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POLYCHLORINATED BIPHENYLS
IN COMMERCIAL BUILDINGS

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SUMMARY

The Bonneville Power Administration (Bonneville) is planning to implement a conservation acquisition program in new and existing commercial buildings. In anticipation of that program, Bonneville is examining the potential environmental effects of conservation measures in commercial buildings. An important conservation measure is the installation of new energy-efficient lighting fixtures. Some of the old lighting fixtures that these new lights will be replacing were manufactured before 1978, when polychlorinated biphenyls (PCBs) were still used in the capacitors of the lighting ballasts.

A key concern is whether changing normal fluorescent lamps to energy-efficient lamps causes ballast failure, which, in turn, can cause leaking and the release of PCBs into the atmosphere and onto surfaces. Exposure to PCBs has been found to cause skin rashes, vomiting, abdominal pain, and temporary blindness. It also is suspected of causing birth defects and cancer. Pacific Northwest Laboratory (PNL) has prepared this summary of information about PCBs in fluorescent light fixtures in commercial buildings to aid Bonneville in its assessment of potential environmental effects of its commercial acquisition program.

Polychlorinated biphenyls are regulated primarily through the Toxic Substances Control Act (TSCA), enacted by Congress in 1976. This Act gave the U.S. Environmental Protection Agency (EPA) authority to control the production and use of chemicals in the United States. The rules issued by EPA pursuant to the TSCA (40 CFR 761) remain the primary means of regulating the manufacture, distribution, use, storage, and disposal of PCBs. Polychlorinated biphenyls from nonleaking lighting ballasts are excluded from the manufacturing and disposal regulations insofar as a lighting ballast contains only "small capacitors." However, the EPA interprets that provision to apply only to individual households, not to commercial establishments. Also, Washington State has enacted Dangerous Waste Regulations (173-303 WAC), which also regulate the transport, storage, and disposal of PCBs.

Fluorescent lamps, commonly used in commercial buildings, represent a good opportunity for energy savings through either delamping (simply removing some of the bulbs) or relamping (replacing old lamps with energy-efficient

ones). However, some reports have asserted that both of these strategies caused overheating of the fluorescent ballast, which, in turn, may lead to ballast failure and PCB leaks. The EPA has adopted a policy of discouraging fluorescent lamp change-outs. Nevertheless, an unpublished analysis by the City of Richland, Washington, and observations from other organizations suggest that relamping and delamping do not increase ballast failure. Because ballasts manufactured before 1978 contain PCBs, and many may still remain in service, the potential for contamination poses a real problem. However, reports of relamping and delamping contributing to ballast failure remain controversial and inconclusive.

The National Institute for Occupational Safety and Health (NIOSH) has data showing that incidents of fluorescent light ballast burnout can release PCBs into indoor air, resulting in concentrations above comparable background levels. According to that data, these concentrations often exceed NIOSH-recommended occupational levels (1 microgram per cubic meter [$\mu\text{g}/\text{m}^3$] total PCBs for up to a 10-hr workday, 40-hr week). The NIOSH also found in a study of Seattle classrooms that ballast burnout resulted in surface contamination, with concentrations at levels approximately twice those found in noncontaminated classrooms. The EPA has recommended a cleanup criterion of $0.001 \mu\text{g}/\text{m}^3$ for surfaces where skin contact is likely.

Requirements for mitigating effects from PCB leaks or spills are given in 40 CFR 761. However, because lighting ballasts (as "small capacitors") are exempted from the requirements of the TSCA, the standards stated in that Act are also not required for cleaning up spills from lighting ballasts. Rather, EPA has published guidelines in the form of a fact sheet to be followed in the event of a leak. The EPA fact sheet describes procedures for ventilating the room as well as for cleaning both absorbent and nonabsorbent surfaces. These guidelines specify equipment, detergents, and solvents to be used, as well as the necessary protective clothing to be worn.

Options for disposal of PCB-laden lighting ballasts are also described in the EPA fact sheet. In general, licensed haulers disposing of PCB-contaminated lighting ballasts treat them as "PCB waste" in accordance with 40 CFR 761. The waste is either buried in a "permitted" landfill (i.e., one approved for accepting chemical waste) or is incinerated in one of the eight

EPA-permitted incinerators. Incineration is encouraged by the EPA, and there is some indication that customers are moving toward that option to avoid future liability problems. However, our small telephone survey indicated that PCB-laden lighting ballasts are usually packed in drums approved by either the EPA or the Department of Transportation (DOT) and transported to a permitted chemical waste landfill (usually Arlington, Oregon) for burial.

We gathered information on the costs of disposing of PCB-laden lighting ballasts from three sources: local haulers of toxic waste; one of the large regional utilities; and a lighting vendor contracted to retrofit commercial buildings. The range of quoted prices is wide. Also, it is difficult to compare prices because they are often given in different units (e.g., weight versus number of barrels or dollars per loaded mile versus dollars per driver hour). Based on these diverse figures, we have tried to estimate approximate disposal costs per ballast for landfill and incineration. These costs range from about \$1.40 to \$15 per ballast, with incineration significantly more costly than landfill burial.

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1.0 INTRODUCTION

The Bonneville Power Administration (Bonneville) has taken a leading role among federal agencies in assessing the environmental impacts of its conservation acquisition programs. These efforts have included extensive research programs into residential ventilation and indoor pollution characterization and monitoring. Bonneville has also prepared three environmental documents under the National Environmental Policy Act of 1969 (NEPA) focusing on indoor air quality issues (Bonneville 1982, 1984, 1988).

