Appliance Recycling Guide

1.0 Introduction

In 1991, about 3.4 million appliances (536,000,000 pounds) were discarded in California. Included were refrigerators, freezers, clothes dryers, washing machines, dishwashers, microwave ovens, ranges/ovens, furnaces, hot water heaters, and air conditioners.

The California Legislature determined that major appliances and other large metallic discards in solid waste landfills needlessly uses scarce landfill capacity and that these items can be effectively separated from the waste stream and recycled. On January 1, 1994, a new law took effect in which the objective was to divert appliances and other large metallic discards from disposal and to recycle these items in an environmentally sound and safe manner. A primary provision of this law is the requirement to remove special materials from major appliances and other large metallic discards prior to crushing the discard for transport or transferring to a baler or shredder for recycling.

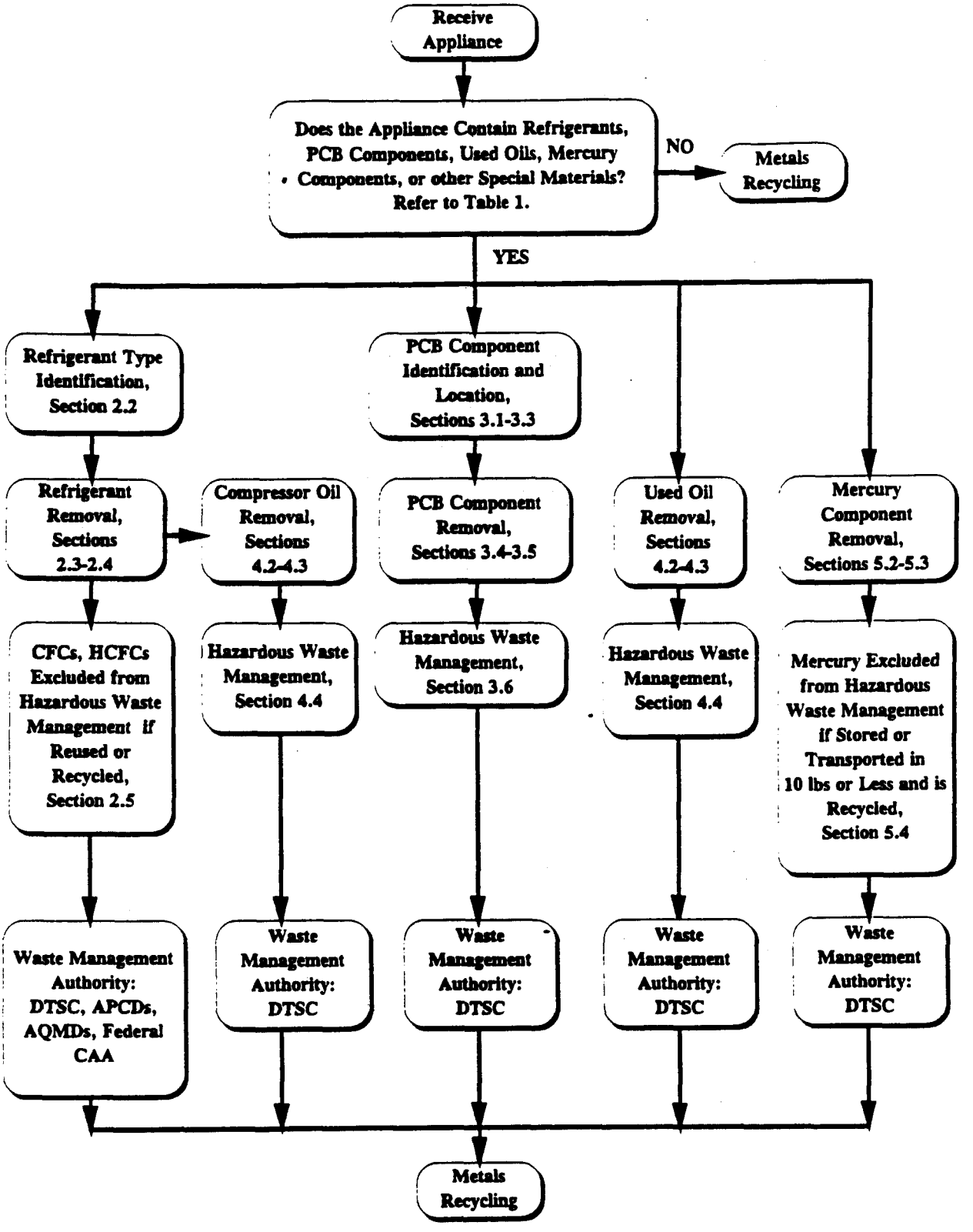
The special materials specifically outlined in this law are chlorofluorocarbons (CFCs) used as refrigerants in air conditioning and refrigeration equipment, polychlorinated biphynels (PCBs) used in some motor capacitors and fluorescent lighting ballasts, and sodium azide used to inflate automobile air bags. Sodium azide will not be an issue of discussion for this recycling guide since most vehicles are already diverted from solid waste facilities. This law also requires the removal of other special materials regulated by the Department of Toxic Substances Control such as used oil found in compressors and transmissions and mercury found in switches and temperature control systems.

