIRES may release: ◊ liquids [directly, through rupture of transformers] ◊ HCl, PCB and trichlorobenzene vapors ◊ aerosols, particulates and soot highly-contaminated with the contained fluids and furans and dioxins.
Quantity released	• Event specific. • Current federal or provincial regulations do not stipulate cleanup requirements on the basis of quantity of contaminant released. • Spill reporting and waste disposal requirements may vary according to the quantity of contaminant released. These requirements vary from province to province.
Extent of contamination	• Must be determined by monitoring and assessment for each event. • Will influence the selection of practical and appropriate cleanup techniques.
Contaminated surface type, condition, configuration	• Cleanup techniques must be compatible with: ◊ surface type [smooth/rough, porous/non-porous, reactive/inert, fragile/durable] ◊ configuration [accessible/inaccessible] ◊ surface condition • For example, a sealed porous surface may be highly absorbant if the sealant is pitted, or deteriorated.
Potential for harmful exposure	• Consider potential types of harmful exposure to contaminants from future use of contaminated surfaces or media. ◊ The significance of residual contamination will vary with end use. ◊ For example, residual surface contamination is of high concern in public use or eating areas, and of much lower concern in isolated or unoccupied industrial use areas. • Consider potential types of harmful exposure to contaminants which may result from the application of different decontamination techniques, including: ◊ exposure of cleanup personnel, other site users, and people and environments adjacent to [or within the zone of influence of] the contaminated area.
Required rate of removal	• The urgency [hence, rate] of decontamination may be important. For example: ◊ rapid decontamination of a key process control area may be necessary to prevent costly down time ◊ rapid cleanup of a spill may avoid the complications and dispersal caused by precipitation ◊ cleanup may be pressured by media attention, with potential for lost credibility or business.
Physical constraints	• Physical conditions [accessibility, proximity to sensitive activities, or weather] may constrain decontamination procedures.
Safety	• The safety of the cleanup crew is of prime importance. • Assess the potential of cleanup techniques for harmful types or terms of exposure to toxic contaminants.
Liability	• Consider the potential liability associated with the application of [and/or the contaminant residuals from] cleanup techniques.
Secondary effects	• Consider secondary effects of decontamination techniques on decontaminated surfaces. For example: ◊ solvents may attack and destroy many surfaces [including plastics and asphalt] ◊ steam cleaning may melt materials or cause heat damage. ◊ solvents or detergents may be absorbed by porous surfaces, causing penetration of contaminants or degradation of incompatable sealants applied following decontamination ◊ some techniques disperse existing contamination.
Volume of generated waste	• Determine the volume of waste material generated during the application of decontamination techniques. • Wastes will generally be classified as hazardous and will require costly disposal or special storage if disposal is not immediately available.
Cost	• A primary selection factor. • Decontamination techniques vary greatly in the costs of implementation and residue disposal

suggested sequences of surface decontamination techniques are presented in SECTIONs 6.2, 6.3 and 6.4 according to the specific types of release [spill, pressurized release and fire] and contaminated media [air, water, soil, and various surfaces].

Where the cleanup involves serious or widespread contamination of PCBs, furans and dioxins, it is recommended that the planning and implementation of decontamination activities be undertaken under the supervision of a coordinating committee with representation of the site owner, involved regulatory agencies and technical experts (as required).

TASK 3B: Selecting appropriate surface decontamination techniques

A variety of techniques are available for cleaning surfaces contaminated by releases of PCBs, furans and dioxins. These techniques are described in SECTION 6.5. As noted above, the selection of specific techniques depends on the factors identified in Table 6.1, and suggested sequences of these techniques are presented in SECTIONs 6.2, 6.3 and 6.4.

TASK 3C: Developing safety plans and procedures

The decontamination program must give appropriate consideration to the safety of personnel who implement the plan. For minor spills of liquid PCBs, safety plans and procedures may be straightforward and simple to implement. In contrast, safety procedures and personnel protective equipment will be elaborate for decontamination programs involving widely-dispersed PCBs, furans and or dioxins.

Specific safety considerations and recommendations for personnel protective equipment are presented in SECTION 6.6.

TASK 4

Establish cleanup criteria

A decontamination program must achieve compliance with target residual contaminant levels which are consistent with the protection of the environment and the safety of personnel who will re-occupy the site. Accordingly, cleanup criteria [where required] should be developed concurrently with the planning of the decontamination program. The final criteria should be carefully considered before finalizing and implementing the decontamination program.

SECTION 8.0 summarizes existing quantitative criteria for the cleanup of sites contaminated by various types of PCB releases. These criteria include:

- allowable surface residual concentrations of PCBs,
- allowable residual concentrations of PCBs in air,
- allowable surface residual concentrations of dioxins and furans, and
- allowable residual concentrations of dioxins and furans in air.

Provincial Ministries of the Environment have frequently stipulated criteria for residual levels of PCBs in soils or water. However, quantitative cleanup objectives for furan and dioxin residuals from fire cleanups have been the subject of intense consideration and controversy. Accordingly, it is recommended that the establishment of criteria and the subsequent planning and implementation of assessment and decontamination activities be undertaken under the supervision of a coordinating committee with representation of the site owner, involved regulatory agencies and suitably qualified technical experts. The implementation of such a committee may reduce the economic burden of cleanup activities. For example, considerable analytical cost savings were achieved when a committee overseeing the cleanup of one recent incident (53) developed a "PCB-equivalent" criteria for target cleanup levels of PCDDs and PCDFs.

TASK 5

Decontaminate the site

Once the decontamination program is planned and approved [as required by the involved regulatory agencies], decontamination activities may proceed. All decontamination activities should be supervised by appropriately trained and experienced personnel, and careful written and photographic documentation of the cleanup is recommended [video documentation is preferred]. The progress of the cleanup program should be periodically evaluated in light of any unexpected factors which arise during the cleanup activities.

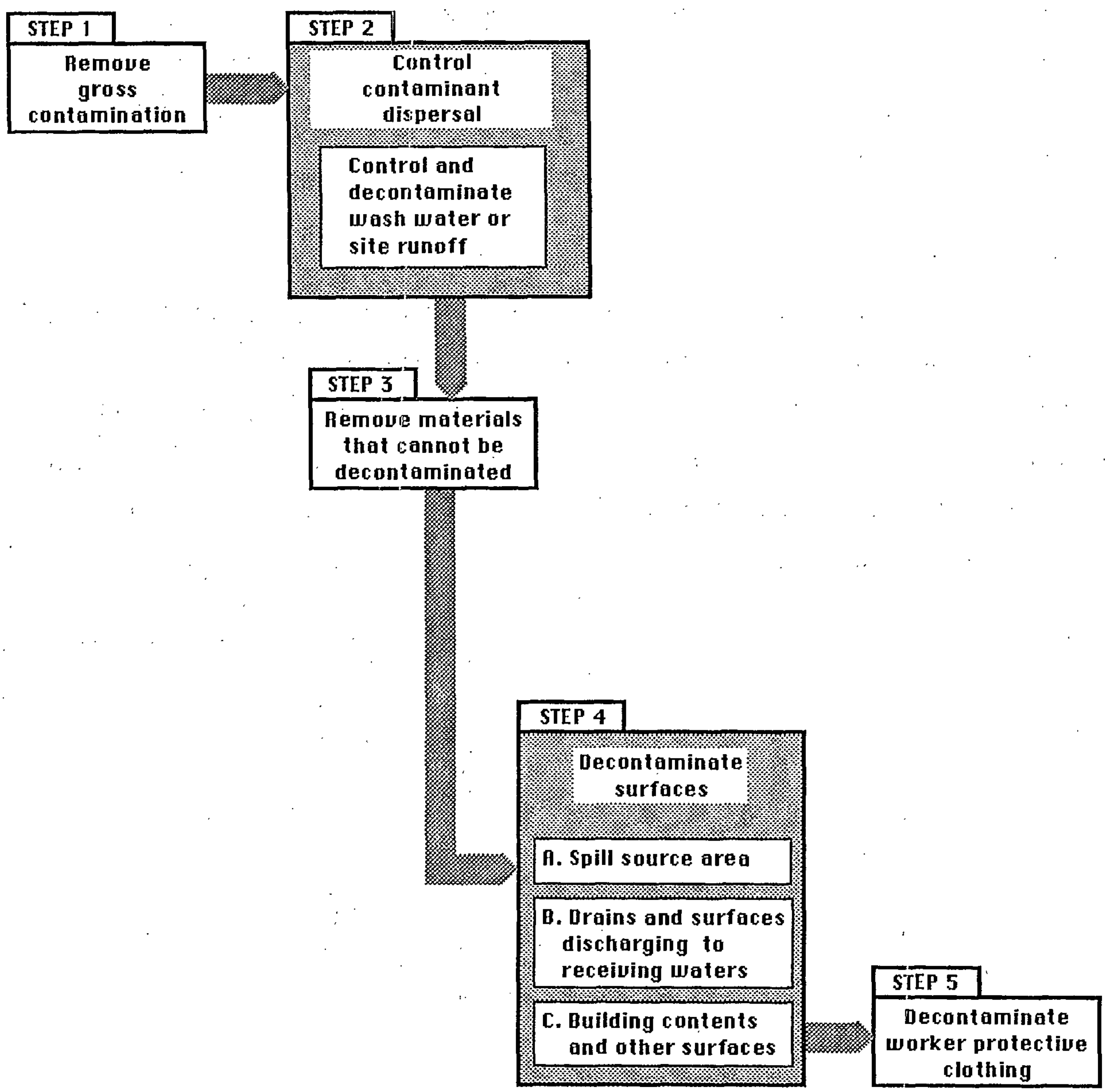
TASK 6

Verify compliance

On completion of the cleanup, additional monitoring, sampling and assessment may be required to determine and document the effectiveness of the decontamination program, to demonstrate compliance with regulatory requirements, and to identify additional decontamination activities which are required. In cases of major releases, a phased cleanup program may be advisable, with alternating monitoring/assessment and decontamination activities.

FIGURE 6.3

PCB SPILLS: The steps of a spill decontamination program



6.2 PCB SPILLS: Site decontamination

Description of spill contamination

The composition of the spilled fluid depends on the type and history of the specific equipment involved. Liquid spills generally involve askarel fluids, PCB, or PCB-contaminated mineral oil. It is commonly assumed that furans or dioxins are not present in spills of PCB fluids released by mechanical causes. However, if PCB fluids have been subjected to high temperature or fire prior to or during the spill, trace contamination of furans or dioxins in the dispersed liquids should be assumed and evaluated through appropriate monitoring activities [Task 2, SECTION 6.1].

Decontamination steps

FIGURE 6.3 presents a suggested order for specific steps to decontaminate sites contaminated by PCB spills. The order of steps reflects experience gained in the decontamination of major PCB spills, and addresses the need to limit dispersal of spill residues during the cleanup operations.

Step 1

Remove gross contamination

- Isolate and contain standing liquid [isolate slightly-contaminated materials for later decontamination]:
    - ◊ Remove liquids with absorbent material
    - ◊ Scrape up heavily-contaminated residues and place in secure containers

Step 2

Limit contaminant dispersal

STEP 2A: Control air flow patterns and releases

For liquid spills, air concentrations will be low unless temperatures of the spilled liquid exceed 55° C. Where air concentrations are unacceptably high (see SECTION 8.0) the spill area (if enclosed) should be thoroughly ventilated before and during the cleanup activities. Ventilation gases should be discharged to the exterior atmosphere well-removed from occupied site areas and personnel.

STEP 2B: Control water releases from the site

- Provide appropriate collection and containment of any site runoff (if applicable) which may be generated during cleanup activities at exterior sites.
- Where major contamination has occurred and extended cleanup activities are required: install a suitable water treatment system for decontaminating all aqueous wash waters and contaminated runoff waters. Typical treatment system components include:
    - ◊ a receiving tank,
    - ◊ a settling tank (for phosphate removal from detergents),
    - ◊ a sand filter,
    - ◊ oil/PCB sorbent pads, and
    - ◊ charcoal filters.
- Undertake routine sampling and analysis to ensure compliance with water quality criteria prior to the release of any wash waters (where applicable), site runoff from the contaminated area, or treated waters.
- Contain (for approved disposal) all contaminated liquid residues (or treatment residues, if applicable) generated during the cleanup .

Step 3

Remove materials that cannot be decontaminated

- Remove and contain [for disposal] any materials that cannot be easily or economically decontaminated (for example, paper, cloth, insulation, unpainted concrete surfaces). For many exterior spill situations, the excavation and disposal of contaminated soil and material at the spill site will constitute the major cleanup activity.

Step 4

Decontaminate surfaces

Step 4A: Spill source area

- This area will have the heaviest contamination and should generally be decontaminated first to avoid the dispersal of contaminants to other areas.

Step 4B: Drains and surfaces discharging to receiving waters

- Following the cleanup of the spill source area, all contaminated drain surfaces (including all surfaces which could ultimately discharge liquids to off-site receiving waters) should be thoroughly decontaminated.

Step 4C: Other surfaces and building contents

- The wide variety of techniques used to clean surfaces contaminated by spills of PCB are described in SECTION 6.5.
- For many surfaces, a detergent wash may be sufficient to achieve compliance with the cleanup criteria.

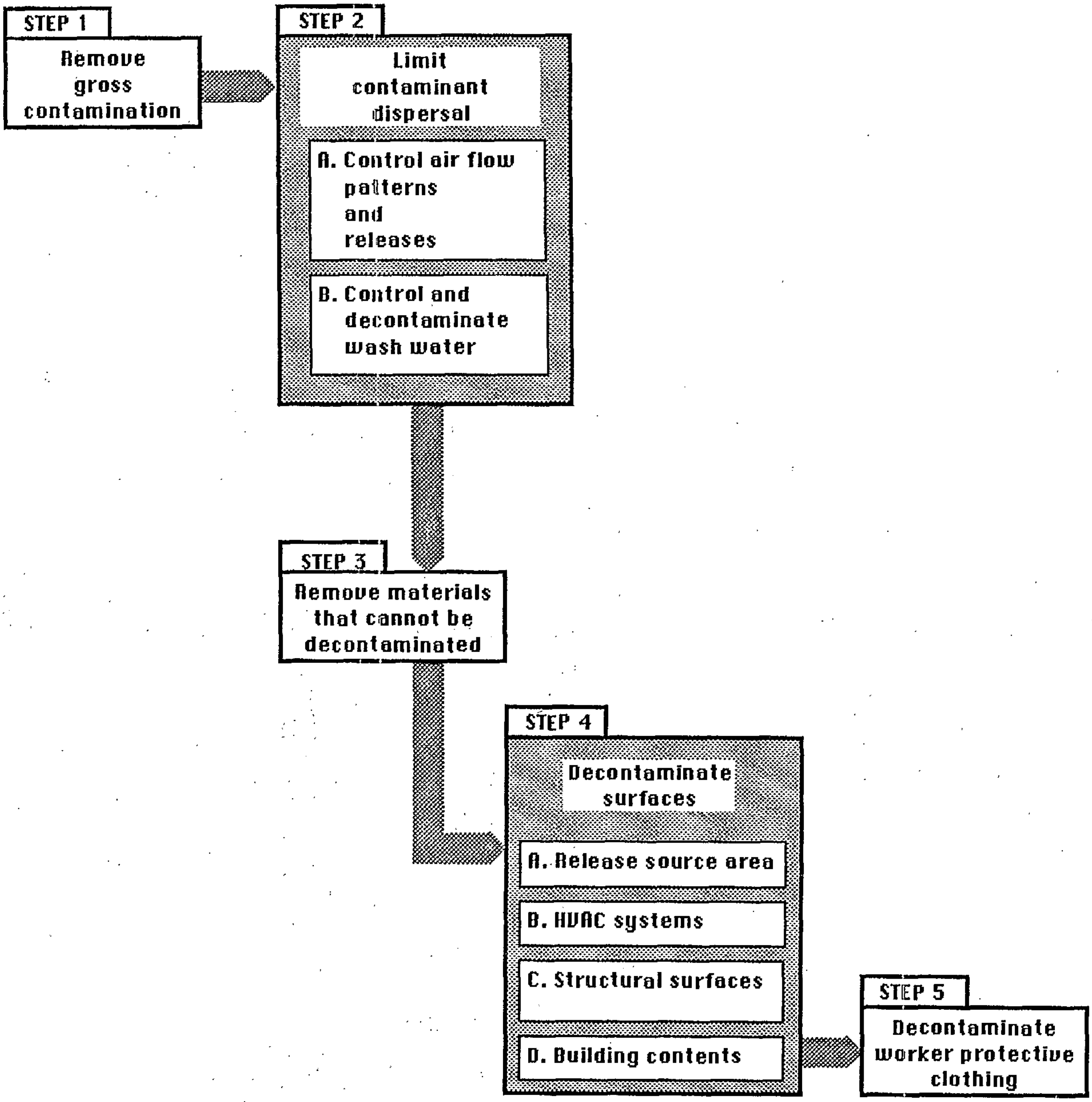
Step 5

Worker protective clothing and gear

- In cases of extended cleanups, it may be impractical to discard protective clothing at the end of each shift. Workers should segregate reusable clothing and equipment at the end of each shift for reuse. Commonly accepted criteria for clothing reuse have not been published and should be developed by the involved regulatory agencies on a case-specific basis.