One of these documents, the Environmental Assessment of Energy Conservation Opportunities in Commercial-Sector Facilities in the Pacific Northwest (Bonneville 1982), supported conservation programs in existing commercial buildings. Bonneville is now planning the implementation of aggressive commercial conservation acquisition programs in both new and existing buildings. Because of changing information, and because of the change in scope of the programs being designed, Bonneville is now reexamining the potential environmental effects of conservation activities in commercial buildings. Pacific Northwest Laboratory (PNL)^(a) prepared this review of information about polychlorinated biphenyls (PCBs) in commercial buildings to aid Bonneville in its assessment of potential environmental effects.

Polychlorinated biphenyls belong to a broad family of organic chemicals called chlorinated hydrocarbons. The PCBs comprise a family of 209 individual man-made compounds of varying toxicity; seven classes of PCBs represent about 98% of these compounds sold commercially in the United States since 1970. Polychlorinated biphenyls range in consistency from heavy oily liquids to waxy solids. Prior to 1979, PCBs were widely used as coolants in electrical equipment, such as transformers, capacitors, and switches, because the compounds do not easily burn, conduct electricity, or react with other chemicals. When released into the environment, PCBs do not easily decompose. The compounds are relatively insoluble in water and have high solubility in lipids (fats).

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This report focuses on a summary of information about PCBs in fluorescent light fixtures manufactured before 1978. A key issue associated with these PCBs is the potential effect of lamp change-outs on ballast failure. The U.S. Environmental Protection Agency (EPA) speculates that installing energy-efficient lamps in old, PCB-laden ballasts may contribute to ballast failure and PCB leaks, which is addressed in Section 3 of this report. Section 2 discusses applicable standards and regulations; Section 4 describes PCB concentrations in commercial buildings. Sections 5 and 6 discuss clean-up practices and disposal options.

2.0 STANDARDS AND REGULATIONS

Polychlorinated biphenyl (PCB) wastes have inspired a vast, indeed daunting, trail of federal paperwork (see Rodgers 1988). In fact, concern over PCB wastes was one of the principal motivations for enacting the Toxic Substances Control Act of 1976 (TSCA) (Pub. L. 94-469, 15 USC 2601, et seq.). Rules issued by the EPA pursuant to that act remain the primary means of regulating that chemical. This act enables the EPA to regulate the manufacture, distribution, processing, use, storage, and disposal of PCBs in concentrations of 50 parts per million (ppm) or greater, as well as asbestos, dioxin, and chlorofluorocarbons. Activities regulating only the disposal of PCBs are specified in Subsection 6(e)(1) of the TSCA. The pertinent regulations are codified in 40 CFR 761.

While these regulations generally control the marking, storage, and disposal of PCBs, fluorescent light ballasts are excluded from the regulations insofar as they are "small capacitors" (40 CFR 761.60(b)(2)(ii)). However, if the capacitor is leaking, it is regulated, regardless of its size or the exemption provision. At 40 CFR 761.60(b)(2)(ii), "any person may dispose of PCB Small Capacitors as municipal solid waste" unless they are a manufacturer of PCB capacitors; and at 40 CFR 761.3, fluorescent light ballast is defined as a small capacitor, i.e., a "capacitor containing 0.1 kg or less of dielectric." The provision exempting small capacitors was written in to exempt individual households, which would be disposing of only one or two light fixtures at a time and only at infrequent intervals, from having to comply with regulations directed toward the commercial and industrial sectors.

According to the EPA's Region 10 Office,^(a) the EPA's policy is to strongly encourage disposal of PCB-laden light ballasts as a regulated waste as the prudent and environmentally responsible approach, despite its not being a legal requirement. This policy is partly based on the assumption that if there is a large number of ballasts to be disposed of, then there is likely to be at least one leaking capacitor among them, and that leaking capacitor

(a) Telephone conversation with Elaine Barrick, EPA Region 10, on August 8, 1990.

cannot be accepted into a municipal landfill. This policy is articulated in the form of a fact sheet issued by EPA's Region 10 Office in 1985, in which EPA states that arrangements should be made to ship "ballasts, PCB-soiled items, or fluorescent fixtures containing PCBs to an EPA-approved chemical waste processing site: (EPA 1985). The fact sheet goes on to state that "for homeowners ..., small numbers (less than five)) of non-leaking fluorescent light ballasts can be dropped off at one of four collection points maintained by the Seattle-King County Health Department," after which the Department arranges to have the ballasts shipped to an EPA-approved chemical waste landfill for PCBs.

The state of Washington has its own Dangerous Waste Regulations [WAC (ch. 173-303) amended 1989]. According to the Washington State Department of Ecology,^(a) these regulations are more stringent than EPA's and cover PCBs from light ballasts. The regulations provide an exemption (under WAC 173-303-071 "Excluded categories of waste") for wastes whose disposal is regulated under the TSCA, but if the TSCA exempts the waste and Section 071 does not apply, then the material is regulated. Because lighting ballasts are excluded from the TSCA, they fall under the realm of the state's Dangerous Waste Regulations even though, in general, the regulations cover wastes containing PCBs at less than 50 ppm concentration. In WAC 173-303 (p. 142), PCBs are identified as a "state-only listed waste" (i.e., they are an addition to EPA's list of dangerous wastes), and their disposal must comply with the requirements of the regulations. In addition to paperwork required to track the storage and disposal of the waste, the regulations specify licensing requirements for transporters and storage of dangerous waste. They also list detailed requirements for "Generators" (any person who produces the waste in excess of the "quantity limit" of 220 lb), for containers storing the waste, for transporters, and for treatment, storage, and disposal facilities. Under these regulations, only a permitted treatment disposal facility can accept the PCB waste.