This recycling guide is developed to assist those persons in the disposal and recycling sectors who intend on processing appliances and the special materials contained within them. This guide is not intended for use by the home repair person, known as the do-it yourselfer.

The appliance recycling guide focuses on the; 1) identification of special materials which require removal, 2) special materials removal and extraction methods, 3) identification of health and safety hazards in removing and handling special materials, and 4) management of special materials in accordance with state and federal regulations.

The appliance management system is shown in Figure 1. Section numbers refer to sections within this guide. A matrix of appliances and special materials contained within these appliances is shown in Table 1. These appliances are either known to contain or have a likelihood of containing special materials.

Figure 1
Appliance Management System



DTSC - Department of Toxic Substances Control
APCDs - Air Pollution Control Districts
AQMDs - Air Quality Management Districts
CAA - Clean Air Act

Table 1
Special Materials Matrix

Discard	Refrigerants							PCB Capacitor / Ballasts*	Lubricant Oil	Mercury Switches
	CFC-12	CFC - 114	HCFC - 22	SO2	NH3	CFC-500	CFC-502			
Refrigerator	X	X		X	X				X	
Freezer	X				X				X	X
Window A/C			X			X	X	X	X	
Central A/C			X					X	X	
Dehumidifier	X					X			X	
Microwave								X		
Clothes Washer									X	X
Fluorescent Lighting								X		
Gas Stoves										X
Water Heaters										X

*** Pre 1979 appliances with a significant likelihood of containing PCB capacitors or ballasts There have been suggestions that some refrigerators and freezers contain PCB capacitors.**

2.0 Refrigerants

2.1 Discards Containing Refrigerants

The types of refrigerants typically found in appliances are CFC-12 in refrigerators, freezers, and dehumidifiers and HCFC-22 in window and central air conditioners[1]. CFC-114 may also be found in a small percentage of refrigerators. Some older refrigerators may also contain sulfur dioxide as the refrigerant and the occurrence of these in the waste stream is minimal, ranging from 2-5%[3,4]. A significantly fewer number of older refrigerators and freezers may contain ammonia as the refrigerant. Some dehumidifiers may contain CFC-500[1] and few window air-conditioning units may contain CFC-500 or CFC-502[4]. Some new refrigerators contain refrigerant HFC-134a but these units are not occurring in the disposal or recycling streams at this time.

2.2 How to Identify Types of Refrigerants

Knowing the refrigerant type prior to extraction from the unit is very important. Mixing different types of refrigerants will most likely contaminate a load thereby rendering it non-recyclable. Ask your refrigerant reclaimer about refrigerant acceptance specifications.

The first step in determining the type of refrigerant used in an appliance is to look at the identification tag attached to the unit (see Figures 2 & 3). The location of the tag varies as to the manufacturer and for refrigerators and freezers, it may be located on the front or back of the unit, inside the refrigerated compartment or on side of the door, or on the compressor unit[10,11]. For window or central air-conditioning units, removal of the face plate or other external body panels may be required to locate identification tag[10].

One physical characteristic used to identify ammonia and sulfur dioxide refrigerators is the compressor. The compressor used in ammonia and sulfur dioxide refrigerators are approximately 2-3 times larger by volume than the compressors within CFC type refrigerators[11].

The tops of sulfur dioxide and ammonia refrigerators are typically constructed as a separate section unlike the unibody of the CFC units (see Figures 3 & 4)[11]. The evaporator coil is located directly underneath this top section[19].

Refrigerators containing ammonia refrigerant usually require natural gas to operate them and can be identified by looking on the back of the unit for a natural gas hook-up[3]. Note: there may also be an electrical cord attached which is used only for the light within the refrigerator.