FIGURE 6.4

PCB PRESSURIZED RELEASES: The steps of a pressurized release decontamination program



6.3 PCB PRESSURIZED RELEASES: Site decontamination

Description of pressurized release contamination

Pressurized releases from PCB equipment can extensively contaminate building interiors and contents with PCB fluids (including trichlorobenzene in the case of PCB transformers). In some cases (see reference 46), toxic products of PCB decomposition including polychlorinated dibenzofurans (furans) and polychlorinated dibenzo-p-dioxins (dioxins) have been found in the residues of such releases. Unfortunately, there are few data documenting the occurrence of these compounds in residues from pressurized releases, and the potential presence of furans or dioxins must be evaluated on a case-specific basis. If the pressurized release involves arcing or high temperature, it is recommended that the presence of furans and dioxins be investigated during the monitoring and assessment program.

Decontamination steps

FIGURE 6.4 presents a suggested order for specific steps to decontaminate sites contaminated by pressurized releases of PCB . The order of steps reflects experience gained in the decontamination of similar releases, and addresses the need to limit dispersal of release residues during the cleanup operations.

Step 1

Remove gross contamination

• Isolate and contain standing liquid and heavy surface residues of liquid or particulates [isolate slightly-contaminated contents for later decontamination]:

  ◊ Remove liquids with sorbent material

  ◊ Wipe up heavy surface deposits and place in secure containers

  ◊ Vacuum with a high efficiency particulate absolute system [HEPA: see TABLE 6.2]

Step 2

Limit contaminant dispersal

STEP 2A: Control air flow patterns and releases

In cases of widespread major contamination:

- Install vapour-phase activated carbon exhaust treatment system(s) to decontaminate all air which is exhausted from the contaminated areas of the facility. Install alarm systems to warn of system malfunctions.
- Establish a negative air flow pattern back to contamination source [from areas of low to high concentration].
- If concentrations of air contaminants are demonstrated to be within acceptable limits (see SECTION 8), ventilate the area thoroughly before and during the cleanup.

STEP 2B: Control water releases from the site

In cases of widespread major contamination:

- Install a suitable water treatment system for decontaminating all aqueous wash waters and contaminated firefighting waters. Typical treatment system components include:
  - ◊ a receiving tank,
  - ◊ a settling tank (for phosphate removal from detergents),
  - ◊ a sand filter,
  - ◊ oil/PCB sorbent pads, and
  - ◊ charcoal filters.
- Undertake routine sampling and analysis to ensure compliance with water quality criteria prior to the release of any treated liquids.
- Contain phosphate sludges (from detergents), sand, sorbent pads and any other treatment residues for approved disposal.
- If the scope and extent of contamination do not justify the installation of a system to treat aqueous residues from the cleanup, all liquids must be collected and securely contained for approved disposal.

Step 3

Remove materials that cannot be decontaminated

- Remove and contain [for disposal] any materials that cannot be easily or economically decontaminated (for example, paper, cloth, acoustic or drop ceiling tiles, insulation, unpainted concrete surfaces).

Step 4

Decontaminate surfaces

<u>Step 4A: Release source area</u>

- This area will have the heaviest contamination and should be decontaminated first to avoid the dispersal of contaminants to other areas.

<u>Step 4B: HVAC [heating, ventilation, air-conditioning systems]</u>

Contaminated HVAC systems should be thoroughly cleaned to prevent the subsequent dispersal of contaminants when they are reactivated. Where widespread contamination has occurred, or if furans or dioxins are present:

- Vacuum ductwork interiors [if accessible] with high efficiency vacuums.
- Wash with detergent and/or solvent.
- Rinse with water jets.
- Wipe with clean cloth or absorbent gauze.
- Sample and analyze to determine residual contamination levels.
- Rewash (with solvents if necessary) as required to achieve compliance with cleanup criteria.
- If ductwork is too small or inaccessible for hand cleaning, holes may have to be cut for access or the removal of elbows, vanes or dampers may be necessary.
- Foam "pigs" may be useful for washing and rinsing ductwork systems
- A specialized technique has been developed for cleaning air ducts. A machine sends a swab through the ductwork, emitting cleansing chemicals and providing mechanical agitation (4, page 46).

Step 4C: Structural surfaces

- Decontaminate porous and non-porous structural surfaces utilizing the techniques described in SECTION 6.5.

Step 4D: Building contents

Where widespread contamination has occurred, or if furans or dioxins are present, thorough decontamination of the building contents will be required :

- The wide variety of techniques used to decontaminate the contents of a facility are described in SECTION 6.5.
- For many surfaces, the detergent wash may be sufficient to achieve compliance with the cleanup criteria.
- Computers and electrical equipment may require vapour degreasing for effective cleaning.
- If document and archive restoration is not possible, documents can be photocopied or converted to microfiche.

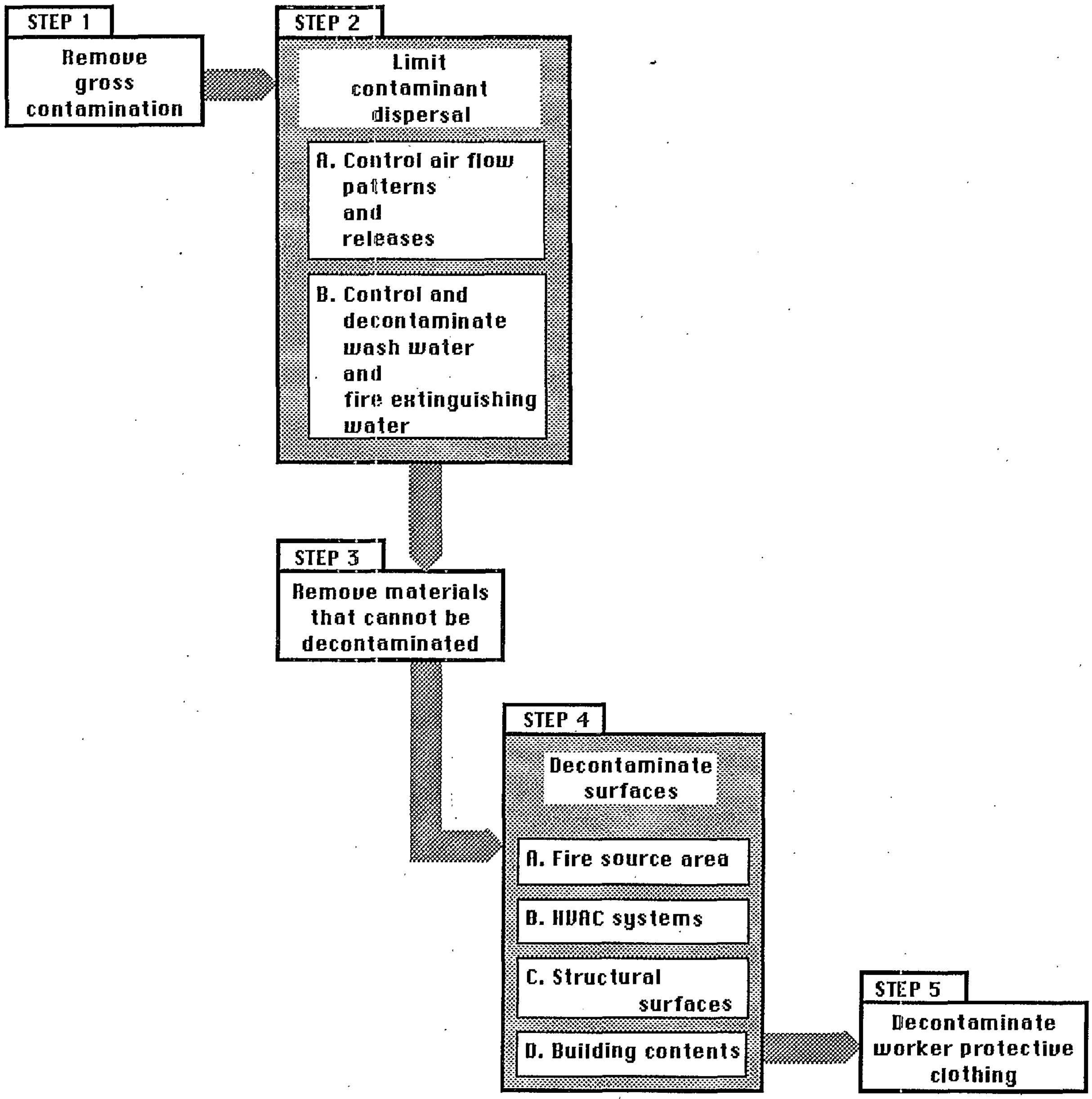
Step 5

Worker protective clothing and gear

- For extended cleanup activities, it is impractical to discard protective clothing at the end of each shift.
- Workers should segregate reusable clothing and equipment at the end of each shift for reuse.
- Items not reusable should be properly contained pending approved disposal.

FIGURE 6.5

PCB FIRES: The steps of a fire decontamination program



6.4 PCB FIRES: Site decontamination

Description of fire contamination

Fires involving PCB equipment can contaminate building interiors and contents with PCBs, as well as with toxic products of PCB decomposition including hydrogen chloride, polychlorinated dibenzofurans (furans) and polychlorinated dibenzo-p-dioxins (dioxins). PCBs and dioxin and furan compounds are generally concentrated in the particulates of smoke and soot, and can contaminate both air and surfaces of fire sites. These compounds may also be contained in extinguishing waters which are generated during firefighting activities.

The Environment Canada publication Fires in Electrical Equipment Containing PCBs: Recommendations to Prevent Contamination by PCDFs provides detailed background on the mechanism and nature of contamination from fires involving PCBs. Any event involving the exposure of PCBs to fire or high temperature (600 to 900°C) can potentially produce furans and dioxins. Certain of these compounds are highly toxic (the human lethal dose of the most toxic dioxin compound is of the order of picograms[1]/kg of body weight), and toxic residues may be widely dispersed at the fire scene in smoke, soot and firefighting media residues. It should be assumed that hazardous levels of these compounds are present until otherwise determined from the monitoring program.

Decontamination steps

FIGURE 6.5 presents a suggested order for specific steps to decontaminate sites contaminated by PCB fires. The order of steps reflects experience gained in the decontamination of major PCB fires, and addresses the need to limit dispersal of fire residues during the cleanup operations.

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[1] A picogram is one trillionth [10-12] of one gram.

Step 1

Remove gross contamination

- Isolate and contain standing liquid and heavy soot:
  - ◊ isolate slightly-contaminated contents for later decontamination,
  - ◊ remove liquids with absorbent material,
  - ◊ scrape up heavy soot deposits and place in secure containers, and
  - ◊ vacuum with a high efficiency particulate absolute system [HEPA: see TABLE 6.2].

Step 2

Limit contaminant dispersal

STEP 2A: Control air flow patterns and releases

- Install vapor-phase activated carbon exhaust treatment system(s) to decontaminate all air which is exhausted from the contaminated areas of the facility. Install alarm systems to warn of system malfunctions.
- Establish a negative air flow pattern back to contamination source [from areas of low to high concentration].
- Dehumidify affected areas to reduce corrosive acid formation [see comments in the description of TASK 1B].

STEP 2B: Control water releases from the site

- Install a suitable water treatment system for decontaminating all aqueous wash waters and contaminated firefighting waters. Typical treatment system components include:
  - ◊ a receiving tank,
  - ◊ a settling tank (for phosphate removal from detergents),
  - ◊ a sand filter,
  - ◊ oil/PCB sorbent pads, and
  - ◊ charcoal filters.
- Undertake routine sampling and analysis to ensure compliance with water quality criteria prior to the release of treated liquids.
- Contain phosphate sludges (from detergents), sand, sorbent pads and other treatment residues for approved disposal.

Step 3

Remove materials that cannot be decontaminated

- Remove and contain [for disposal] porous materials that cannot be easily or economically decontaminated (for example, paper, cloth, acoustic or drop ceiling tiles, insulation, unpainted concrete surfaces).

Step 4

Decontaminate surfaces

Step 4A: Fire source area

- This area will have the heaviest contamination and should be decontaminated first to avoid the dispersal of contaminants to other areas.

Step 4B: HVAC [heating, ventilation, air-conditioning] systems

Contaminated HVAC systems should be thoroughly cleaned to prevent the subsequent dispersal of contaminants when they are reactivated.

- Vacuum ductwork interiors [if accessible] with high efficiency vacuums.
- Wash with detergent and/or solvent.
- Rinse with water jets.
- Wipe with clean cloth or absorbent gauze.
- Sample and analyze to determine residual contamination levels.
- Rewash (with solvents if necessary) as required to achieve compliance with cleanup criteria.
- If ductwork is too small or inaccessible for hand cleaning, holes may have to be cut for access or the removal of elbows, vanes or dampers may be necessary.
- Foam "pigs" may be useful for washing and rinsing ductwork systems
- A specialized technique has been developed for cleaning air ducts. A machine sends a swab through the ductwork, emitting cleansing chemicals and providing mechanical agitation (4, page 46).

Step 4C: Structural surfaces

- Decontaminate porous and non-porous structural surfaces utilizing the techniques described in SECTION 6.5.

Step 4D: Building contents

- The wide variety of techniques used to decontaminate the contents of a facility are described in SECTION 6.5.
- For many surfaces, the detergent wash may be sufficient to achieve compliance with the cleanup criteria.
- Computers and electrical equipment may require vapor degreasing for effective cleaning.
- If document and archive restoration is not possible, documents can be photocopied or converted to microfiche.

Step 5

Worker protective clothing and gear

- It is impractical to discard protective clothing at the end of each shift.
- Workers should segregate reusable clothing and equipment at the end of each shift for reuse.
- Items not reusable should be properly contained pending approved disposal.

6.5 SURFACE DECONTAMINATION TECHNIQUES

TABLE 6.2 summarizes various techniques which have been successfully used to clean surfaces contaminated with PCB, furan and/or dioxin residues. These techniques are presented in the following general categories:

- dry removal of contaminants,
- wet removal of contaminants using:
  - ◊ water blasting or steam cleaning,
  - ◊ detergent foams,
  - ◊ detergent-based solutions,
  - ◊ solvent-based solutions,
  - ◊ solvent foams,
  - ◊ detergent/solvent solutions, or
  - ◊ chemical-based solutions,
- surface sealing or encapsulation,
- surface removal, and
- *in-situ* treatment of contaminants.

TABLE 6.2 briefly describes the basis and applicability of each technique. More detailed description of the techniques can be found in references 13,19 and 26.