(a) Telephone conversation with Dave Davies, Washington State Department of Ecology, June 12, 1990.

Although Oregon has adopted more stringent siting requirements for land-fill and incineration facilities accepting PCBs (Oregon Administrative Rule 340-110), that state has in general adopted the storage and disposal portions of the TSCA. According to the Montana State Department of Health and Environmental Sciences and the Idaho Department of Health and Welfare, neither Montana nor Idaho has adopted state regulations addressing the disposal of PCBs beyond what is required under the TSCA.

3.0 SOURCES OF POLYCHLORINATED BIPHENYLS

Sources of PCBs in commercial buildings are discussed in this section.

3.1 FLUORESCENT LIGHTING FIXTURES

Some of the issues related to the release of PCBs resulting from changes in operating schedules or replacement of fluorescent fixtures, lamps, and ballasts as part of energy conservation retrofits are summarized here. Fluorescent lighting is common in commercial buildings and represents an excellent opportunity for energy savings via retrofit or control strategy modification.

3.1.1 Fluorescent Lamp Ballast Failure

Fluorescent lamps, the predominant type of commercial building lighting, contain electric ballasts as part of the fixtures. The ballast serves the function of providing current-limiting capabilities because the fluorescent tube itself has no inherent current-limiting capabilities. Prior to 1978, most ballasts contained capacitors that used a dielectric fluid consisting of nearly 100% PCBs. The EPA banned the U.S. manufacture of PCBs in 1978. Since that time, most ballast manufacturers have ceased using PCBs in their ballasts, although some foreign manufacturers may still produce ballasts containing PCBs. Ballasts that now do not contain PCBs should be clearly marked "No PCBs." If the ballast does not contain such a marking, it should be assumed to contain PCBs. It should be noted that older ballasts containing PCBs may still be stockpiled in some warehouses.

Ballast failure can result in the discharge of PCBs. During ballast failure, the capacitor may break open, allowing the PCB-contaminated oil to leak from the fixture. Ballast failure is generally accompanied by a rise in the temperature of the ballast. Thus, any excessive heating of the ballast can increase failure rates. Certain retrofit practices, such as a bulb replacement program that combines energy-efficient bulbs with standard ballasts, can result in the excessive buildup of heat in fluorescent ballasts.

The National Electrical Code (NEC) requires that all fluorescent fixtures used indoors incorporate ballast thermal protection. This requirement covers

all but the simple reactor ballast types. As a result of the NEC, Underwriters Laboratory (UL) has developed a standard that requires thermally protected (Class P) ballasts for indoor fixtures. The Class P ballasts meeting the standard contain thermal devices or fuses that open automatically when the temperature of the ballast rises. Only Class P ballasts should be used in fixtures designed for their use. Non-Class P ballasts should be used in earlier fixtures to prevent nuisance tripping and early failure. Improper application of ballasts can lead to early ballast failure and subsequent discharge of PCBs.

The Illuminating Engineering Society (IES) reports field data that indicates a 12-year median ballast life when subjected to a duty cycle of 16 hours per day, 6 days per week, or 5,000 hours per year. The rating on a ballast is based on the observation that the ballast operates at a peak temperature rating for 12 out of the 16 hours each day. The remaining 4 hours represents the ballast warm-up time. Based on the IES data, it appears that a potentially large number of ballasts manufactured prior to 1978 may still remain in service. However, these ballasts should be approaching the end of their useful lives.

3.1.2 Retrofit and Replacement Strategies

Four strategies are generally employed to acquire energy savings from lighting in existing buildings. These strategies involve 1) the delamping of fixtures to reduce lighting levels and energy consumption, 2) the relamping of fixtures by installing energy-efficient bulbs, 3) replacing existing ballasts with energy-efficient ballasts, or 4) total fixture replacement. Delamping may result in earlier ballast failure and the release of PCBs if not performed properly. Relamping cannot be clearly shown to impact PCB release in buildings.

Delamping of fixtures is generally done as an energy-saving measure when existing light levels can be shown to be excessive. A typical delamping operation would remove two bulbs from a four-bulb fixture. During delamping operations, the ballast serving the removed lamps should also be disconnected. Turner (1982) reports that delamping without a disconnection of the ballast results in the ballast continuing to consume power. This, in turn, results in

a shortening of the ballast life, thus accelerating ballast failure. The shortened ballast life results from the ballast continuing to operate and generate heat, even though the lamps are not installed. Delamping is frequently employed in older buildings where lighting levels might be excessive. These older fixtures are more likely to have ballasts that contain PCBs.

Relamping operations involve the changeout of existing fluorescent bulbs with newer, energy-saving bulbs in existing fixtures. When relamping existing fixtures, care should be taken to ensure the matching of lamps and ballasts for best performance and longest life. This is done by combining standard lamps with standard ballasts and power-saving lamps with power-saving ballasts. In a fact sheet (EPA 1985) the EPA cites privately conducted tests that indicate that mixing power-saving and standard lamps and ballasts tends to significantly increase ballast temperatures and decrease ballast life span. These conclusions are somewhat controversial and not necessarily widely supported. Apparently, the EPA position is based largely on the results of a study performed by Electro Systems of Oklahoma (Electro Systems 1981).