Figure 2

Sample Refrigerant Identification Tag

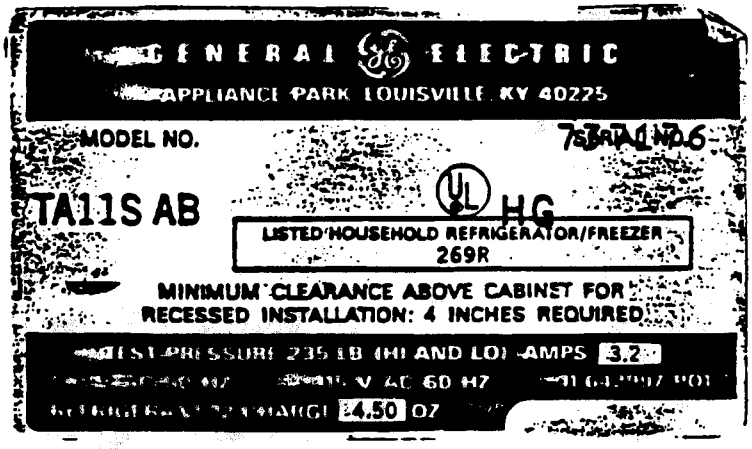


Figure 3

Refrigerator Components (Typical Configuration)

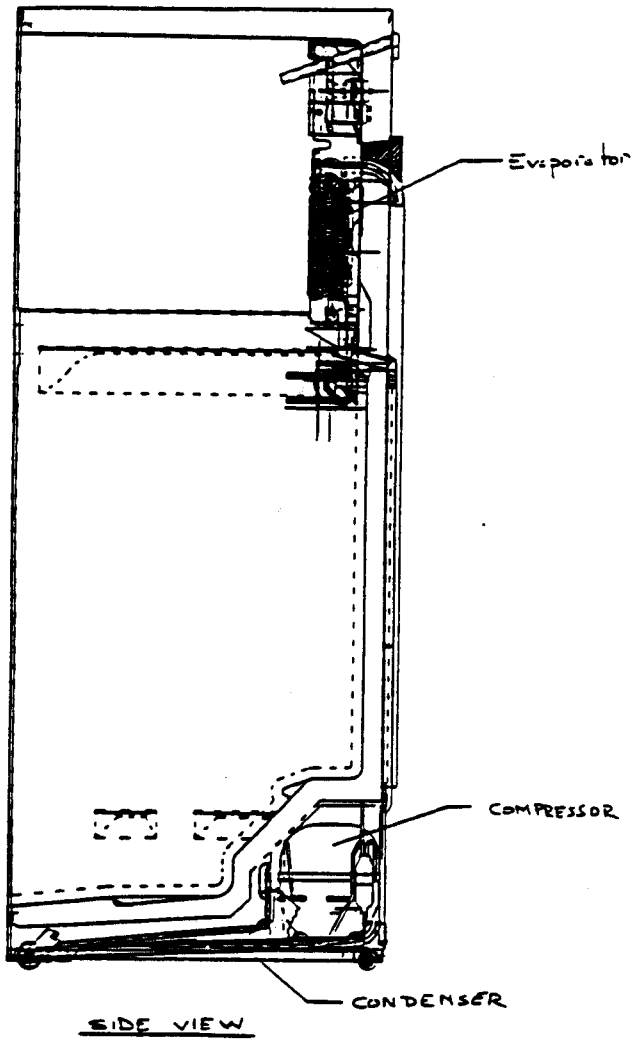


Figure 4

Top Configurations of Sulfur Dioxide and Ammonia Refrigerators

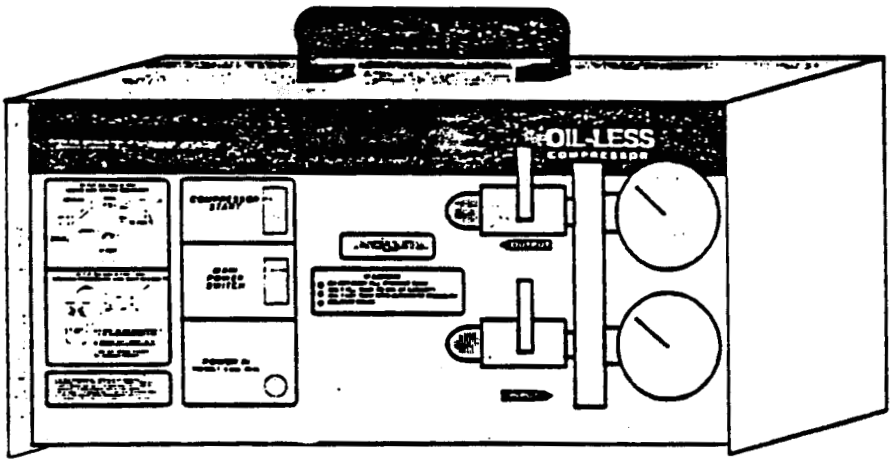


Figure 5

Refrigerant Extraction Set-up Configuration

A test which is used by some appliance recyclers to determine type of refrigerant is the pressure/temperature test. The type of refrigerant is determined by measuring the pressure within the system and the external atmospheric temperature. There are charts available which correlate the type of refrigerant to the known pressure and temperature. This method may result in inaccurate readings because of low system pressures. Refrigeration or air conditioning units in the recycling and disposal sectors may have reduced system pressure due to leakages caused during handling or system failure.

Note: The pressure/temperature method does not work well in determining whether a certain refrigerant and air conditioning unit contains CFC-12 or HFC-134a because both of these refrigerants operate at similar conditions[12].

If the refrigerant type is still unknown, call your refrigerant reclaimer or equipment manufacturer for further information. One appliance recycler is storing all unknown refrigerants into a container labeled as "mixed" refrigerants. Although this container would be managed as hazardous wastes, it would keep from contaminating other loads of recyclable refrigerants[14].

2.3 Refrigerant Extraction Methods

Tools / Equipment Needed

The basic tools and equipment needed for extracting refrigerants are; 1) piercing valve, 2) recovery or recycling equipment, and 3) storage containers.

The piercing valve is used to puncture the refrigeration coil to allow the transfer of refrigerant from the air conditioning or refrigeration system to the recovery or recycling equipment (see Figure 5).

There are two types of equipment that are used to extract refrigerant from appliances; recovery and recycling. The recovery equipment removes the refrigerant from an appliance and transfers it to a storage tank without further processing. Two types of recovery equipment are system-dependent and self-contained. The system dependent recovery equipment requires the assistance of components contained in an appliance to remove the refrigerant from the appliance. The self-contained recovery equipment is capable of removing the refrigerant from an appliance without the assistance of components contained in the appliance.