FIGURE 6.6 illustrates typical sequences of the decontamination techniques which have been successfully applied in the cleansing of porous, non-porous and delicate surfaces.

TABLE 6.2

Suggested surface decontamination techniques

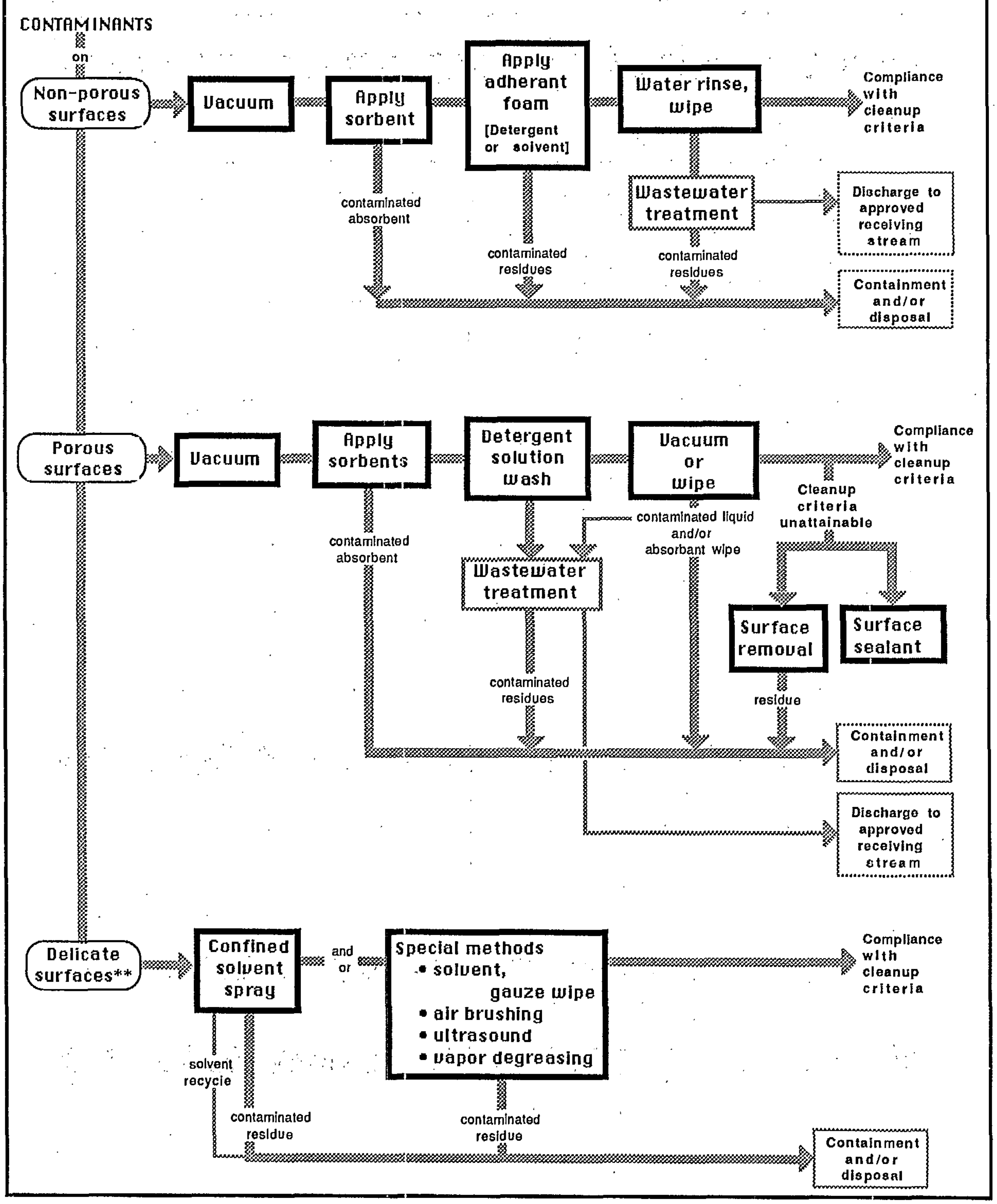
Technique	Comments
Dry removal	
SORBENTS	• For removal of free liquids from any surface • Sorbents include: ◊ Commercial granular or mat sorbents [see product directory] ◊ Kitty litter ◊ Vermiculite ◊ Rags
VACUUM	• High Efficiency Particulate Absolute (HEPA) • Fast, dry method for pick up of dry soot and dust
SURFACE REMOVAL ◊ Sand blasting	• For concrete • For painted surfaces permeable to PCB, PCDF, and PCDD • Without vacuum collection or with vacuum collection and abrasive recycle (Note: even with vacuum filtration sandblasting can result in significant redisposition of PCB
◊ Surface scarifying (grinding)	• For concrete with slight penetration • Removes material by routing or scoring the surface
◊ Shot blasting	• For concrete contamination removal by surface abrasion • Depth of removal depends on shot blast speed and shot size • Fitted with vacuum for particulate and shot collection • Shot and concrete dust separated by cyclone • Avoid slower speeds resulting in friction heating which may vaporize PCB
◊ Scabbling	• For concrete with removal depth to 1 inch • Material chipped away by pneumatic piston heads
◊ Hand chipping	• For hard, porous surfaces, including concrete • Material removal by chipping manually with a hammer and chisel
Wet removal	
WATER BASED ◊ Hydroblasting	• Removes contaminants or loose surface material • High pressure systems can remove surface material • Low pressure systems are used to remove loose particles or fluids • Waste liquids are removed by wet vacuum
◊ Steam cleaning	• Used for pressure surface washing • Waste liquids are removed by wet vacuum
DETERGENT BASED ◊ Manual surface wiping/scrubbing	• Use full-strength detergent • On horizontal surfaces ◊ Use sorbent to form a retaining wall around the spill surface ◊ Pour detergent on the spill ◊ Scrub with a bristle brush or wire broom ◊ Remove free liquid with sorbent and repeat as required
Hydroblasting	• As above, using detergent solution as the washing fluid
Steam cleaning	• As above, using detergent solution as the washing fluid
Mechanical surface scrubbing	• Application of detergent solution with an industrial floor cleaning machine ◊ Liquid is sprayed on the surface ◊ The surface is scrubbed with rotating brushes ◊ Waste liquid is removed by an internal vacuum • For porous surfaces like concrete, cleaning may not be possible due to "leachback" over time • Removes surface contamination
DETERGENT FOAM Water-jet rinsed	• Used to remove "oily" soot; additives used to remove corrosion residue • Requires waste water collection and treatment system • Detergents may include non-ionic and alkaline synthetic detergents such as L.O.C. Amway, Penetone Power Cleaner 155 Citriclean, and Triton-X • The use of chemical surface adherents will assist in uptake and reduce run off

TABLE 6.2

Suggested surface decontamination techniques	...continued
Technique	**Comments**
	Wet removal [continued]
DETERGENT BASED [continued] DETERGENT/SOLVENT Jet wash (water rinsed)	• Applied at high pressure, removes "oily" soot and soluble residues • Requires waste water collection and treatment system
SOLVENT BASED Manual surface wiping/scrubbing	• Solvents may include low odour kerosene, mineral spirits, trichlorotriflouroethane, methylene chloride, or a mixture of 1,1,1 - trichloroethane and trichlorobenzenes HARD, POROUS SURFACES • Pour solvents directly on surfaces and scrub • QUICKLY remove solvent with absorbants or wet vacuum ◊ CAUTION: the use of solvents may drive the contamination deeper into the concrete ◊ For porous surfaces like concrete, cleaning may not be possible due to "leachback" over time NON-POROUS SURFACES • Spray or pour directly on the surface, scrub, and wipe with rags
Solvent bath	• Cleaning by immersion in a bath • Useful for small or intricate items
Solvent spray	• High pressure spray in sealed chambers with minimum solvent losses • Used to decontaminate sensitive electrical equipment, computers, and documents • Also applied outside sealed chambers for in-situ decontamination of electrical equipment (with high solvent losses)
Mechanical surface scrubbing	• Application of solvent with an industrial floor cleaning machine [as described above for detergent application] • Commercial systems using solvents are available [see directory]
SOLVENT FOAM Water-jet rinsed	• Used to remove "oily" soot; additives used to remove corrosion residue • Requires waste collection and treatment system • The use of chemical surface adherents will assist in uptake and reduce run off • Solvents may include low odour kerosene, mineral spirits, trichlorotriflouroethane, methylene chloride, or a mixture of 1,1,1 - trichloroethane and trichlorobenzenes • CAUTION: the use of solvents may generate high concentrations of organic vapour which will reduce the service life of carbon cartridge respirators
CHEMICAL BASED Stripping	• For painted surfaces permeable to PCB, PCDF, and PCDD
	Sealing/encapsulation
Surface sealing [with/without decontamination]	• For porous surfaces • Heated polyethylene glycol-based mixture applied using sprayer or brush (See Reference 26: this technique is currently being researched for effectiveness) • Liquid penetrates up to 2 inches • On contact with PCB reacts to form non-PCB by-products
Surface sealing [without decontamination]	• Formation of an impermeable seal with an elastomeric, abrasion and flame-resistant sealer • For concrete surfaces that cannot be removed but still have contmination levels above cleanup criteria from porous and non-porous surfaces
	Permanent removal
Surface removal [containment/disposal]	• For porous and absorbent materials which cannot be decontaminated [for example, ceiling tile, exposed insulation]
	In-situ treatment
In-situ treatment	• Physical, chemical or biological degradation of contaminants in-place [for example, biological degradation of soil contaminants] • Generally in the developmental stage ◊ Clients currently usually prefer positive and permanent removal of contamination

FIGURE 6.6

Suggested sequence of decontamination techniques for cleaning surfaces



6.6 PERSONNEL PROTECTION

TABLE 6.3 defines the general support tasks which may be required to protect site personnel during the implementation of the facility decontamination procedures described in the previous SECTIONs. These tasks include:

- establishing a medical monitoring program for the cleanup crew,
- developing health and safety plans for site personnel,
- establishing a decontamination facility for workers entering and leaving the site,
- establishing requirements for protective gear, and
- establishing an equipment and material supply administration.

The necessity for and scope of each of these tasks will depend on the specific circumstances of the release event, and the applicability of each of the tasks is indicated in the table. In general, a full complement of support tasks will only be required for complex cleanup operations and for releases involving dioxins and/or furans.

TABLE 6.4 lists suggested protective equipment for personnel who enter contaminated areas in major cleanups where the presence of dioxins and furans has been established. The suggested protocol (Reference 19) defines three levels of contamination (low, moderate and high) and assigns protective equipment according to the degree of contamination. Generally-accepted definitions of the levels of contamination have not been formulated, and quantitative definition of contamination categories must be established on a site-specific basis.

TABLE 6.4 summarizes the exposure concerns which should be addressed in determining the requirements for personnel protection in site cleanup activities. Care should be taken to identify all site-specific factors which influence the selection of protective equipment. For example, HCl vapors may be initially present at the fire scene, and this compound has often been overlooked in the selection of personnel protective equipment.

Additional information on the selection of protective equipment can be found in the Environment Canada Handbook on in Electrical Equipment.

TABLE 6.3

Recommended support tasks for the protection of cleanup site personnel

Task	Applicability	Task steps
Establish a medical monitoring program for the cleanup crew	SPILLS ◊ Advisable if exposure is frequent and on-going [repeated cleanups over weeks to months]. PRESSURIZED RELEASES ◊ Not normally required. ◊ Advisable if exposure is frequent and on-going. ◊ Should be required if dioxin or furan presence is established. FIRES ◊ Recommended as mandatory	• Where applicable, provide medical monitoring of all personnel until reoccupancy criteria are met • Provide entry, interim and exit medical exams for cleanup personnel, including: ◊ personal clinical history ◊ a complete physical examination ◊ biological tests o blood count o liver function o cholesterol o triglycerides o plasma protein electophoresis o PCB plasma test ◊ previous PCB exposure history ◊ identification of physical constraints which limit the use of protective gear
Develop health and safety plans for the cleanup crew	Recommended for crews involved in any cleanup activity	The plans should address [as applicable]: ◊ security ◊ entry and exit procedures ◊ training procedures ◊ protective equipment use and maintenance including repirator use, how to avoid skin contact when removing contaminated clothing ◊ worker identification programs ◊ personal hygiene ◊ fire and smoke alarm system ◊ alarm-activating emergency exits ◊ building temperature control [to allow comfort for workers wearing several layers of protective clothing] ◊ length of worker shift ◊ common terminology for building areas and cleanup operations
Establish a decontamination facility for workers	SPILLS ◊ Advisable if exposure is frequent and on-going [repeated cleanups over weeks to months]. PRESSURIZED RELEASES ◊ Not normally required. ◊ Recommended as mandatory if dioxin or furan presence is established. FIRES ◊ Recommended as mandatory if dioxin or furan presence is established.	• Provide an on-site facility for worker entry and exit to the contaminated area • The facility should include: ◊ locker room for clothing ◊ toilets ◊ change room ◊ "store" for issue of protective clothing ◊ canteen (53) • The following entry and exit procedures are suggested: ◊ enter security check ◊ surrender ID card ◊ enter locker room and remove street clothes ◊ enter dressing room and don protective gear ◊ enter contaminated area ◊ participate in decontamination activities ◊ exit contaminated area ◊ enter dressing room and remove contaminated protective gear ◊ enter shower area and wash down ◊ enter locker room and don street clothes ◊ enter security check and retrieve ID card ◊ exit decontamination facility
Establish protective gear requirements related to the level contamination [Table 6.6]	Appropriate protective gear should be mandatory for all site cleanup personnel	• Delineate the building or cleanup site by contamination level: ◊ for example, designate light [3], moderate [2], and heavily contaminated [1] zones [Quantitative definition of zones will be site-specific] ◊ contamination level designation allows safe and cost effective prescription of protective gear requirements for each individual area ◊ Table 6.4 outlines suggested personnel protection equipment.
Establish an equipment and material supply administration	Recommeded for all complex cleanups and/or when the presence of dioxins or furans is established	• Control the appropriate selection and use of materials through administration by trained personnel

TABLE 6.4

Suggested personnel protection equipment for PCB cleanup*
Level 1 protection [maximum]
• Cap with supplied-air respirator [operated in positive-pressure demand mode and equipped with auxilliary positive-pressure self-contained breathing apparatus]
• Zippered coverall with attached drawstring hood made of non-woven fabric [for example, Saranex-coated Tyvek , Viton-coated neoprene, vitrile, Viton SF, butyl, or nitrile]
• Viton Gloves taped to suit sleeves at the seams
• Workboots with neoprene overshoe taped to suit legs at the seams
• Cotton overalls/underclothing / socks [washed daily]
• Cotton or surgical glove liners
• Walkie-talkies
• Safety glasses or face shield
Level 2 protection
• Positive-pressure self-contained breathing apparatus
• Zippered coverall with attached drawstring hood made of non-woven fabric [for example, Saranex-coated Tyvek, Viton-coated neoprene, vitrile, Viton SF, butyl, or nitrile]
• Viton Gloves taped to suit arms at seams
• Neoprene safety boots
• Cotton overalls/underclothing / socks [washed daily]
• Cotton or surgical glove liners
• Walkie-talkies
• Safety glasses or face shield
Level 3 protection [minimum]
• Hard hat
• Air-purifying respirator with suitable organic vapor cartridges
• PVC chemical suit and gloves
• Neoprene safety boots
• Cotton overalls/underclothing /socks [washed daily]
• Cotton or surgical glove liners
• Walkie-talkies
• Safety glasses or face shield
* Definition of personnel protective equipment should always be site-specific. Three levels of protection are not required for spills of PCB liquids, but should be considered for complex or widely dispersed cleanups, or whenever the presence of dioxins and furans is established.