The Electro Systems test involved both standard and power-saving ballasts from two manufacturers, as well as standard and power-saving lamps from four manufacturers. The test results showed higher ballast temperatures when power-saving lamps were used with standard ballasts than when standard lamps were used with standard ballasts. Standard lamps used with power-saving ballasts yielded similar higher temperatures. The higher ballast temperatures tend to shorten the ballast life (Valmont Electric 1990, p. 50). One questionable aspect of the tests involves reported ballast temperatures after 20,000 hours of operation, or nearly 2.5 years of continual testing. This test cycle is uncharacteristic of typical commercial lighting operating schedules.

Confidential conversations with a number of companies in the commercial lighting field indicated findings of early ballast failure when energy-efficient fluorescent tubes were combined with existing standard ballasts. No documented reports or data were provided to substantiate their position.

Similar discussions with other organizations did not indicate any significant problems in this area. Dr. Rudy Verderber of the Lighting Research

Group at Lawrence Berkeley Laboratory has taken the position that energy-efficient lamps installed on standard ballasts do not cause early ballast failures. The field experience of utilities located in the Pacific Northwest suggests a similar conclusion; utility staff indicated no observed increase in ballast failures after relamping (Bonneville 1990).

The city of Richland, Washington reported on 12 years of experience with ballast replacement.^(a) The city recorded ballast failure rates over a 3-year period (1979 through 1981) when using standard 40-W fluorescent bulbs. In 1982, nearly 6,000 bulbs in city facilities were replaced with the 34-W energy-saving bulbs. The city continued to record annual ballast failure rates during the time period from 1983 through 1989. Mean ballast failure rates were the same when energy-saving bulbs were combined with standard ballasts, while median ballast failure rates increased by 13.6%. The slightly higher median ballast failure rates may have been due to normal aging of the ballasts, because the ballasts were not replaced at the time of bulb replacement.

Information obtained from a major ballast manufacturer (Valmont Electric 1990) does not clearly address the combining of energy-saving bulbs with standard ballasts and the resulting impact on ballast life. In one comparison of lamp-ballast combinations to assess relative energy savings, the company compares standard ballasts with standard lamps, energy-saving ballasts with either standard or energy-saving lamps, and electronic ballasts with energy-saving lamps. They do not compare the savings of an energy-saving lamp with standard ballast, which is a common retrofit option. Another section of the catalog indicates that certain ballasts are not compatible with reduced-wattage (energy-saving) lamps. The specification table for rapid-start ballasts does indicate allowable combinations of standard ballasts and energy-saving lamps.

Based on the available evidence, it is not possible to clearly conclude that combining energy-saving lamps with existing standard ballasts leads to increased ballast failure. Additional research is needed to resolve the

(a) Letter from J. F. Riedy to Tom Osborn, Bonneville Power Administration, December 28, 1989.

issue. As more of the older ballasts containing PCBs are retired, this will become less of an issue. In many cases, the lighting industry is tending toward complete fixture replacement rather than relamping as a method of achieving greater energy savings. The new fixtures include newer ballasts, thus removing the concern of PCB contamination.

3.2 OTHER LIGHTING FIXTURES

Other lighting fixtures that contain ballasts are known as high intensity discharge (HID) fixtures. The HID fixtures come in several types, such as mercury vapor, metal halide, and high-pressure sodium. In general, these HID fixtures are used in outdoor applications such as parking lot or roadway lighting due to the high light levels produced and the reduced color rendition of the light source. The most common indoor use is in warehouses and high-bay areas. Typically, mercury vapor lights are used inside because of their whiter light, which improves color rendition.

Ballasts for mercury vapor and other HID lights may contain capacitors which may, in turn, contain PCBs. However, no information was readily available that provided any indication of the potential for PCB contamination from ballast failures in HID fixtures. Nevertheless, the potential exists for PCB contamination during ballast replacement.

3.3 OTHER POTENTIAL SOURCES

Electric motors may be an additional source of PCBs. Electric motors may require capacitors, either as a part of the motor itself or as a part of the motor control unit. Some electric motors are of the capacitor-start or capacitor-run variety. These capacitors are included as an integral part of the motor. In the case of motor control units, the capacitors may be included in the control unit itself. All of the capacitors may contain PCBs, and care should be taken when replacement is considered.

Some small electrical and electronic appliances may also contain small amounts of PCBs. Most of these appliances would generally not be considered for replacement as part of an energy conservation program and, thus, would not

be likely to have an impact on PCB concentrations in buildings. No information was readily available that provided any indication of the potential for PCB contamination from these sources.

4.0 POLYCHLORINATED BIPHENYL CONCENTRATIONS IN COMMERCIAL BUILDINGS

In an effort to characterize background and contaminated PCB concentrations, Oatman, Roy, and Grey (1985) found that the average level of airborne PCBs in buildings with transformers containing PCBs was nearly twice the level in buildings without transformers, 0.457 and $0.227 \mu\text{g}/\text{m}^3$, respectively. The sample in this study included four office buildings, two schools, and a state-owned laboratory.

In measurements taken in Seattle classrooms 34 days after ballast burnout, the National Institute for Occupational Safety and Health (NIOSH 1987) found airborne PCB concentrations ranging from 0.74 to $1.2 \mu\text{g}/\text{m}^3$. The PCB levels were much greater immediately after the ballast failure. The NIOSH did not detect PCBs in classrooms that had not experienced burned-out ballasts. Two classrooms had levels greater than noncontaminated rooms 140 days after burnout. The NIOSH reports that these findings are similar to results found by MacLeod in a study of a single ballast burnout. MacLeod found PCB concentrations of $11.6 \mu\text{g}/\text{m}^3$ initially, $1.3 \mu\text{g}/\text{m}^3$ at 31 days, and $0.50 \mu\text{g}/\text{m}^3$ at 61 days after burnout (as reported in NIOSH 1987, p. 8).