Recycling equipment removes the refrigerant from an appliance and then cleans the refrigerant by oil separation and cycling through one or more filter dryers to remove moisture, acidity, and particulate matter. The refrigerant is then transferred back into the appliance or to a storage tank. Recycling equipment would typically be used by those individuals in the appliance repair sectors because the refrigerant extracted is typically put back into the appliance after repairs or maintenance operations.

Persons in the disposal and recycling sectors do need to certify to the US EPA that such person has acquired recovery equipment that is capable of either:

1. **Removing 90% of the refrigerant when the compressor of the small appliance is operating and 80% of the refrigerant when the compressor of the small appliance is not operating.**

2. **Evacuating the small appliance to four inches of vacuum when tested using a properly calibrated pressure gauge.**

The recovery equipment may include system-dependent equipment or self-contained equipment.

Refrigerant Extraction

To begin the refrigerant extraction process, the piercing valve is attached to either the high pressure side or low pressure side of the compressor. The high pressure side of the compressor is the line connected between the compressor and the condenser. The low pressure side of the compressor is the line between the compressor and evaporator (see Figure 3). In some operations, piercing valves are placed on both the high and low pressure sides of the compressor.

Note: If air conditioning and refrigeration equipment has been non-operational for a period of time, the pressure within the system equalizes and consequently there is no distinction of pressure at either side of the compressor.

The refrigerant recovery unit is then attached to the piercing valve, and with the valve opened and the recovery unit on, refrigerant is extracted. Several refrigeration systems may be evacuated at one time (manifolded) depending on the type of equipment used. The time of refrigerant extraction is dependent on the equipment or process used. It is recommended that the equipment manufacture be contacted for equipment and process specifications. Persons in the disposal sector who are recovering refrigerant from air conditioning and refrigeration units must either:

1) **Recover 90% of the refrigerant in the appliance when the compressor in the appliance is operating, or 80% of the refrigerant in the appliance when the compressor in the appliance is not operating; or**

2) **Evacuate the small appliance to four inches of mercury vacuum.**

The refrigerant is then either transferred to an internal storage tank within the recovery unit or is transferred directly to an external tank. Once the capacity of the internal storage tank has been achieved, the refrigerant needs to be transferred to external storage tanks. External storage tanks are usually supplied by a refrigerant reclaimer.