Table 6.5

Summary of contaminant exposure concerns for PCB release events

Type of release	Contaminants of concern	Potential types of exposure	
		Contact	Inhalation
Spills	PCB	Yes	No [unless the fluid temperature exceeds 60° C and/or there is poor ventilation in the cleanup space]
	Trichlorobenzene	Yes [askarels generally contain trichlorobenzene as a diluant]	
	Dioxins and/or furans	No [releases with mechanical causes (most spills)]	No
		Yes [if the fluid has been subjected to high temperatures or fire prior to or during the release]	No [unless atomization or vaporization has occurred: see pressurized releases]
Pressurized releases	PCB	Yes	Yes [vaporization, atomization or particulate formation may have occurred]
	Trichlorobenzene	Yes [for transformer fluids and askarels]	
		No [For capacitors, ballasts and equipment containing pure PCB fluids]	No [For capacitors, ballasts and equipment containing pure PCB fluids]
	dioxins, furans	Yes [Confirmation of absence is advisable if the cause of the release is non-mechanical] (involving arcing, explosion, high temperatures or fire)	Yes [Confirmation of absence is advisable if the cause of the release is non-mechanical] (involving arcing, explosion, high temperatures or fire)
Fires	PCB	Yes [vaporization, atomization and/or particulate formation should be assumed]	Yes [vaporization, atomization and/or particulate formation should be assumed]
	Trichlorobenzene	Yes [for transformer fluids and askarels]	Yes [for transformer fluids and askarels]
		No [For capacitors, ballasts and equipment containing pure PCB fluids]	No [For capacitors, ballasts and equipment containing pure PCB fluids]
	dioxins, furan	Yes [presence (adsorbed on particulates) is assumed until confirmed otherwise]	Yes [presence (adsorbed on particulates) is assumed until confirmed otherwise]
	HCl	Yes	Yes

7.0 SAMPLING AND ANALYTICAL PROTOCOLS

The major objectives of a cleanup process include:

- minimizing environmental dispersion,
- minimizing any present or future human exposure to PCBs,
- protecting the health and safety of the cleanup crew, and
- properly disposing of collected materials .

To achieve these objectives and to facilitate response/cleanup , a sampling and analytical program must be designed to:

1. Obtain data on PCB dispersal from release events.
2. Obtain data on PCB , PCDF and PCDD and HCl dispersal from fire events.
3. Provide evidence to rigorously demonstrate that a spill/fire site has been adequately cleaned and is in compliance with cleanup criteria.

7.1 Health and Safety Precautions for Analytical and Cleanup Crews

In general every precaution should be taken to minimize exposure of personnel to PCBs and, in the case of PCB fires and pressurized releases, their combustion products (furans, dioxins and HCl). Protective clothing must be worn to prevent inhalation of PCBs, furans, dioxins and HCl, and to prevent skin contact with soot, and contaminated surfaces. Personal protection requirements are identical to those described in Table 6.4.

7.2 Sampling Strategies

Table 7.1 outlines suggested sampling strategies (ie. locations and techniques) for three types of release events: spills, pressurized releases, and fires. Sampling and analysis usually occur after initial decontamination efforts. This is because proper chemical analysis requires specialized analytical techniques which may result in considerable time delays between sampling and receipt of results. Another factor is the shortage of laboratories capable of furan and dioxin analysis.

As a result, cleanup efforts may have to be initiated in the absence of analytical support. The extent of the area to be initially decontaminated after a PCB spill or fire is decided upon by visual inspection and various site-specific factors such as proximity to environmentally sensitive areas or potential health concerns. Subsequently, analyses of environmental samples are required to provide input into decisions for safeguarding public health and environmental quality. Therefore, the chosen sampling designs must provide information on average concentrations of contaminants, data reliability, distribution of contaminants and location of any additional "hot spots". The high cost of specialized analytical techniques, the potential for litigation and public awareness require a planned sampling strategy to produce reliable and defensible results. It is important to incorporate a statistical design into a systematic sampling plan at the outset. This facilitates the analysis of data and interpretation of results.

Where the contaminant distribution in the environment has a directional component (e.g. a plume evolves after a fire via a preferential wind direction), a systematic sampling design is the only reliable method for locating the contamination[3]. The use of a hexagonal grid design (composed of two equilateral triangles) to model a detection problem has been proposed by the U.S. EPA for use in enforcement monitoring of PCB spill cleanup. Boomer et al (1985) provide detailed guidance on how to set out hexagonal grids in the field. The sampling design must be site-specific and be developed in consultation with an analytical laboratory and regulatory agencies.

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[3]This is because the assumption in random sampling is that the chances of selection of a measurable parameter must be the same throughout the medium/area to be sampled.

TABLE 7.1

OVERVIEW OF SUGGESTED SAMPLING and ANALYTICAL REQUIREMENTS

EVENT	SAMPLING: Approach (Sampling Locations)	SAMPLING: Techniques	ANALYTICAL: Techniques	ANALYTICAL: Required Detection Limits
SPILL	**SURFACE SAMPLES (soil, floor)** • USE GRID SAMPLING DESIGN AS PER U.S. EPA (40) AND WHERE NECESSARY JUDGEMENTAL SAMPLING FOR AREAS SUCH AS CRACKS OR CREVICES OR SUSPICIOUS STAINS. • CENTER GRID IN APPARENT CENTER OF SPILL	**SMOOTH SURFACES (nonporous)** • SINGLE WIPE OF DEFINED AREA WITH ABSORBENT TISSUE DAMPENED WITH HEXANE OR TOLUENE **POROUS MATERIAL (wood, concrete)** • PHYSICAL REMOVAL OF DEFINED AREA OF SURFACES (1 cm depth) **WATER** • GRAB SAMPLES WITH STORAGE IN TEFLON OR FOIL LINED CAPPED GLASS CONTAINERS **SOIL** • CORE SAMPLES TO EVALUATE DEPTH OF PENETRATION	• USE OF EXTRACTION WITH PORTABLE TEST KITS e.g. Clor-N-oil McGraw Edison ONLY FOR SEMI-QUANTITATIVE INFORMATION ON PCB LEVELS TO AID CLEANUP • ASSESSMENT OF DISPERSION AND CLEANUP BY USE OF CONVENTIONAL GAS CHROMATOGRAPHY-ELECTRON CAPTURE	• AS DECIDED UPON IN CONSULTATION WITH ALL PARTIES
PRESSURIZED RELEASE	**SURFACE SAMPLES (floor, walls, equipment)** • GRID SAMPLE DESIGN AS PER U.S. EPA (40) • CENTER GRID AT SOURCE FOR FLOOR SAMPLES OF ROOM • GRID SAMPLE EACH ROOM WALL • RANDOM SAMPLE ADJACENT ROOMS OR ROOMS EXPOSED TO COMMON VENTILATION SYSTEM • JUDGEMENTAL SAMPLE EQUIPMENT **AIR SAMPLES*** • HIGH RATE SAMPLERS OR LONG TERM SAMPLERS IN AFFECTED AREAS	**SMOOTH SURFACES (nonporous)** • AS ABOVE **POROUS MATERIAL** • AS ABOVE **WATER** • AS ABOVE **AIR** • USE OF SAMPLING TRAIN WITH FILTER, SORBENT (FORISIL), PUMP AND VOLUME OR FLOW-RATE MEASUREMENT DEVICE	• CONVENTIONAL GAS CHROMATOGRAPHY-ELECTRON CAPTURE AS PER U.S. EPA (37)	• AS DECIDED UPON IN CONSULTATION WITH ALL PARTIES
FIRE	**SURFACE SAMPLES (floor, walls, equipment)** • GRID SAMPLE DESIGN AS PER U.S. EPA (40) • CENTER GRID AT FLOOR, WALL AND CEILING • JUDGEMENTAL SAMPLE ALL EXPOSED EQUIPMENT AND VENTING PARTICULARLY ALONG PLUME. **AIR SAMPLES*** • HIGH RATE SAMPLERS OR LONG-TERM SAMPLES IN AFFECTED AREAS	**SMOOTH SURFACES (nonporous)** • AS ABOVE **POROUS MATERIAL** • AS ABOVE **WATER** • AS ABOVE **AIR** • AS ABOVE, WITH USE OF SILICA GEL AS ABSORBENT AND WITH USE OF HIGH RATE, LONG-TERM PUMP	• GAS CHROMATOGRAPHY/MASS SPECTROMETRY AS PER REF. (56)	• AS DECIDED UPON IN CONSULTATION WITH ALL PARTIES

* Required at all times during sampling for occupational health assessment

Judgmental sampling is often used with one of the other methods to include collection of samples outside of the designated sampling area where residual contamination is suspected. Judgmental sampling, with its' built in bias, should never be used on its own.

Control areas should be sampled, especially if the study is attempting to determine the extent and presence of localized contamination. Sites for control samples should be as representative as possible of the actual sampling area.

Discussions of the sampling strategies and aspects such as sample sizes are required by the decision group responsible for overseeing the cleanup operation.

7.3 Sampling Techniques

PCBs are an inert non-polar class of semi-volatile organic compounds. Therefore, with the exceptions of air and water sampling techniques which concentrate PCBs from the matrix onto a sorbent, most PCB sample collections utilize standard methods for semi-volatile organics in the subject matrix. Field blanks should be obtained for all samples. Several duplicates should also be collected. The types of media to be sampled after a PCB spill, pressurized release, or fire are site specific and may include: air, solids, surfaces, water and vegetation. Provision must be made for split sampling for quality control assurance.

Air

Air sampling techniques must quantitatively concentrate PCBs from the air in such a way that the PCBs are recoverable, the sorbent medium does not generate interferences, and the collected specimen is representative of the whole. Solid sorbents are preferable to liquid sorbents.

Common solid sorbents that have been used for collection of PCBs from air include polyurethane foam (PUF), Florisil and XAD-2. PCBs are bound loosely on the sorbents and migrate slowly through the medium with the air flow. The more volatile lower chlorinated PCBs may therefore show poorer recoveries than the less volatile higher chlorinated PCBs.

Florisil, a magnesium silicate salt is the most widely used solid sorbent.

The sampling apparatus for PCBs is similar to that for other semivolatile organics. It includes a filter, sorbent, pump and a volume or flow-rate measurement device. A glass fiber filter is used to remove particulates, etc. In cold climates a large fraction of the PCBs may be adsorbed to particulates therefore analysis of the filter should also be considered. Air is drawn through the filter and sorbent by the vacuum pump. To detect PCBs at low concentrations either a high sampling rate or long sampling period is required (53). As an example, air samples taken by IREQ (Table 3.3) used a flow rate of

1 L/min for 20-24 hours per sample. The air was passed through Florisil sorbent tubes. The sampling procedures for PCDF, PCDD and PCB analysis used a high volume sampling device. It consisted of a microfibre filter followed by an absorption unit containing glass fiber and silica gel. The flow rate was 20 L/min for a 120 hour sampling period.

Solids

Contaminated soil surfaces require the collection of core samples. Efforts should be made to evaluate PCB concentrations at specific depths. The sample should be stored in a precleaned glass bottle.

Surface samples

Wipe samples can be obtained from non-porous, smooth surfaces such as floors, tabletops, drum interiors, etc. A predetermined area [e.g. 10 x 10 cm (100 cm2)] is marked out by means of a sampling template or masking tape. Absorbent tissue, gauze pad, or filter paper is dampened with an appropriate solvent (e.g. hexane, toluene) and then used to carefully wipe the measured surface a single time. Boomer et al (1985) recommend holding the moistened absorbent paper with stainless steel forceps. The wipe sample is then sealed in a precleaned glass jar and stored in the dark at 4° C.

Water samples

Water samples may either be collected by grab or integration techniques. Grab sampling is the most common method. Integration techniques include: automatic composite samples, adsorption onto a solid (XAD, PUF) and liquid-liquid extraction. Automatic composite samplers generally consist of a pump, tubing, timer and collection vessel.

Grab samples must be collected in a glass container, preferably with Teflon™ coated lids (or foil-lined). pH adjustment to between 6.0 - 8.0 is necessary if samples are to be stored for longer than 48 hours. Water sampling for PCB analysis is the same as for any semi-volatile organic and standard procedures can be followed for guidance (for example, EPA Handbook for Sampling and Sample Preparation of Water and Wastewater).

Sampling of waters requires recognition that PCBs are dissolved in matrices of variable density which will influence their location in a water body. PCBs in mineral oil will tend to float on the surface. Therefore, samples should be collected by grab techniques. PCBs in Askarel or other heavier-than-water matrices will sink. Therefore, samples should be taken near the bottom by lowering a bottle with the cap on. The cap is removed at depth and then recapped once filled. Specialized sampling equipment would be required to perform the latter procedure.

Samples should be stored in the dark at 4° C until analysis.

7.4 Analyses

Appropriate analytical procedures for PCB determinations must be selected to obtain needed information, depending on the particular situation.

In the case of spills or pressurized releases, the issue is not the identification of PCBs but the measurement of Aroclor concentrations to determine whether PCB contamination exceeds a particular concentration. Conventional gas chromatography-electron capture (GC-EC) determination of PCBs as Aroclors will easily provide the needed information. The GC-EC methodology can be set up near the contamination site (for example, in a trailer) to rapidly provide results. GC-EC methodology should be the minimum degree of technology used to provide assurance of adequate cleanup following a PCB spill.

If required, portable field test kits (for example, the McGraw-Edison Centec Kit, Dexsil Clor-N-Oil Kit, Syprotec Kwik-Skrene Kit) may be adapted and used to aid the cleanup efforts (6). However, the results should not be used for verification of cleanup.

In the case of fires, the issue is not only PCBs but also the combustion products PCDDs and PCDFs. The information produced by a mass spectrometric detector is essential, because these three classes of components and other potential sample components have similar GC retention times and EC detection responses.

In addition, samples would not be expected to contain intact Aroclors. The requirement of mass spectrometry implies the need for a very high degree of analytical sophistication and possible time delays for results.

Quality assurance (QA) must be applied throughout the entire monitoring program. Quality control (QC) measures and sample QC should be stipulated in the QA plan. They may include protocols, certification and performance checks, procedural QC, sample QC, and sample custody as appropriate. The quality assurance program is usually an integral component of an analytical laboratory's services. However the adequacy of the program should be reviewed by the regulatory authorities in consideration of the broad range of concentrations of concern and the variety of samples (wipe samples, ash and soot).

7.5 Legal Requirements

In order to ensure that court-defensible results are obtained, attention must be paid to collecting, identifying and storing samples properly. There can be no doubt that all necessary technical procedures were followed in securing and holding the samples; and that analytical results accurately define contaminated zones. Legally credible sampling and analytical procedures might have significant impact on future liabilities, the extent of the required cleanup, down time, and re-occupancy criteria

8.0 GUIDELINES, STANDARDS AND OBJECTIVES for CLEANUP/REOCCUPANCY CRITERIA

This section outlines examples of cleanup/reoccupancy criteria established from previous PCB related events and government policy. The extent to which contamination from PCB accidents must be cleaned up is dependant upon the circumstances surrounding the release, location, materials contaminated, volume released, worker access and jurisdictional responsibility.

Although guidelines for reoccupancy and reuse of areas contaminated as a result of PCB release have been proposed by a number of jurisdictions (nationally and internationally), each event must be considered unique. The required decontamination levels must be established by a consensus of the appropriate regulatory authorities (Environment Canada, Health and Welfare Canada, Provincial Ministry of Environment, Workers Compensation Board, Provincial Ministry of Health and Labor representatives). The cleanup criteria proposed will be related to past experience, workplace standards, laboratory studies, environmental criteria and the risk of human and environmental exposure in the area of the PCB release.

In North America, the original criteria for reoccupancy is based on established permissible exposure limits (PEL), promulgated by organizations such as the Occupational Safety and Health Administration (OSHA), the American Conference of Governmental Industrial Hygienists (ACGIH) and the National Institute for Occupational Safety and Health (NIOSH). The limits were developed from exposure studies using PCB, PCDFs and PCDDs on experimental animals.