MacLeod (as reported in U.S. PHS 1989, pp. 93-94) found that "normal" indoor air in a number of laboratories, offices, and homes had PCB concentrations an order of magnitude greater than PCB concentrations found outdoors. For example, average PCB levels were $0.10 \mu\text{g}/\text{m}^3$ in an industrial research building and $0.21 \mu\text{g}/\text{m}^3$ inside the building's laboratories, compared with $<0.02 \mu\text{g}/\text{m}^3$ outside the facility. The average PCB level inside one home was $0.31 \mu\text{g}/\text{m}^3$, while outside on the same day the level was $0.004 \mu\text{g}/\text{m}^3$. MacLeod suggested that certain electrical appliances, such as fluorescent lighting ballasts, which have PCB-containing components, can emit PCBs into the indoor air, thus pushing indoor concentrations above those found outdoors. The NIOSH (1987, p. 6) reports typical background concentrations in commercial office buildings ranging from below detection to $0.33 \mu\text{g}/\text{m}^3$.

These data show that incidents of fluorescent light ballast burnout can release PCBs into indoor air and result in concentrations above comparable background levels. Further, the contamination may exceed NIOSH-recommended occupational levels. The NIOSH-recommended standard for occupational exposure

is a time-weighted average of $1 \mu\text{g}/\text{m}^3$ total PCBs in air for up to a 10-hour workday, 40-hour work week (NIOSH 1987, p.6). The Occupational Safety and Health Administration (OSHA) permissible occupational exposure limits are 0.5 and $1.0 \text{ mg}/\text{m}^3$ for specific PCBs for an 8-hour workday (U.S. PHS 1989, p. 7).

4.1 SURFACE CONTAMINATION FROM BALLAST FAILURE

Ballast failure may also lead to surface contamination. The NIOSH (1987) found that PCB concentrations in classrooms with burnout ranged from below detection to $2.4 \mu\text{g}/100 \text{ cm}^2$. The classrooms without burnout ranged from below detection to $1.2 \mu\text{g}/100 \text{ cm}^2$. The mean concentration of the contaminated rooms was about twice that of the noncontaminated rooms, 0.57 and $0.23 \mu\text{g}/100 \text{ cm}^2$, respectively. Oatman, Roy, and Gray (1985) also found that PCB surface levels may be elevated in buildings with contaminated transformers, as compared to other buildings.

The NIOSH investigators use 50 to $100 \mu\text{g}/\text{m}^2$ as a guideline to assess PCB exposure from contaminated surfaces in commercial office buildings (NIOSH 1987, p.7). The EPA has recommended a clean-up criterion of $0.001 \mu\text{g}/\text{m}^2$ for surface areas where high skin contact is likely (52 FR 10688). The NIOSH (1987, p. 7) reports typical background surface concentrations in commercial office buildings ranging from below detection to $21 \mu\text{g}/\text{m}^2$.

4.2 CONTAMINATION FROM FIRE

In addition to ballast failure, fire may also cause PCB contamination in buildings. Fire-related incidents are defined as incidents in which heat from any source causes the release of PCBs from electrical equipment casings. In soot-producing incidents, an actual fire exposes PCBs to extremely high temperature and forms black carbonaceous material. Polychlorinated biphenyls have been identified in soot following numerous electrical equipment fires (NIOSH 1987).

5.0 MITIGATION

Fluorescent light ballasts manufactured before 1978 contain about 1.5 oz of PCB fluid in the capacitor. If the capacitor ruptures as part of a ballast failure, PCB fluid will drip out of the fixture, thus constituting a "release" or "leak." The requirements for cleaning up and other measures to mitigate leaks of PCB are addressed under the PCB Spill Cleanup Policy (52 FR 10688) articulated as part of the TSCA (40 CFR 761). However, since lighting ballasts are exempted from the TSCA, and because the amount of PCB released is so small (1.5 oz) that it is not strictly characterized as a "spill," the standards articulated in 52 FR 10688 (Part IV) are also not required for cleanup of PCB spills from lighting ballasts.

Rather, EPA specifically addresses PCBs in light fixtures in a fact sheet (EPA 1985), which offers guidelines to be followed to clean up leaks. The first is to vacate and ventilate the room. Mitigation procedures are given for nonabsorbent and absorbent materials. Nonabsorbent surfaces (e.g., tabletops, uncarpeted floors) contaminated with PCBs are to be cleaned twice with one of the following specified solvents: mineral spirits, deodorized kerosene, turpentine, or rubbing alcohol. To avoid further spreading the contamination by wiping it with the solvent, the bulk of the material should first be removed with a spatula or paper towel (NIOSH 1984). Certain detergents containing trisodium phosphate may also be used, but only at full strength, applied directly with a cloth rather than diluted in a bucket. (The PCB-laden cloth dipped into a solution of water and detergent would contaminate the solution, thus making it illegal to dispose of it in the sewer system). Leaks onto absorbent materials (e.g., carpet) cannot be cleaned; the only option is to cut out and dispose of the contaminated material (NIOSH 1987). All contaminated materials used to clean up the leak (e.g., rubber gloves, clothing, cleaning rags) should be disposed of as described in Section 6.