The clean up and reoccupancy criteria presented in Tables 8.1 and 8.2 give an indication of the levels likely to be required after a PCB spill, pressurized release or fire.

TABLE 8.1 A

PCB Cleanup Criteria

Target Level	Target Scope	Target Jurisdiction	Criteria Type	Ref.
Contaminated SOILS				
<1 mg/kg: LEAVE IN PLACE 1-20 mg/kg: ADD 15 cm COVER >20 mg/kg: REMOVE	Urban and Recreational Areas	Pottersburg Creek [Technical Review Committee convened by ONTARIO MOE]	Consensus	47
< 1mg/kg	Not Specified	Quebec	Recommendation	43
< 5 mg/kg	Not Specified	Saskatchewan	Target Level	43
0.5 mg/kg (dry weight)	Agricultural Soils	Canada	Target Level Under Consideration	43
5 mg/kg (dry weight)	Urban and Remote (Wilderness Soils)	Canada	Target Level Under Consideration	43
25 mg/kg (dry weight)	Industrial Soils	Canada	Target Level Under Consideration	43
25 mg/kg with 25 cm cap clean soil	Public Access Areas	U.S.A. (Environment/Industry Coalition)	Proposed Guideline	44, 49
10 mg/kg (capped with clean material @ <1 mg/kg equal to depth of excavation)	Potential High Contact Areas	USEPA	Proposed Rule	18, 44
Clean to level below 50 mg/kg as practical	General Electric Industrial Site	USEPA	1984 Administrative Law Judgement	48
25 mg/kg	Reduced Public Access Areas	USEPA	Proposed Rule	18
50 mg/kg	Restricted Access Electrical Substations With Posted Warning, Otherwise 25 mg/kg	USEPA	Proposed Rule	18
1 - 5 mg/kg	Residential Area	Netherlands	Target Level	43
1 mg/kg	Not Specified	France	Guideline for Further Investigation	43
5 mg/kg	Not Specified	France	Guideline for Remediation	43
Average 10 mg/kg (upset limit 25 mg/kg)	Company Property	Detroit Edison	Acceptable Operating Standard	4-47*

TABLE 8.1 B

PCB Cleanup Criteria				
Target Level	**Target Scope**	**Target Jurisdiction**	**Criteria Type**	**Ref.**
Contaminated SURFACES				
2.5 mg/cm2 (Askarel 1242) 1.2 mg/cm2 (Askarel 1254, 1260)	Not Specified	Quebec	Proposed Under Dangerous Waste Regulations	43
2.5 mg/m2 (Askarel 1242) 1.25 mg/m2 (Askarel 1254, 1260)	Interior Surface IREQ Facility	Hydro-Quebec	Evaluation Committee Acceptance Criteria	53
0.5 - 0.7 µg/100 cm2	Interior Surfaces	NIOSH	Guideline	12,26
1 µg/100 cm2	General Occupancy	Dept. of Public Health, City & County of San Francisco	Agency Health Based Clean-up Criteria	12,26,46
10 µg/100 cm2	Restricted Access Transformer Vault	Dept. of Public Health, City & County of San Francisco	Agency Health Based Clean-Up Criteria	12,26
10 µg/100 cm2	Potential High Contact Areas	USEPA	Proposed Rule	18,26
100 µg/100 cm2	Reduced Public Access Areas	USEPA	Proposed Rule	18,26
100 µg/100 cm2	Restricted Access Electrical Substations	USEPA	Proposed Rule	18,26
1 µg/100 cm2	General Exposure (Binghamton, N.Y. Office Building)	New York, Dept. of Health	Agency Health Based Clean-Up Criteria	26,46
50 µg/100 cm2	Office Building, Sante Fe, N.M.	Expert Advisory Panel Appointed by Governor of New Mexico	Re-entry Guidelines	46

TABLE 8.1 C

PCB Cleanup Criteria

Target Level	Target Scope	Target Jurisdiction	Criteria Type	Ref.
Contaminated AIR				
150 ng/m3 - 24 hour average 450 ng/m3 - 0.5 hour average	Ambient Air	Ontario	Ambient Air Quality Criteria	43
1 mg/m3 - 8 hr (42% Cl) 2 mg/m3 - 15 min (42% Cl) 0.5 mg/m3 - 8 hr (54% Cl) 1 mg/m3 - 15 min (54% Cl)	Occupational Exposure	U.S.A. - ACGIH Standard Adopted by: OSHA, Canada, B.C., Alberta, Quebec, New Brunswick Newfoundland	Occupational Air Quality Criteria	26,43
0.05 mg/m3 - Average 40 hour work week	Occupational Exposure	Ontario	Ministry of Labor Recommendation	43
450 ng/m3 - 0.5 hr maximum	Occupational Exposure	Ontario	Ministry of Labor Recommendation	43
1 µg/m3 - Average 40 hour work week	Occupational Exposure	U.S.A. - NIOSH	NIOSH Recommendation for Amendment to Occupational Safety & Health Act	26,43
1 µg/m3	Office Building Binghamton, N.Y.	New York Dept. of Health	Agency Health Based Criteria	46
0.5 µg/m3	Office Building Santa Fe, N.M.	Expert Advisory Panel Appointed by Governor of New Mexico	Re-occupancy Criteria	46
1 µg/m3	One Market Plaza San Francisco, C.A.	San Franscisco Dept. of Health, California State Health Dept.	Re-occupancy Criteria	17,46
1.0 mg/m3 - 8 hr aver. (42% Cl) 0.5 mg/m3 - 8 hr aver. (59% Cl)	Not Specified	West Germany	Occupational Exposure	43
1.0 mg/m3 - 8 hr average	Not Specified	East Germany	Occupational Exposure	43
0.5 mg/m3 - 8 hr average	Not Specified	Sweden	Occupational Exposure	43
1.0 mg/m3 - 8 hr average	Not Specified	Australia	Occupational Exposure	43
1.0 mg/m3 - 8 hr aver. (42% Cl) 0.5 mg/m3 - 8 hr aver. (54% Cl)	Not Specified	Czechoslovakia	Occupational Exposure	43
1.0 mg/m3 - 8 hr aver. (42% Cl) 0.5 mg/m3 - 8 hr aver. (54% Cl)	Not Specified	Romania	Occupational Exposure	43
1.0 mg/m3 - 8 hr aver. (42% Cl) 0.5 mg/m3 - 8 hr aver (54% Cl)	Not Specified	Finland	Occupational Exposure	43
1.0 mg/m3	Not Specified	Japan	Occupational Exposure	43

TABLE 8.1 D

PCB Cleanup Criteria

Target Level	Target Scope	Target Jurisdiction	Criteria Type	Ref.
Contaminated WATERS				
0.002 µg/L	Ambient Water	Manitoba	Ambient water quality objective	43
0.001 µg/L	Ambient Water	Ontario	Ambient water quality objective for unfiltered sample	43
0.001 µg/L	Ambient Water	Quebec	Ambient water quality objective	43
0.001 µg/L	Ambient Water	IJC - Great Lakes	Water quality objective estimated to meet the recommended level in fish and aquatic life of 0.1 µg/g wet weight	43
0.00079 µg/L 0.000079 µg/L 0.0000079 µg/L	Ambient Water	U.S. E.P.A.	Water quality criteria for protection of human health (cancer risk 1:100,000) (cancer risk 1:1,000,000) (cancer risk 1:10,000,000)	43
0.014 µg/L	Ambient Water	U.S. E.P.A.	Water quality criteria for protection of freshwater aquatic life	43
0.03 µg/L	Ambient Water	U.S. E.P.A.	Saltwater quality criteria for protection of saltwater aquatic life	43
0.001 µg/L	Ambient Water	Indiana	Water quality criteria for protection of aquatic life	43
0.001 µg/L	Ambient Water	Ohio	Water quality criteria for protection of aquatic life	43
0.001 µg/L	Ambient Water	Pennsylvania	Water quality criteria for protection of aquatic life	43
0.1 µg/L	Recreational Water	Quebec	Recommended standard	43
0.001 µg/L	Recreational Water	Indiana	Recommended standard	43

TABLE 8.2

Dioxin, Dibenzofuran, Dioxin Equivalent* Decontamination Criteria					
Contaminant	**Target Level**	**Target Scope**	**Target Jurisdiction**	**Criteria Type**	**Ref.**
Contaminated SURFACES					
2,3,7,8-DIOXIN	3-28 ng/m2	Interior/Office building [Binghamton, N.Y.]	N.Y. State Health Department	Reoccupancy	13,17
2,3,7,8-FURAN	12-110 ng/m2	Interior/Office building [Binghamton, N.Y.]	N.Y. State Health Department	Reoccupancy	13, 17
Dioxin Equivalent	3-25 ng/m2	Interior/Office building [Binghamton, N.Y.]	N.Y. State Health Department	Reoccupancy	13,17 46
Dioxin Equivalent	3 ng/m2	Interior One Market Plaza, San Francisco, C.A.	San Francisco Health Department, California State Dept. of Health	Re-entry Guideline	17,46
Dioxin Equivalent	1 ng/m2	Interior Office Building Santa Fe, N.M.	Expert Advisory Panel Appointed by Governor of New Mexico	Re-entry Guideline	13,46
Dioxin Equivalent	25 ng/m2	Interior IREQ Facility Quebec	Coordinating Committee IREQ Fire Quebec	Reoccupancy Concensus	4-50*
2,3,7,8-FURAN	50 ng/m2	Not Specified	Sweden	Reoccupancy	17
2,3,7,8-FURAN	5 ng/m2	Not Specified	Finland	Suggested Reoccupancy	17
Total Furan	50 ng/m2	Not Specified	Finland	Suggested Reoccupancy	17
2,3,7,8-DIOXIN	5 ng/m2	Not Specified	Finland	Suggested Reoccupancy	17
Contaminated AIR					
2,3,7,8-DIOXIN	10 pg/m3	Interior Office Bldg. Binghamton, N.Y.	N.Y. State Health Dept.	Reoccupancy	13,17
2,3,7,8-FURAN	39 pg/m3	Interior Office Bldg. Binghamton, N.Y.	N.Y. State Health Dept.	Reoccupancy	13,17
Dioxin Equivalent	ND-10 pg/m3	Interior Office Bldg. Binghamton, N.Y.	N.Y. State Health Dept.	Reoccupancy	13,17
Dioxin Equivalent	10 pg/m3	Interior One Market Plaza San Francisco, CA	San Francisco Health Dept., California State Dept. of Health	Re-entry Guidline	17,46
Dioxin Equivalent	2 pg/m3	Interior Office Bldg. Sante Fe, NM	Expert Advisory Panel Appointed by Governor of New Mexico	Reoccupancy	13,46
Dioxin Equivalent	10 pg/m3	Interior IREQ Facility Quebec	Coordinating Committee IREQ Fire, Quebec	Reoccupancy Concensus	4-50*

9.0 WASTE STORAGE

At the time of writing, there are no operating PCB destruction facilities available in Canada[1]. As a result, PCB equipment, PCB-contaminated mineral oil or PCB-contaminated residuals from clean-up operations generally must be stored on-site pending the availability of suitable destruction alternatives.

The Provincial Governments have jurisdiction over PCB waste materials. The Provincial Environment Authorities should be contacted for appropriate regulations, guidelines and approvals where necessary to safely store PCB material (Provincial Contacts are listed in Section 12).

Environment Canada published the Manual for the Management of Wastes Containing Polychlorinated Biphenyls (PCBs) referenced in Section 1. The document details proper waste management techniques and is available from the Regional Offices of Environmental Protection. (The Regional Environmental Protection Offices are listed in Section 12)

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1 Hazardous or special waste destruction facilities will ultimately be established in several provinces and are at stages of development ranging from conceptual planning to construction. Transformer decommissioning facilities are operating at the Alberta Waste Treatment Corporation Facility (Swan Hills, Alberta), although the incineration facility (which is designed to accept PCBs) is not yet tested or operating commercially. The Alberta Facility will accept Alberta wastes only.

10.0 RESPONSIBILITIES AND LIABILITIES

The safe management of PCB-containing equipment is a serious responsibility. Previous sections of the Manual have demonstrated the extent of the implications that can result from an accident involving PCB-containing equipment. It is therefore in the best interest of all concerned and the environment that the recommendations made regarding prevention and contingency planning be implemented to avoid or at least minimize the potential contamination from a PCB accident. The extent of the measures implemented will be dependent upon the amount and type of PCB-containing equipment located at a particular facility.

PCBs are regulated both federally and provincially. It is the responsibility of the owner/manager to be familiar and keep current with the federal regulations under the Canadian Environmental Protection Act, as well as pertinent provincial regulations governing PCB management. Some provincial governments [including Ontario and Quebec] have specific PCB regulations in place. Other provincial governments are in the process of formulating specific policy regarding PCB management.

The publications referenced in Section 1 and available from Environment Canada outline the regulatory requirements under the Canadian Environmental Protection Act. In addition, the Fisheries Act could be enforced in the event of a release to water.

The question of liability is harder to define because of the uniqueness of individual events. The first action an owner/manager should take is to find out the scope of his insurance coverage with respect to PCB equipment, both in-service and in storage. The availability of Environmental Impairment Liability Insurance is almost nil given the massive financial exposures some insurance firms have faced after environmental disasters. Therefore, it is advisable to take a worst case scenario such as some of the events in Section 2 and discuss the potential liability exposure with the company insurer.

11.0 DIRECTORY OF SERVICES

This directory of services lists and enumerates companies providing most of the products or services referred to throughout the Manual. This directory information is intended to:

- expedite the implementation of measures designed for preventing PCB-related events, and
- assist those who must prepare for and respond effectively to emergencies.

Products and services have been grouped according to key words. The numbers following the key words correspond to those companies (as identified in the following pages) which provide the particular service or product . Since expertise and experience vary among companies, users of the Manual should carefully evaluate capabilities prior to selection. In some cases only head offices are listed. Contact with the head office may be necessary to locate a branch office or distributors close to the user.

The majority of the listed companies that provide specific hands-on decontamination expertise are located in the United States. This is due to the greater number of incidents involving PCB release as a result of a much larger industrial base. In addition, the existence of PCB disposal facilities in the United States allows companies offering site remediation and decontamination services to manage a cleanup project from start to finish. There are a number of companies in Canada who can provide overall assessment and management services, but few have actual hands-on experience in PCB decontamination.

Every effort was made to provide a comprehensive and accurate listing. However, because of the short duration of the project, it is anticipated that additional companies will wish to be included in the manual. The manual is designed to allow for updating of the information as required.

Directory of Products and Services for PCB Emergency Response

Numbers following each product or service category refer to Company Numbers as identified in the alphabetic listing of Companies which follows this section

Products

Adsorbants, absorbants [spill]
10,13,32,39,40,49,67,68,84, 88,89,96,106,111,112,117, 132,139,142,154,155,156, 157,160,161,167,174,177, 178,179,181,184,190,196

Analysis kits, PCB
109,113,118,126,172

Cleaners, industrial
141,155,156,174

Drums, containers
18,22,25,39,53,60,80,89,92, 166,180,191

Face protection
11,14,16,21,33,40,54,55,84, 85,106,108,117,124,127,152, 153,154,171,173,197,201

Fire detection systems
75,145,151,169

Fire suppression systems
26,31,69,73,75,85,108,115, 121,107,118,127,169,171, 179,181,185,197,203

Gloves [PCB-resistant]
09,11,40,47,55,64,66,69,85, 90,106,108,117,127,137,153, 154,171,173,176,185,197

Labels, signage, placards
01,03,05,07,08,15,17,20,27, 35,37,40,56,59,63,71,84,91, 97,99,104,105,106,108,114, 117,120,135,143,146,152, 153,154,157,162,163,164, [illegible]

Leak detection and warning, leak prevention systems
38,145,151

Protective garments [Tyvek]
06,09,11,28,40,85,90,106, 108,117,140,150,152,153, 154,185,194

Respiratory protection equipment
11,14,33,54,55,85,103,108, 117,127,152,153,154,171, 173,179,194,197

Sealants
44,62,189

Spill control, cleanup equipment
50,90,93,106,107,133,134, 147,149,155,156,174,190, 193

Spill response kits
40,80,89,106,117,154,178, 186,190

Vacuum systems, pumps
-

Services

Analytical services: see Laboratory analysis

Containment systems: see Design/construction of...