6.0 POLYCHLORINATED BIPHENYL DISPOSAL

The options available for disposing of PCBs are summarized in this section. The costs associated with those disposal options are also discussed.

6.1 DISPOSAL OPTIONS

Strictly speaking, it is legally possible to dump a PCB-laden lighting ballast into any landfill so long as the capacitor is not leaking. In practice, most municipal landfills will not accept them. Also, in practice, licensed haulers disposing of large numbers of such ballasts treat it as "PCB waste"; thus, in accordance with the TSCA, they are limited to two options: a Class-1 landfill (approved for accepting chemical waste) or incineration. Although both Bonneville and the EPA explicitly stated a preference for incineration, and both said "they strongly encourage" the incineration option, that option is neither required nor routinely chosen. Our informal telephone survey (admittedly a very small sampling) found only three cases which routinely chose to incinerate lighting ballasts. For the most part, PCB-laden lighting ballasts are packed in EPA-approved (i.e., conforming to the requirements of TSCA, 40 CFR 761.65) 55-gal drums and transported to a Class-1 landfill, which locally tends to be Arlington, Oregon.

A list (as of April 1989) of the EPA-permitted incinerators and chemical waste landfills (i.e., can accept PCBs) is included with this report as Appendix A. Of the eight incinerators, five are in the East and three in the Midwest; none is in the West. Bonneville indicated that two new incineration plants were scheduled for operation in Arizona by the end of 1989, although they were not on the list provided us by the EPA.^(a) There are 10 permitted chemical waste landfills. Thirteen applications for PCB disposal sites are pending, two of which are from companies in Oregon.

(a) Memo from Bob Guddat to Phyllis Dourty regarding "Review Comments on Appendix B to Commercial Consistency Review Report--PCB Contamination Report in Commercial Buildings." May 3, 1989.

6.2 COST INFORMATION

The number of disposal options is limited to two, but the number of different prices quoted by various haulers of toxic waste, as well as lighting vendors and utilities who contract with haulers to dispose of their PCB-laden equipment, makes a wide range as shown in Table 6.1. We gathered cost information from three different types of sources: local (Seattle and Portland) haulers of toxic waste; one of the large regional utilities; and a major lighting vendor having a number of contracts for replacing old lighting fixtures in commercial buildings. For the most part, disposal costs were given for ballasts in a four-lamp fixture (48 in.), which has two ballasts, each weighing about 4 lb. These are packed in a 55-gal drum, which holds 175 to 300 ballasts, depending on the size of the ballast, the competence of the packer, and which hauler you ask.

6.2.1 Local Haulers

A general manager at one of the region's larger companies handling toxic waste offered the following information on their procedure for disposing of PCB-contaminated lighting ballasts. This same procedure is generally followed by the other haulers. They use the standard 55-gal drums, with a Washington state identification number or an EPA identification number for hazardous waste. The whole ballast is packed in the drum. With normal 4-ft or 8-ft lamps, the drum holds 175 to 250 ballasts. In general, a partial drum costs

TABLE 6.1. Summary of Estimated Disposal Costs for Lighting Ballasts

<u>Source</u>	<u>Landfill (\$/Ballast)</u>	<u>Incineration (\$/Ballast)</u>
Hauler 1	1.98+	4.23
Hauler 2	1.49+	--
Hauler 3	1.28+	--
Hauler 4	3.00	15.00
Hauler 5	--	14.00
Utility	--	5.30
Lighting Vendor	1.67	5 to 6.00 (or 1.86 if only the capacitor)

as much to dispose of as a full one (the landfill cost). The packed drum is transported from the site to the hauler's storage facility, where it is stored until they have a full truck load (about 40 drums) of hazardous waste; about four trucks per week go to the Arlington, Oregon, landfill. Because this material is buried, the pricing is on a per drum basis, not by weight; the drum space takes up landfill space.

One of their sales representatives cited the following prices. A profile approval sheet costs \$100.00 (this is required paperwork that accompanies the waste and allows it to be transported and accepted into the landfill); \$210.00 per drum covers the landfill disposal and the transportation from Seattle to Arlington. Transport from the pickup site to the storage facility is \$77.00 per hour; this hourly rate is for the truck traveling from the hauler's garage facility in Tacoma, to the pickup site, to the storage facility in South Seattle, and back to Tacoma. They said one can assume a maximum of 8 hr of local transportation (\$616.00) to pick up 10 drums. This hauler did not cite prices for removing the ballasts or packing them or for the drum itself. According to the sales representative, an electrical firm usually handles the removing and packing, which is consistent with the information from the lighting vendor (Section 6.2.3). When this hauler provides the drum, they charge about \$80 per drum. Table 6.2 presents an estimate of the cost per ballast based on this cost information. To reflect all of the costs, the estimate adds the price of the drum and a labor charge for packing the ballasts (using the price quoted by one of the other haulers to split out this activity). Assuming 200 ballasts per drum, the cost per ballast is slightly more than \$1.98. If this hauler is asked by its customer to incinerate the material, the cost is \$660.00 per drum for incineration and transportation from Seattle to the Rollins facility in Texas. All other charges remain the same, making the total slightly more than \$4.23 per ballast.

A major Portland-based disposal company gave the following information on its disposal procedure and prices. Company personnel remove and pack the whole ballast in 55-gal drums and ship them to EnviroSAFE Services Inc. (ESI's) Class-1 landfill in Boise, Idaho. This company cited the following figures: \$200.00 per drum for landfill disposal and transportation from its

TABLE 6.2. Cost Estimates for Hauler 1

<u>Charges</u>	<u>Landfill Costs</u>	<u>Incineration Costs</u>
Profile Sheet ^(a)	\$100.00/site	\$100.00/site
Landfill Disposal ^(b)	210.00/drum	--
Local Transportation ^(c)	61.60/drum	61.60/drum
Drum	80.00	80.00
Packing Ballast ^(d)	45.00 ^(d)	45.00 ^(d)
Incineration	--	660.00
Total/Drum	396.60 + profile fee	846.60 + profile fee
Total Ballast ^(e)	1.98 + profile fee	4.23 + profile fee

- (a) Since profile sheets are per site pickup, they cannot be disaggregated into costs per drum or ballast without knowing the number of drums per pickup.
- (b) Includes transportation from Seattle to Arlington, Oregon, disposal site.
- (c) $\$77.00/\text{hr} \times 8 \text{ hr} = \$616.00/10 \text{ drums (assumed)} = \61.60
- (d) Taken from Hauler 3's quoted estimates.
- (e) Assuming 200 ballasts/drum.

facility to the disposal site; the \$100.00 profile fee; a \$50.00 pickup fee within the Portland metropolitan area, or \$3.25 per loaded mile for transportation outside the Portland area from the pickup site to their storage facility. An estimate of disposal cost per ballast (slightly more than \$1.49) is given in Table 6.3.

The third waste hauler is one of the two regional companies that has applied to the EPA for PCB disposal. This company cited the following figures used to charge customers for hauling 10 drums of PCB-contaminated waste to the Arlington landfill: \$45.00/hr for driver; \$120.00/day for truck; 8 to 10 per hr round trip from Portland to Arlington; \$100.00/drum for landfill burial; two persons to package 10 drums at \$45.00/hr for 4 to 6 hr; \$52.00 charge for each 55-gal drum; and \$12.00 for packing material. These figures are used to estimate a per-ballast disposal cost of slightly more than \$1.28, the lowest figure quoted, as shown in Table 6.4.

TABLE 6.3. Cost Estimates for Hauler 2

Charges	Costs
Profile sheet ^(a)	\$100.00/site
Landfill disposal ^(b)	200.00/drum
Local transportation	50.00 or \$3.25/loaded mile ^(c)
Drum and packing material	36.00/drum ^(d)
Packing ballasts	11.67 ^(e)
Total/drum	267.67 + profile fee
Total/ballast	1.49 + profile fee

- (a) Since profile sheets are priced per site pickup, their costs cannot be disaggregated into costs per drum or ballast without knowing the number of drums per pickup.
- (b) Includes transportation from its Portland facility to a disposal site in Idaho.
- (c) \$50.00 pickup fee if within the Portland metropolitan area; \$3.25/loaded mile if outside the metropolitan area (e.g., Eugene). We used the minimum \$50.00 charge to estimate total price per ballast.
- (d) \$30.00 for each drum and \$6.00 vermiculite (two bags @ \$3.00 each to fill the barrel).
- (e) \$35.00/man-hour divided by three drums/hour for one man = \$11.67.

In comparison, the Milwaukee, Wisconsin School District project reported \$2.00 per ballast to incinerate the ballasts (Baechler 1989), and Bonneville (1989) has cited \$1.50 per ballast for landfill disposal.

More recent conversations with two other waste handler/haulers indicated that more customers are requesting that the waste be incinerated, citing fear of future liability. Both haulers also indicated that complying with the additional requirements for notification and manifesting (additional recordkeeping and reporting requirements) that "constitute the PCB waste tracking system" that went into effect February 5, 1990 (54 FR 52716) have increased the prices for PCB disposal. One hauler cited about \$4.00/lb for

TABLE 6.4. Cost Estimates for Hauler 3

<u>Charges</u>	<u>Costs</u>
Profile sheet ^(a)	\$100.00/site
Packing ballasts	45.00/drum ^(b)
Drum and packing material	53.20/drum ^(c)
Transportation	57.00/drum ^(d)
Landfill disposal	100.00/drum
Total/drum	255.20 + profile fee
Total/ballast	1.28 + profile fee

- (a) Since profile sheets are priced per site pick-up, their costs cannot be disaggregated into costs per drum or ballast without knowing the number of drums per pickup.
- (b) Two persons to package ten drums at \$45.00/hour for five hours = \$450.00.
- (c) \$52.00 for each drum + \$12.00 vermiculite for ten drums (\$1.20/drum) = \$53.20.
- (d) \$45.00/hour x 10-hour round-trip from Portland to Arlington + \$120.00/truck = \$570.00/10 drums = \$57.00.

transport and incineration, or a total of about \$3000 for "repackaging," paperwork, storage, transport and incineration of one drum of PCB ballasts (she also cited about \$600/drum for landfill disposal), for an extraordinarily high \$15.00/ballast. The other hauler quoted \$3.00 to 3.50/lb for transport and incineration from the West Coast to the Rollins incinerator in Texas. The first hauler estimated the weight at 600 lb; the second estimated 700 lb. For some measure of comparability, we will ignore these cited weights and continue to assume 200 ballasts in a drum to estimate a cost per ballast. Therefore, the cost per ballast from the first hauler would be about \$15 and \$14 from the second hauler.