Contingency planning/response [spill and fire]
24,41,65,77,155,156,174,178

Decontamination, planning: see Formulation of decontamination plans [spill and fire]

Design/construction of containment systems/storage facilities
02,39,41,65,77,107,148,155, 156,174

Emergency fire response: consulting
19,24,77,101,155,156,168, 174

Emergency fire response: hands-on
19,24,101,155,156,168,174

Emergency spill response: consulting
02,04,10,19,24,39,41,43,45, 65,77,95,101,129,136,138, 144,148,155,156,168,174, 182,186,195,202

Emergency spill response: hands-on [including decontamination and cleanup]
04,10,19,24,39,45,79,95, 101,129,136,148,155,156, 168,174,178,182,186

Equipment inspection
02,39,41,65,77,148,155,156, 174

Equipment servicing
36,39,58,148

Fire contingency planning: see Contingency planning/ response [spill and fire]

Fire decontamination, planning: see Formulation of decontamination plans [spill and fire]

Fire response planning: see Contingency planning/ response [spill and fire]

Fire response [consulting]: see Emergency fire response: consulting

Fire response [hands-on]: see Emergency fire response: hands-on

Services(continued)

Formulation of decontamination plans [spill and fire]
24,41,65,77,155,156,174,178

Information services: see Training/information services

Laboratory analysis: dioxins and furans
12,23,24,51,72,110,128,131, 198,205

Laboratory analysis: PCB
02,19,24,30,34,39,41,43,46, 51,57,58,61,65,72,78,82,98, 101,110,116,128,131,136, 141,148,155,156,159,170, 172,174,186,198,205

Medical surveillance, occupational health monitoring
24,101,155,156,174

Occupational health monitoring: see Medical surveilance...

On-site PCB handling and storage
04,19,24,39,45,79,96,101, 136,148,155,156,174,178

PCB handling: see On-site ...

PCB storage: see On-site ...

Risk assessment: see safety audits

Safety audits, risk assessment
02,04,24,41,65,74,77,100, 129,146,148,155,156,174, 195

Sampling
02,10,19,24,30,39,41,43,51, 58,65,77,101,129,136,138, 148,155,156,159,174,186

Spill contingency planning: see Contingency planning/response [spill and fire]

Spill decontamination, planning: see Formulation of decontamination plans [spill and fire]

Spill response planning: see Contingency planning/ response [spill and fire]

Spill response [consulting]: see Emergency spill response: consulting

Spill response [hands-on]: see Emergency spill response: hands-on

Storage facilities: see Design/ construction of...

Training/information services
19,36,41,65,74,77,100,175, 202

Water treatment systems: deployment
24,30,36,102,130,155,156, 174

Co.#	Company Name	Street address	City, Province	P Code	Phone	Contact
1	Acme Signalisation Incorporated	12625 April, Pointe aux Trembles	Montreal, Quebec	H1B 5P6	(514)645-2261	
2	Acres International Limited	5259 Dorchester Road, P.O. Box 1001	Niagara Falls, Ontario	L2E 6W1	(416)374-5200	I.K. Hill
3	Ad-Print Markings Limited	1915 Stainsbury Avenue	Vancouver, B.C.	V5N 2M6	(604)872-7622	
4	ADS Associes Ltee. - Group Conseil	2155 Guy, 12th Floor	Montreal, Quebec	H3H 2L9	(514)288-2672	Charles Lavoie, associate
5	AIM Zytron Corporation	65 Irondale Drive	Weston, Ontario	M9L 2S6	(416)741-5220	
6	Aisco Industrial Safety Apparel	103 - 8077 Alexandra Street	Richmond, B.C.	V6X 1C3	(604)278-4244	J. Green
7	Alberta Traffic Supply Limited	P.O. Box 5684, Station L	Edmonton, Alberta	T6C 4G1	(403)440-4414	
8	Albion Decals	140 Adrien-Robert, Parc Ind. Richelieu	Hull, Quebec	J8Y 3S2	(819)777-2761	
9	Allwest Industrial Supplies Limited	7 - 13530 76th Avenue	Surrey, B.C.	V3W 7P8	(604)590-1858	
10	Al-Tec Sanitation Systems Ltd.	Iron Avenue S.E., P.O. Box 45	Medicine Hat, Alberta	T1A 7E5	(403)526-0445	Terry Allen, Manager
11	Am Sal Incorporated	11465 Sherbrooke Street E.	Montreal, Quebec	H1B 1C2	(514)645-7477	
12	Analytical Service Laboratories (ASL) Limited	1650 Pandora Street	Vancouver, B.C.	V5L 1L6	(604)253-4188	
13	Anco Chemicals Limited	P.O. Box 400, 85 Malmo Court	Maple, Ontario	L0J 1E0	(416)832-2276	Peter Mitchell
14	AO Safety, AOCO Limited	60 Mobile Drive	Toronto, Ontario	M4A 2R7	(416)752-8780	
15	Arco Display Incorporated	2024 Quebec Avenue	Saskatoon, Sask.	S7K 1W4	(306)652-9988	
16	Aristrocrat Manufacturing Company Limited	4500 Dixie Road	Mississauga, Ontario	L4W 1V7	(416)624-0200	
17	Astrographic Industries Limited	7541 - 134A Street	Surrey, B.C.	V3W 7B3	(604)596-1731	
18	Barrel Accessories and Supply Company	4647 West 47th Street	Chicago, Illinois	60632	(312)767-8100	
19	Batelle Columbus Labs	505 King Avenue	Columbus, Ohio	43201	(614)424-5024	Dr. Marcus Cooke
20	Beaver Decalcomanie	5545 Cote de Liesse, St-Laurent	Montreal, Quebec	H4P 1A1	(514)748-8877	
21	Bilsom International Limited	1 St. Clair Avenue East	Toronto, Ontario	M4T 2V7	(416)922-7807	Francine Parry
22	Bio-Nuclear Diagnostics	3896 Chesswood Drive	Downsview, Ontario	M3J 2W6	(416)638-1086	S.K. Choudry, President
23	Bioquest International Inc.	204 - 2989 Pembina Highway	Winnipeg, Manitoba	R3T 2H5	(204)269-3067	Dr. Martin Samoiloff
24	Blackmon Mooring Steamatic Catastrophe, Limited	31 Durward Place	Waterloo, Ontario	N2L 4E5	(519)886-7900	Bill Witt
25	Bondico Incorporated	2410 Silver Street	Jacksonville, FL	32206	(904)358-2602	Mark D. Shaw, VP
26	Boss Canada Incorporated	53 Woodbridge Avenue	Woodbridge, Ontario	L4L 2S6	(416)851-1169	Lorne Brown
27	W.H. Brady Incorporated	10 Marmac Drive	Rexdale, Ontario	M9W 1E6	(416)675-7111	Peter Kaminski
28	Brant Packaging and Manufacturing Limited	426 Elgin Street, P.O. Box 1687	Brantford, Ontario	N3T 5V7	(519)752-4369	Anna Maddalena
29	BVC Limited	Leatherhead	Surrey, England		Ashtead 76121	
30	Calgon Canada	27 Finley Road	Bramalea, Ontario	L6T 1B2	(416)457-5310	
31	Canada Safety Products Incorporated	701 King Street West	Toronto, Ontario	M5W 2W7	(416)366-6680	
32	Can Ross Environmental Services Limited	441 Wyecroft Road	Oakville, Ontario	L6K 2H2	(416)849-4566	Ted Edgar, VP Marketing
33	Can Safe Sales Incorporated	607 Beaverdale Road, P.O. Box 2294	Cambridge, Ontario	N3C 3P8	(519)658-1123	
34	Can Test Limited	1523 West 3rd Avenue - 2nd Floor	Vancouver, B.C.	V6J 1J8	(604)734-7276	A.D. Timuss, Gen. Manager
35	Canadian Aqualine Products Limited	3503 - 62nd Avenue SE	Calgary, Alberta	T2C 1P5	(403)279-7407	
36	Canadian General Electric Company Limited	703 Evans Avenue	Toronto, Ontario	M9C 3E9	(416)620-2155	Bob Figol
37	Canadian Traffic Control Limited	7566 - 134A Street	Surrey, B.C.	V3W 7B3	(604)596-7855	
38	Can-Am Instruments Limited	2495 Haines Road	Mississauga, Ontario	L4Y 1Y7	(416)277-0331	Hans Leygraaf
39	Canchem Incorporated	10 - 800 Windmill Road	Dartmouth, NS	B3B 1L1	(902)465-7563	Larry Frederiksen, Pres.
40	Canlab	80 Jutland Road	Toronto, Ontario	M8Z 2H4	(416)252-5151	
41	Canviro Consultants	600 - 180 King Street South	Waterloo, Ontario	N2J 1P8	(519)579-3500	Douglas E. Metcalfe, P.Eng.
42	Cascade Technologies	6330 des Grandes Prairies Blvd.	Montreal, Quebec	H1P 1A2	(514)326-9590	
43	Ceda Reactor Limited	230 - 6712 Fisher Street SE	Calgary, Alberta	T2H 2A7	(403)253-3233	Neil Beatty
44	Ceilcote Canada	7065 Fir Tree Drive	Mississauga, Ontario	L5S 1G7	(416)671-1790	Don Cadwell
45	Chem Security Limited	1331 - 44th Avenue NE	Calgary, Alberta	T2E 7A1	(403)250-3742	Rod Leyland
46	Chemex Labs Alberta (1984) Limited	100 - 2021 41st Avenue NE	Calgary, Alberta	T2E 6P2	(403)291-3077	Don LaBerge, Manager
47	Chemical By Products Limited	23 Racine Road	Rexdale, Ontario	M9W 2Z4	(416)743-8853	
48	Chemical Disposal Consultants Incorporated	200 - 440 West Hastings Street	Vancouver, B.C.	V6B 1L1	(604)685-9876	Irena Gerke
49	C-I-L Incorporated	90 Shepherd Avenue E., P.O. Box 200 St. A	North York, Ontario	M2N 6H2	(416)229-7000	
50	Clark Products Company	916 West 25th Street	Norfolk, VA	23517	(804)625-5917	Stephen Clark
51	Clayton Environmental Consultants	400 Huron Church Road	Windsor, Ontario	N9C 2J9	(519)255-9797	
52	Clean Sites Incorporated					
53	Clearing Container	5100 West 67th Street	Chicago, IL	60638	(312)767-2990	
54	Coll Health and Safety Incorporated	1 - 1260 Fewster Drive	Mississauga, Ontario	L4W 1A4	(416)625-3994	
55	Collins Safety Incorporated	353 Manitou Drive	Kitchener, Ontario	N2G 3W9	(519)893-4100	

Co.#	Company Name	Street address	City, Province	P Code	Phone	Contact
56	Color Tech Limited	16 - 1833 Inkster Boulevard	Winnipeg, Manitoba	R2C 1R3	(204)694-3595	
57	Concord Scientific Corporation	2 Tippett Road	Downsview, Ontario	M3H 2V2	(416)630-6331	Phil Fellon
58	Con-Test	345 Kingston Road	Toronto, Ontario	L1V 1A1	(416)286-1271	R. Hubbard, President
59	Continental Decal Industries Incorporated	1911 Albion Road	Rexdale, Ontario	M9W 5S8	(416)674-5611	Jake Ally, President
60	Continental Fibre Drum	21 Harbor Plaza, P.O. Box 10303	Stamford, Conneticut	6904	(203)964-6717	
61	Core Laboratories Canada Limited	1540 25th Avenue NE	Calgary, Alberta	T2E 7R2	(403)250-5600	Richard Jackson, Manager
62	Corrosion Services Company Limited	369 Rimrock Road	Downsview, Ontario	M3J 3G2	(416)630-2600	
63	Cowan Decals Limited	9253 48th Street	Edmonton, Alberta	T6B 2R9	(403)468-7220	Del MacMillan, President
64	Deb Swarfega Incorporated	P.O. Box 730	Waterford, Ontario	N0E 1Y0	(519)443-8697	
65	M.M. Dillon Limited	47 Sheppard Avenue E., P.O. Box 1850 St.A	Willowdale, Ontario	M2N 6H5	(416)229-4646	Wally Wells, Manager
66	Dominion Power Press Equipment Limited	2390 Industrial Street, P.O. Box 125	Burlington, Ontario	L7R 3X8	(416)335-5547	
67	Dow Chemical Canada Incorporated	170 Attwell Drive	Toronto, Ontario		(416)675-7374	
68	Dubois Chemicals of Canada Limited	64 Kenhar Drive	Weston, Ontario	M9L 1N3	(416)749-0720	Frank Kotsovolos, Manager
69	DuPont Canada Incorporated	P.O. Box 26 Toronto Dominion Centre	Toronto, Ontario	M5K 1B6	(416)365-5621	
70	Dustbane Products Limited	P.O. Box 8381	Ottawa, Ontario	K1G 3K1	1-800-267-2383	
71	East Coast Plastics and Screen Print Limited	390 Rothesay Avenue, P.O. Box 1281	Saint John, NB	E2L 4G7	(506)693-3004	
72	ECO Research Canada Incorporated	121 Hymus	Point Claire, Quebec		(514)697-3273	
73	Edwards - A Unit of General Signal	625 6th Street East	Owen Sound, Ontario	N4K 1G5	(519)376-2430	
74	Electro Test Incorporated	3470 Fostoria Way, P.O. Box 159	San Ramon, CA	94583		John Moore, President
75	Engineered Fire Safety	17 - 80 Esna Park Drive	Markham, Ontario	L3R 2R6	(416)475-7574	Mario Bonnett, P. Eng.
76	Enmet Canada Limited	100 - 2600 Edenhurst Drive	Mississauga, Ontario	L5A 3Y4	(416)276-2202	Ross Humphry, Gen. Man.
77	Envirochem Services	111 Discovery Park, 3700 Gilmore Way	Bumaby, B.C.	V5G 4M1	(604)434-3656	Tom Finnbogason
78	Enviroclean - Division of MacLaren Plansearch	320 Adelaide Street South	London, Ontario	N5Z 3L2	(519)686-5711	Dr. Roy Whitehead, Manager
79	Envirocorp (1984) Incorporated	10700 est, Henri-Bourassa	Montreal, Quebec	H1C 1G9	(514)325-8810	Renc Landry, Manager
80	Environmental Container Corporation	P.O. Box 161	Delafield, Wisconsin	53018	(414)646-2480	James B. Caldwell,VP Sales
81	Environmental Systems Company (ENSCO)	1015 Louisiana Street	Little Rock, ARK	72202	(501)375-8444	Bill Prioskis
82	Envirotest Laboratories	9936 67th Avenue	Edmonton, Alberta	T6E 0P5	(403)434-9509	Dennis Erickson, President
83	Field, Wigham and Company Incorporated		Great Neck, NY			
84	Fisher Scientific	112 Colonnade Road	Nepean, Ontario	K2E 7L6	(613)225-6752	
85	Fleck Brothers	4084 McConnell Court	Bumaby, B.C.	V5A 3N7	(604)420-3535	K.J. Holland
86	Form and Substance Incorporated	756 Lakefield Road - Suite B	Westlake Village, CA	91361	(805)497-8529	Mac Meconis
87	Fruitland Tool and Manufacturing	324 Leaside Avenue	Stoney Creek, Ontario	L8E 2N7	(416)662-6552	Mike Dziuba
88	Gedcor Environmental Protection Corporation	1313 Newburgh Road	Westland, Michigan	48185	(313)326-0600	
89	George Mann and Company, Incorporated	Harborside Blvd., P.O. Box 9066	Providence, RI	2940	(401)781-0600	Mr. Stonemann
90	Georgian Bay Fire and Safety Supplies Limited	P.O. Box 803	Owen Sound, Ontario	N4K 5W9	(519)376-6120	Nels McKay, President
91	Glenwood Distributors Limited	125 - 251 Midpark Boulevard SE	Calgary, Alberta	T2X 1S3	(403)256-1106	
92	Greif Containers Incorporated	4219 Park Street	Niagara Falls, Ontario	L2E 6S8	(416)358-3271	S. Timsans, President
93	Gundle Lining Systems	1340 East Richey Road	Houston, Texas	77073	(713)443-8564	Robert Johnston
94	Harrier Marine Limited	Pilsworth Road, Bury	Lancashire, England	BL9 8RL	(061)796-8703	
95	Haztech Incorporated	5280 Panola Industrial Boulevard	Decatur, Georgia	30035	(404)981-9332	Arlene Selber
96	Hi-Point Peat Limited	207 - 35 Blackmarsh Road	St. John's, NFLD	A1E 1S4	(709)726-1252	Bill Butler
97	Hi Signs Manufacturing Limited	4403 - 84 Avenue	Edmonton, Alberta	T6B 2S6	(403)468-6181	
98	IEC Beak Consultants Limited	10751 Shellbridge Way	Richmond, B.C.		(604)273-1601	
99	Imprimerie ABG Printing Incoporated	2223 Coleraine	Montreal, Quebec	H3K 1S2	(514)989-1011	
100	Industrial Risk Insurers	85 Woodland Street	Hartford, Conneticut	6102	(203)520-7412	P.A. Sasso
101	International Technology Corporation	23456 Hawthorne Boulevard	Torrance, CA	90505	(213)378-9933	John P. Woodyard, P.E.
102	IPC Systems Incorporated	39 Riverside Avenue	Westport, CT	6880	(203)226-5642	
103	Jones Canada	13071 34th Street	Edmonton, Alberta	T5A 3K1	(403)478-9587	
104	Kel-Ex Agencies Limited	1427 Crown Street, P.O. Box 86643	North Vancouver, B.C.	V7J 1G4	(604)986-4617	J. Valiquette
105	La Signalisation de la Capitale Inc.	1802 de L'Aeroport	Ste. Foy, Quebec	G2E 3L9	(418)872-5931	
106	Levitt Safety Limited	33 Laird Drive	Toronto, Ontario	M4G 3S9	(416)425-8700	
107	Lexcan Industrial Supply Limited	85 Vulcan Street	Rexdale, Ontario	M9W 1L4	(416)249-8361	Dominic Petruzzi
108	Malkin and Pinton Industrial Supplies	325 East 5th Avenue	Vancouver, B.C.	V5T 1M6	(604)879-7171	Andy Lamb
109	Manleh Engineering Corporation (MEC)	12 Alfred Street	Woburn, Mass.	1801	(617)938-8338	Tom Crook
110	Mann Testing Laboratories Limited	5550 McAdam Road	Mississauga, Ontario	L4Z 1P1	(416)890-2555	Tim Munshaw