6.2.2 Large Utility

According to an Environmental Affairs staff person at one of the region's largest utilities, the utility has a contract with one of the eight EPA-permitted incinerator companies to dispose of all of its PCB-contaminated material (e.g., transformers, lighting ballasts, soil, clothing). This

utility's contract distinguishes between leaking and nonleaking equipment. Nonleaking ballasts are packed in wooden boxes by the utility; leaking or seriously damaged light ballasts are packed in the approved 55-gal sealed drums, along with other PCB-contaminated material, and treated as a PCB waste. In both cases, they are picked up at the utility's salvage area by the disposal company and transported to the company's facility in Coffeyville, Kansas, where they are incinerated. The utility pays \$0.48/lb for incineration of nonleaking material and \$0.70/lb for incineration of leaking material. These are strictly incineration costs. In addition, it pays \$3.00 per loaded mile, for a transportation cost of \$4,500. Assuming 10 drums, 200 ballasts at 4 lb each in a 55-gal drum weighing about 70 lb, this would be 870 lb X \$0.70 for about \$609/drum, plus \$450.00 for transportation. This totals \$1,059/drum, or about \$5.30/ballast.

As a final note: two of the region's utilities with large commercial retrofit programs do not specify to the building owner or contractor how to dispose of the replaced ballasts. They simply provide information in the form of the EPA fact sheet (EPA 1985) describing removal options, and leave it to the building owner to dispose of them.

6.2.3 Lighting Vendor

This represents an atypical report. A major lighting vendor in Orange County, California (with a branch office in Seattle) has a contract with the state of Hawaii to replace 8000 ballasts. A subcontractor is handling the removal and disposal of the old lamps. The subcontractor has cut the ballasts in half and removed and packed the capacitors in the standard 55-gal drums. The drums are shipped by barge to the mainland and by railroad cars to an approved incinerator in Arkansas. This lighting vendor quoted \$1.86/ballast for removing, separating, shipping, and incinerating. The vendor said it would have cost \$5.00 to \$6.00 for disposing of (incinerating) the whole ballast because of the increased weight. This example is anomalous for the following three reasons:

- The vendor chose the incineration option over burial in a landfill
- The capacitor was separated from the ballast and only the capacitor was incinerated

- The price quoted for incineration is dramatically lower than that quoted by the other sources reporting incineration prices. For one of its California contracts, this lighting vendor buries the whole ballast in a Class-1 landfill (Kettleman City, California) at \$4.50 per ballast, indicating the higher cost of waste disposal in California.

This lighting vendor also has a major retrofit project in Seattle, where it uses a local (Seattle) hauler to dispose of the old fixtures. In this case, the lighting vendor packed 2700 ballasts in ten 55-gal drums. The capacitor was not separated from the ballast; rather, the whole ballast was packed in a drum and buried in the Arlington landfill. The vendor cited a cost of about \$1.50/ballast for disposal, which includes everything except packing the drum because the lighting contractor does that and incurs the cost. It includes the price of the drums, which are purchased from the hauler for \$40.00 each. If the \$45.00/drum packing charge is added, the total price per ballast disposal is about \$1.67 ($\$45/270 \text{ ballasts} = \$0.17 \text{ plus } \$1.50 = \1.67).

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APPENDIX A

POLYCHLORINATED BIPHENYL DISPOSAL COMPANIES

APPENDIX A

POLYCHLORINATED BIPHENYL DISPOSAL COMPANIES

The companies listed below are commercially permitted (as of April 10, 1989) to dispose of PCBs. An asterisk after a company name indicates that company is permitted to operate in all 10 EPA regions.

<u>Company</u>	<u>Address</u>
<u>Incinerator</u>	
ENSCO	P.O. Box 1957 El Dorado, AR 71730
ENSCO*	P.O. Box 8513 Little Rock, AR 72215-8513
General Electric	100 Woodlawn Ave. Pittsfield, MA 01201
Pyrochem/Aptus	P.O. Box 907 Coffeyville, KS 67331
Rollins	P.O. Box 609 Deer Park, TX 77536
SCA Chemical Services	11700 South Stony Island Ave. Chicago, IL 60617
U.S. Department of Energy/ Martin Marietta Energy Systems	Federal Office Building Room G-108 P.O. Box E Oak Ridge, TN 37830
WESTON*	One Weston Way West Chester, PA 19380
<u>Chemical Waste Landfills</u>	
Casmalia Resources	559 San Ysidro Road P.O. Box 5275 San Barbara, CA 93150
CECOS International	56th St. & Niagara Falls Boulevard Niagara Falls, NY 14302
CECOS International	5092 Aber Road Williamsburg, OH 45176

<u>Company</u>	<u>Address</u>
<u>Chemical Waste Landfills (contd)</u>	
Chemical Waste Management	Alabama Inc. Box 55 Emelle, AL 35459
Chemical Waste Management	Box 471 Kettleman City, CA 93239
Chem-Security Systems Inc.	Star Route Arlington, OR 98712
Envirosafe Services Inc. of Idaho	P.O. Box 417 Boise, ID 83701
SCA Chemical Services	Box 200 Model City, NY 14107
U.S. Ecology, Inc.	Box 578 Beatty, NV 89003
U.S. Pollution Control, Inc.	Grayback Mountain Knolls, UT 84074

APPENDIX B

ORGANIZATIONS CONSULTED

APPENDIX B

ORGANIZATIONS CONSULTED

Bonneville Power Administration
Chemical Handling Corporation
Environmental Protection Agency
Tacoma City Light
Seattle City Light
Sylvania Lighting Co.
ChemPro
Western Compliance Service
Reidel Environmental Services
Electric Power Research Institute
Northwest EnviroService Inc.
Washington State Department of Ecology
Oregon Department of Environmental Quality
Idaho Department of Health and Welfare
Montana State Department of Health and Environmental Sciences

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