Co.#	Company Name	Street address	City, Province	P Code	Phone	Contact
111	Mateson Chemical Corporation	1025 E. Montgomery Avenue	Philadelphia, PA	19125	(215)423-3200	Jean F. Mateson, Pres.
112	McAllister Pollution Control		Montreal, Quebec			
113	McGraw-Edison Limited	3595 St. Clair Avenue East	Scarborough, Ontario	M1K 1M1	(412)777-3200	
114	Mid-North Mine and Safety Supply (1983)	125 - 105th Street East	Saskatoon, Sask.	S7N 1Z2	(306)374-3635	
115	Miller Safety Limited	P.O. Box 1200	Trenton, Ontario	K8V 6B4	(613)392-9231	
116	Morgan Schaffer Corporation	5110 Courtral Avenue	Montreal, Quebec	H3W 1A7	(514)739-1967	Bill Senchak
117	MSA Canada Incorporated	148 Norfinch Drive	Downsview, Ontario	M3N 1X8	(416)667-9400	Gerry Smith
118	Nedco - A Division of Westburne	1355 Meyerside Drive	Mississauga, Ontario	L5T 1C9	(416)677-1410	
119	Nederman Division	839 Central Parkway West	Mississauga, Ontario	L5C 2V9	(416)272-0632	
120	Neeco	3077 Mainway	Burlington, Ontario	L7R 4C5	(416)827-8000	
121	New Trend Safety Products Limited	P.O. Box 1463 Station T	Calgary, Alberta	T2H 2H7	(403)251-1005	
122	NFE Canada Limited	P.O. Box 1277 Station B	Burlington, Ontario	L7P 3S9	(416)634-2342	Mr. J.H. Robb
123	Nilfisk Limited	7 - 200 Connie Crescent	Concord, Ontario	L4K 1M1	(416)669-6003	Gary Gardiner
124	Norhammer Limited	P.O. Box 2042	Gravenhurst, Ontario	P0C 1G0	(705)689-2374	
125	Nortech Corporation	189 Greenwood Avenue	Midland Park, NJ		(201)445-6900	
126	Nortech Control Equipment Incorporated	4 - 135 The West Mall	Etobicoke, Ontario	M9C 1C2	(416)622-7820	
127	North Safety Products - Siebe North Canada Ltd.	26 Dansk Court	Rexdale, Ontario	M9W 5V8	(416)675-2810	
128	Nova Lab Limited	9420 Cote de Liesse	Lachine, Quebec	H8T 1A1	(514)636-6219	John Fenwick
129	OH Materials Company		Toronto, Ontario			Sheldon Lefkowitz
130	Oil Recovery Systems Incorporated	299 Second Avenue	Needham Heights, MA	2194	(617)449-5222	
131	Ontario Research Foundation	Sheridan Park	Toronto, Ontario		(416)822-4111	
132	Patella Environment Services Limited	P.O. Box 2236	Sidney, B.C.	V8L 3S8	(604)652-9519	James A. Cook, VP
133	Pedsco Canada Limited	3 - 180 Finchdene Square	Scarborough, Ontario	M1X 1A8	(416)298-9989	Mr. Bob Pederson
134	Pentek Incorporated	1026 4th Avenue	Coraopolis, PA	15108	(412)262-0725	
135	Plasticraft Limited	Dunlop Lane, P.O. Box 1026	Saint John, NB	E2L 4E3	(506)652-5470	
136	PPM Incorporated	801 - 1 Yonge Street	Toronto, Ontario	M5E 1E5	(416)364-1919	Eric Smith
137	Presses and Equipment T.G. Incorporated	9420 Trans Canada Highway	St. Laurent, Quebec	H4S 1R7	(514)337-6411	
138	Proctor and Redfern Consultants	45 Greenbelt Drive	Don Mills, Ontario	M3C 3K3	(416)445-3600	Grant Lee
139	Protec Enr.	150 Ste. Claire	Chicoutimi Nord, PQ	G7G 2S5	(418)543-3811	Jean-Marie Audet, Director
140	Pro-Tec-Tion Garments	2163 B Kingsway	Vancouver, B.C.	V5N 2T4	(604)435-6715	Al Wagner, President
141	Quantex Chemical Services Incorporated	29 Trillium Park Place	Kitchener, Ontario	N2E 1X1	(519)893-0840	Bob Braid
142	R.B.H. Cybernetics (1970) Limited	P.O. Box 4205 Station A	Victoria, B.C.	V8X 3X8	(604)478-3122	V.N.R. Sewell, President
143	Regency House Promotions Limited	1376 Spruce Street	Winnipeg, Manitoba	R3E 2V7	(204)774-4048	Dick Osantowski
144	Rexnord Incorporated	P.O. Box 2022	Milwaukee, WI	53201	(414)643-2765	R. Scholz
145	Risk and Industrial Safety Consultants Incorporated		Chicago, IL			Sami Atallah, President
146	R.J. Signs Limited	57 Brandon Street, P.O. Box 2891, St A	Moncton, NB	E1C 7E7	(506)855-6306	
147	RNG Equipment Incorporated	32 Stoffel Drive	Rexdale, Ontario	M9W 1A8	(416)249-7383	Gordon Duncan, Gen. Manager
148	Rondar Incorporated	333 Centennial Parkway	Hamilton, Ontario	L8E 2X6	(416)561-2808	Darvin Puhl, Manager
149	RSI Robotic Systems International Limited	9865 West Saanich Road	Sidney, B.C.	V8L 3S1	(604)656-0101	Jack Wilson, President
150	Safe-Pak Supply Canada Incorporated	2615 Clarke Street	Port Moody, B.C.	V3H 1Z4	(604) 939-6622	Robert Holmes
151	Safer Emergency Systems Incorporated	756 Lakefield Road	Westlake, CA	91361	(805)497-8529	Gary Gelinas, President
152	Safety House of Canada Limited	1275 Castlefield Avenue	Toronto, Ontario	M6B 1G4	(416)789-0631	Gerald Yaffe, President
153	Safety Supply Canada	90 West Beaver Creek Road	Richmond Hill, Ont.	L4B 1E7	(416)222-4111	
154	Safety World Incorporated	5 - 45 Lahr Drive	Belleville, Ontario	K8N 5E8	(613)962-4501	Brian Shenton, President
155	Sanexen International Incorporated	7777 Louis-H Lafontaine Boulevard	Anjou, Quebec	H1K 4E4	(514)355-3351	Jean Paquin, P.Eng.
156	Sanivan Incorporated	1705 3rd Avenue	Montreal, Quebec	H1B 5M9	(514)353-9170	Raymond Tremblay
157	Sargent Welch	285 Garyray Drive	Weston, Ontario	M9L 1P3	(416)741-5210	
158	Sciex Incorporated	202 - 55 Glen Cameron Road	Thornhill, Ontario	L3T 1P2	(416)881-4646	James Reynolds, President
159	Seakem Oceanography Limited	2045 Mills Road, P.O. Box 2219	Sidney, B.C.	V8L 3S1	(604)656-0881	Blair Humphry
160	Securitex - Division on Totec	211 - 279 Sherbrooke Street West	Montreal, Quebec	H2X 1Y2	(514)282-0503	Norman Martel
161	Sentinel Canada, Division of SLC	7300 St. Jacques	Montreal, Quebec	H4B 1W1	(514)483-6500	Daniel Pageau
162	Sign Centre Incorporated	R.R. #2	Ayer's Cliff, Quebec	J0B 1C0	(819)876-5111	H. Bar, Director
163	Signal Industries Limited	1300 8th Avenue	Regina, Saskatchewan	S4R 1E2	(306)525-0548	
164	Silk Screen Service Limited	150 Bluewater Road	Bedford, NS	B4B 1G9	(902)835-7315	
165	Sinclair MacDonald Products	359 Enford Road	Richmond Hill, Ont.	L4C 3G2	(416)883-1209	Sinclair MacDonald, Pres.

Co.#	Company Name	Street address	City, Province	P Code	Phone	Contact
166	Skolnik Industries Incorporated	4601 West 48th Street	Chicago, Illinois	60632	(312)735-0700	Howard B. Skolnik
167	Sorbco	5369 Maingate Drive	Mississauga, Ontario	L4W 1G3	(416)624-1264	
168	SOS International					Chris Kwoka
169	Special Electronics and Designs	726 Queen Street	Kincardine, Ontario	N2Z 1Z8	(519)396-2985	
170	Sunohio Canada Incorporated	87 Telson Road	Markham, Ontario	L3R 1E4	(416)479-1433	Dr. Nas Hijazi
171	Supplies Canada Company	33 Fuller Road	Ajax, Ontario	L1S 2E1	(416)683-1700	
172	Syprotec Incorporated	88 Hymus Boulevard	Pointe-Claire, PQ	H9B 1E4	(514)694-3637	J.P. Gibeault, President
173	Taskall Safety - Division of Totec 1985 Inc.	3925 Rachel East	Montreal, Quebec	H1X 1Z4	(514)254-5331	
174	TDL Laval (1983)	205 Rene A. Robert Boulevard	Ste. Therese, Quebec	J7I 4L1	(514)437-2375	Jean Claude Presseau
175	Technology Resource Incorporated	1425 McNair Drive	North Vancouver, B.C.	V7K 1X4	(604)925-2323	Allister Brown, President
176	Tenaquip	5715 Kennedy Road	Mississauga, Ontario	L4Z 2G4	(416)890-2270	
177	Tennier Absorbant Products Limited		Hamilton, Ontario			
178	Thomas Environmental Group	5369 Maingate Drive	Mississauga, Ontario	L4W 1G6	(416)624-1264	Jack Shaw, General Manager
179	3-M Canada Incorporated	P.O. Box 5757	London, Ontario	N6A 4T1	(519)451-2500	John Cousano
180	Tomark Holdings Incorporated	4542 Manilla Road SE	Calgary, Alberta	T2G 4B7	(403)243-0550	
181	TOPP Hygienics Limited	Balcombe Road - Horley	Surrey, England	RH6 9ET		
182	Toxitec Ltee.	P.O. Box 2160, Station B	Longueuil, Quebec	J4C 4K9	(514)455-6251	
183	Transway Systems Incorporated	330 Leaside Avenue	Stoney Creek, Ontario	L8E 2N7	(416)662-5435	John G. Posta
184	The Travelon Oil Company (Canada)	P.O. Box 246, Adelaide Street Station	Toronto, Ontario	M5C 2J4	(416)368-4400	Howard Travers
185	Trelleborg Limited	2600 John Street	Markham, Ontario	L3R 3W3	(416)475-5000	Richard Norman
186	Triangle Resouce Industries	14201 Laurel Park Drive, P.O. Box 370	Laurel, MD	20707	(301)953-9583	Paul Watson
187	United Signs Limited	60 Joseph Zatzman Drive, Burnside Ind Pk	Dartmouth, NS	B3B 1N8	(902)463-7041	
188	Vac-U-Max	37 Rutgers Street	Belleville, NJ	7109	(201)482-1000	
189	Valspar Incorporated	645 Coronation Drive, P.O. Box 200	Westhill, Ontario	M1E 4R6	(416)284-1681	Bill Chambers
190	Versatech Products Incorporated	60 Riverside Drive	North Vancouver, B.C.	V7H 1T4	(604)929-5451	
191	Viking Star Canada Limited	202 - 1111 Albion Road	Rexdale, Ontario	M9V 1A9	(416)745-2642	Bernd Green, President
192	Vikoma International Limited	88 Place Road - Cowers	Isle of Wight, England	P031 7AE	(098)329-6021	
193	Wade-Tech Limited	P.O. Box 730	Brockville, Ontario	K6V 5V8	(613)342-3142	John Goodenough, President
194	Wasip Limited	8 - 2247 Midland Avenue	Scarborough, Ontario		(416)297-5020	
195	Paul B. Waters and Associates Limited	4166 Dundas Street West	Toronto, Ontario	M8X 1X3	(416)236-2569	Paul B. Walters, President
196	Waverly Mineral Products Company		Philadelphia, PA			
197	Wayne Safety Incorporated	59 Alness Street	Downsview, Ontario	M3J 2H3	(416)661-1100	
198	Wellington Environmental Consultants Inc.	2 - 291 Woodlawn Road West	Guelph, Ontario	N1H 6N6	(519)822-2436	Brock G. Chittim, Manager
199	Western Decal Limited	8065H 130th Street	Surrey, B.C.	V3W 7X4	(604)591-8691	
200	Western Safety Sign Company	1643 Dublin Avenue, P.O. Box 26	Winnipeg, Manitoba	R3C 2G1	(204)694-0618	
201	Western Scientific Services Limited	11620 Horseshoe Way	Richmond, B.C.		(604)274-4111	
202	Westinghouse Canada	840 York Mills	Toronto, Ontario		(416)445-0550	
203	The Williams Bros. Corporation	4140 Finch Avenue East	Scarborough, Ontario	M1S 3T9	(416)299-7767	
204	Zenith Graphics Limited	131 West 2nd Avenue	Vancouver, B.C.	V5Y 1B8	(604)682-4521	
205	Zenon Environmental Incorporated	845 Harrington Court	Burlington, Ontario	L7N 3P3	(416)639-6320	Dr. Glynis Foster

12.0 REGULATORY CONTACTS

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4905 Dufferin Street
Downsview, Ontario
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FEDERAL ENVIRONMENT
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Officer, TDGA Program
Waste Management Division
Environmental Protection
Conservation and Protection
Environment Canada
Place Vincent Massey, 13th Floor
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Compliance Officer
Chemical Control Division
Commercial Chemicals Branch
Environmental Protection
Conservation and Protection
Environment Canada
Place Vincent Massey, 14th Floor
351 St. Joseph Boulevard
Hull, **Quebec**
K1A 1C8
Telephone: (819) 953-1676
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National Environmental Emergency
Centre (819) 997-3742*

FEDERAL ENVIRONMENT
Regional Offices:

Pacific and Yukon Region
Contaminants Control Officer
Environmental Protection
Conservation and Protection
Environment Canada
Kapilano 100 - Park Royal, 3rd Floor
West Vancouver, **British Columbia**
V7T 1A2
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Telex: 04-54476
Emergency: (604) 666-6100*

Western and Northern Region
Head, Environmental Quality Branch
Environmental Protection
Conservation and Protection
Environment Canada
Twin Atria No. 2, 2nd Floor
4999-98 Avenue
Edmonton, **Alberta**
T6B 2X3
Telephone: (403) 468-8020*
Telex: 037-2099
Emergency: (403) 468-8020

Ontario Region
Manager, Environmental Contaminants
Branch Environmental Protection
Conservation and Protection
Environment Canada
25 St. Clair Avenue East, 7th Floor
Toronto, **Ontario**
M4T 1M2
Telephone: (416) 973-1075
Telex: 062-3601
Emergency: (416) 346-1971*

Quebec Region
Ingenieur de projet (Project Engineer)
Urgences et residus (Emergency and Wastes)
Environmental Protection
Conservation and Protection
Environment Canada
1179 , rue De Bleury (Bleury Street)
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Telephone: (514) 283-6418
Telex: 055-60234
Emergency: (514) 283-2333*

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* 24-hour service

FEDERAL ENVIRONMENT
Regional Offices (cont'd):

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Environment Canada
Fifth Floor
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45 Alderney Drive
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FEDERAL ENVIRONMENT
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Pleasantville
St. John's, **Newfoundland**
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Prince Edward Island Environmental Protection
Conservation and Protection
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New Brunswick Environmental Protection
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Ontario Environmental Protection
Ottawa District Office
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Manitoba Environmental Protection
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Saskatchewan Environmental Protection
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PROVINCIAL ENVIRONMENT CONTACTS

Ministry of the Environment and Parks
Waste Management Branch
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Alberta Environment
Pollution Control Division
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Dangerous Goods Handling and Transportation
Environment Management Division
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Municipal Affairs and Environment
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BIBLIOGRAPHY AND REFERENCES

1. Environment Canada. 1982. Handbook of PCBs in electrical equipment. Ottawa.

2. Environment Canada. 1987. Manual for the management of wastes containing polychlorinated biphenyls (PCBs). Manual EPS 9/HA/1. Ottawa.

3. Environment Canada. 1986. PCBs: Question and answer guide concerning polychlorinated biphenyls. Ottawa.

4. Electric Power Research Institute. 1986. Proceedings: 1985 EPRI PCB seminar. October 22-25, 1985. Seattle, Washington. EPRI CS/EA/EL-4880.

5. Ministry of Labour, Occupational Health and Safety Division. 1986. Guidelines on the prevention and control of occupational exposure to polychlorinated biphenyls (PCBs).

6. DeBellefeuille, M. 1985. PCB field test kit evaluation. Environment Canada. Ottawa.

7. Environment Canada. 1985. Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), sources and releases. Report EPS 5/HA/2. Ottawa.

8. Environment Canada. 1985. Fires in electrical equipment containing PCBs: recommendations to prevent contamination by PCDFs. Report EPS 1/CC/2. Ottawa.

9. Environment Canada. 1986. National inventory of concentrated PCB (Askarel) fluids (1985 summary update). Report EPS 5/HA/4. Ottawa.

10. Environment Canada. 1986. Identification of fluorescent lamp ballasts containing PCBs. EPS Report 2/CC/2. Ottawa.

11. Illinois State Environmental Protection Agency. 1986. Chicago air quality: PCB (polychlorinated biphenyl) monitoring plan - phase 2. UEPA/APC/86-011. Springfield, Illinois.

12. New York Department of Health. 1985. PCB re-entry guidelines. Document 1330P. Albany, New York.

13. U.S. Department of Health and Human Services. 1986. Polychlorinated biphenyls (PCBs): Potential health hazards from electrical equipment fires or failures. Current Intelligence Bulletin 45. NIOSH Pub. No. 86-111.

14. B.C. Hydro and Power Authority. 1980. Polychlorinated biphenyls (PCBs); policies and procedures. Internal report No. EO-E-4.

15. Navy Environmental Support Office. 1982. PCB compliance, assessment, and spill control guide. NEESA 20.2-028A. Port Hueneme, California.

16. NIOSH, OSHA, USCG, EPA. 1985. Occupational safety and health guidance manual for hazardous waste site activities. DHHS (NIOSH) Pub. No. 85-115.

17. Lee, A. 1984. Assessment of PCDDs and PCDFs from PCB transformer and capacitor fires. Contract No. 68-03-3212. U.S.E.P.A., Cincinnati, Ohio.

18. Environmental Protection Agency. 1985. Polychlorinated biphenyls spill cleanup - draft.

19. Ashley, K. C. 1986. PCB decontamination practices. Proceedings: Institute of Electrical and Electronics Engineers, Conference on PCBs and Replacement Fluids, Montreal, Quebec.

20. Mooring, R. and C. Kwoka. 1986. Brief overview of a PCB transformer failure. Proceedings: Institute of Electrical and Electronics Engineers, Conference on PCBs and Replacement Fluids, Montreal, Quebec.

21. Meade, J.P. and W.D. Ellis. 1985. Decontamination techniques for mobile response equipment used at waste sites (state-of-the-art survey). Report No. EPA/600/2-85/105. U.S. Environmental Protection Agency. Cincinnati, Ohio. Contract No. 68-03-3113.

22. NIOSH. 1980. Hazard evaluation and technical assistance report TA 79-58, Montana State Department of Health, Pierce Packing Company, Billings, Montana. Cincinnati, Ohio. Report No. NIOSH HE/TA 79-58.

23. NIOSH. 1984. Health hazard evaluation report HETA 82-310-1475, Hill-Murray High School, Maplewood, Minnesota. PB85-184166. Cincinnati, Ohio.

24. NIOSH. 1983. Health hazard evaluation report HETA 82-224-1336, Miami Fire Department, Miami, Florida. PB85-102960. Cincinnati, Ohio.

25. Webber, I. 1986. The polychlorinated biphenyl (PCB) decontamination of electrical equipment. Proceedings: Institute of Electrical and Electronics Engineers, Conference on PCBs and Replacement Fluids, Montreal, Quebec.

26. Woodyard, J.P. and E.M. Zoratto. 1986. State-of-the art technology for PCB decontamination of concrete. Proceedings: Institute of Electrical and Electronics Engineers, Conference on PCBs and Replacement Fluids, Montreal, Quebec.

27. Erickson, M.D., K.E. Boggess, P.H. Cramer, G.L. Kelso, J. A. Long and D.T. Heggem. 1986. Evaluation of performance-based cleanup of PCB spills on surfaces. Proceedings: Institute of Electrical and Electronics Engineers, Conference on PCBs and Replacement Fluids, Montreal, Quebec.

28. Environment Canada. 1986. Proceedings of the technical seminar on chemical spills. February 5-7, 1986. Montreal, Quebec.

29. Hazardous Materials Control Research Institute. 1984. Hazardous materials control - directory 1983-1984. Silver Spring, Maryland.

30. Solsberg, L.B. and R.D. Parent. 1986. A survey of chemical spill countermeasures. Report EPS 9/SP/2. Environment Canada. Ottawa.

31. Erikson, M. D. 1986. Analytical chemistry of PCBs. Butterworth Pub.,Toronto.

32. Knight, M.J., S.K. Winship, B.I. Dmyterko, and T.E. Hemminger. 1986. A systematic approach to PCB capacitor spill cleanup compliance sampling. Proceedings: 1985 EPRI PCB seminar. October 22-25, 1985. Seattle, Washington. EPRI CS/EA/EL-4880.

33. Heggem, D.T., R.A. Levy, J.H. Smith, B.A. Boomer, M. D. Erickson, S.E. Swanson, G.L. Kelso, J. K. Turman, D.C. Cox, and B.D. Schultz. 1986. Verification of PCB spill cleanup by sampling and analysis. Proceedings: 1985 EPRI PCB seminar. October 22-25, 1985. Seattle, Washington. EPRI CS/EA/EL-4880.

34. Mills, D. W. 1986. Evaluation of the Clor-N-Oil test kit as a PCB screening tool. Proceedings: 1985 EPRI PCB seminar. October 22-25, 1985. Seattle, Washington. EPRI CS/EA/EL-4880.

35. Wong, L. W. 1986. Comparison of PCB analytical methods. Proceedings: 1985 EPRI PCB seminar. October 22-25, 1985. Seattle, Washington. EPRI CS/EA/EL-4880.

36. Thompson, H.C., D.C. Kendall, W.A. Korfmacher, K. L. Rowland, L. G. Rushing and J. J. Chen. 1986. Assessment of the contamination of a multibuilding facility by polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, and polychlorinated dibenzofurans. Environ. Sci. Technol. 20: 597-603.

37. Erikson, M.D. 1985. Analytical method: the analysis of by-product chlorinated biphenyls in commercial products and product wastes, revision 2. U.S. E.P.A., Washington, D.C. EPA-560/5-85-010.

38. Erikson, M.D. 1985. Analytical method: the analysis of by-product chlorinated biphenyls in water, revision 2. U.S.E.P.A., Washington, D.C. EPA-560/5-85-012.

39. Erikson, M.D. 1985. Analytical method: the analysis of by-product chlorinated biphenyls in air, revision 2. U.S.E.P.A., Washington, D.C. EPA-560/5-85-011.

40. Boomer, B.A. and D.C. Cox. 1985. Verification of PCB spill cleanup by sampling and analysis. U.S.E.P.A., Washington, D.C. EPA-560/5-85-026.

41. Garrett, C.L. 1983. An overview of PCBs and their current status in British Columbia. Dept. of Environment, EPS, Pacific and Yukon Region. Regional Program Report: 83-16.

42. Stanley, J., C. Haile, A. Small, and E. Olson. 1981. Sampling and analysis procedures for assessing organic emissions from stationary combustion sources for EED studies. Methods manual. Environmental Protection Agency, Washington, D.C. Report No. EPA/560/5-82-014.

43. Environment Canada. 1987. Summary of environmental criteria for polychlorinated biphenyls (PCBs). Ottawa. Report No. EPS 4/HA/1.

44. Hwang, S.T., J.W. Falco and C.H. Nauman. 1986. Development of advisory levels for polychlorinated biphenyls (PCBs) cleanup. U.S.E.P.A., Washington, D.C. Report No. EPA/600/6-86/002.

45. Canadian Council of Resource and Environment Ministers. 1986. The PCB story. Toronto, Ontario.

46. J. Kominski, NIOSH. Personal communication.

47. Rush, R.J., J.R. Bray and D.E. Metcalfe. 1986. Remediation of PCB contamination in the Kiwanis Park section of Pottersburg Creek, London, Ontario. Spill Technology Newsletter, June: 40-52.

48. Hansen, W.G., B.W. West and P. Hypnarowski. 1982. PCB spill risks: a comprehensive investigation in California. Hazardous Material Spills Conference.

49. U.S.E.P.A. 1980. Polychlorinated biphenyls: an alert for food and feed facilities. Washington, D.C.

50. Schirmer, J. and T. Liveright. 1985. Health hazard evaluation report HETA 82-319-1569, International Association of Firefighers, New Jersey. NIOSH, Cincinnati, Ohio.

51. Orris, P., D. Hryhorczuk, J. Kominsky, W. Burton, and D. Hinkamp. 1985. Health hazard evaluation report HETA 84-006-1639, First National Bank, Chicago, Illinois. NIOSH, Cincinnati, Ohio.

52. Workers Compensation Board of British Columbia. 1985. Memo to Ken Wile, EP Conservation and Protection RE: Fluorescent Lighting Fixtures. 26 February 1985.

53. Train, D., A. Chamberland, D. Dupont and J. Castonguay. 1986. Decontamination of IREQ's high voltage laboratory following a PCB fire. Proceedings: Institute of Electrical and Electronics Engineers, Conference on PCBs and replacement fluids, Montreal, Quebec.

54. Barros, M.C. , H. Konemann, and R. Visser (eds.). 1983. Proceedings: PCB seminar. 2 vols. , September 28-30, 1983. O.E.C.D., The Hague.

55. Henning, F.A. and D. Stuart. 1982. Common sense response to PCB release. Proceedings: Canadian Pulp and Paper Association, Technical Section. May 19-23, 1982. Jasper, Alberta.

56. Smith, L.M., D.L. Stalling and J.L. Johnson. 1984. Determination of part-per-trillion levels of polychlorinated dibenzofurans and dioxins in environmental samples. Anal. Chem. 56:1830-1842.

57. Canadian Council of Resource and Environment Ministers. No date. First in a series: Controlling PCBs, the nature of the problem. Toronto, Ontario.

58. Grice, H.C. and E.J. Middleton. 1985. A review of the toxicology and human health aspects of PCBs (1978-1982). Health and Welfare Canada. Ottawa. Report No. 85-EHD-113.

59. Miller, S. 1982. The persistent PCB problem. Environ. Sci. Technol. 16(2)98A-99A.

60. Wellington Science Assoc. Inc. 1978. PCB Spill response guidelines. Fisheries and Environment Canada. Contract OSS77-00180.

61. Brown, M.P., M.B. Werner, R.J. Sloan and K.W. Simpson. 1985. Polychlorinated biphenyls in the Hudson River. Environ. Sci. Technol. 19(8):656

62. B.C. Hydro and Power Authority. 1986. PCBs- polychlorinated biphenyls: practises and procedures. Internal report No. AFP-709-R2.

63. Aldrich, J.R. 1985. PCB field test kit, Volume 1: Field testing. U.S.A.F. Engineering and Services Laboratory. Report No. ESL TR 85-24. Florida.

64. MacLeod, K.E. 1979. Sources and emissions of polychlorinated biphenyls into the ambient atmosphere and indoor air. U.S.E.P.A. Report No. EPA/600/4-79-002.

65. Ministry of the Environment of Quebec. 1986. Approach to contaminated soil management. Quebec.

66. Cooke, M. No date. Emergency reponse services for PCB-transformer fires. Battelle Columbus Laboratories, Columbus, Ohio.

67. NIOSH. 1980. Polychlorinated biphenyls in the workplace-special course. 2 vols. Cincinnati, Ohio.

68. Rappe, C., L.O. Kjeller, S. Marklund, M. Nygren, and R. Fournie. 1986. PCB Accident in France. Proceedings: 1985 EPRI PCB seminar, Electric Poower Research Institute. Palo Alto, California. EPRI CS/EA/EL-4480.

69. Trotter, W.T. 1987. PCB Emergency action planning manual. Public Works Canada, Ottawa.

70. West and Hansen Engineers Inc., Fenner Engineering Inc. and Yei Engineers Inc. 1985. Design manual for reduction of airborne polychlorinated biphenyl (PCB) contamination. Electric Power Research Institute. Palo Alto, California.