Your refrigerant reclaimer should be contacted for storage, used refrigerant specifications, and shipping guidelines.

2.4 Hazards / Safety Precautions

All employers must have a Material Safety Data Sheet (MSDS) for any workplace product that contains a hazardous substance(s), and must make it available to employees on request. An MSDS lists the hazardous chemical contents of a product, describes its health and safety hazards, and gives methods for using, storing and disposing of it safely. The employer may obtain an MSDS from the manufacturer of the product which contains the type of refrigerant. An example MSDS for fluorocarbons, sulfur dioxide, and ammonia is provided in appendix A.

The Hazard Evaluation System and Information Service (HESIS) produces fact sheets, booklets, and technical documents on work place chemicals. A HESIS fact sheet regarding fluorocarbons is provided in appendix B. HESIS fact sheets are designed as an aid for worker training programs and does not take the place of an MSDS. The HESIS office is located in Berkeley, California, and can be contacted at (510) 540-3138.

Employees should be trained on operational and safety aspects of any equipment used during refrigerant extraction. Employees should also be trained in first aid.

Persons in the disposal and recycling sectors do need to certify to the US EPA that such person has acquired recovery equipment that meets certain requirements (see prior discussion on Tools / Equipment Needed).

California Law

Section 25143.2(d)(7), Chapter 6.5, Division 20, Health and Safety Code (HSC), excludes CFC or HCFC compounds removed from heat transfer equipment, fire extinguishing products, or rigid foam products, from being regulated as hazardous wastes, provided the materials are reused or recycled and specified conditions are met. These conditions are set forth in HSC sections 25143.2(e), 25143.2(f), and 25143.9. Additionally, reporting requirements for recyclers operating under an exclusion are set forth in HSC section 25143.10. If CFC or HCFC compounds are managed in ways other than recycling, such as incineration, or if the specified conditions for the exclusion are not met, the CFC or HCFC compounds would be hazardous wastes, and would remain subject to all hazardous waste management requirements.

Persons with questions concerning the applicability of a recycling exclusion to a particular case regarding CFC of HCFC compounds may contact the nearest regional DTSC office. See Appendix E for addresses and telephone numbers of regional DTSC offices.

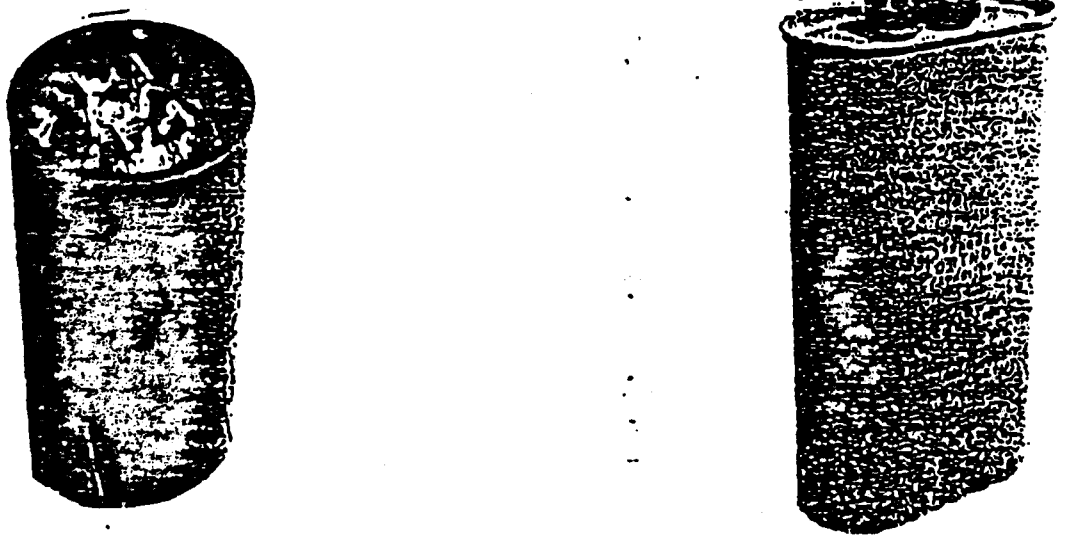
Although there are certain appliances that have been known to contain a capacitor(s), a capacitor(s) may have been installed in other appliances during repair operations. To be sure if an appliance does or does not contain a capacitor(s), all appliances should be visually inspected.

3.2 Physical Characteristics / Location

Starting capacitors are typically cylindrical in shape and the casing is predominately a black bakelite (plastic) material or aluminum shell. Some earlier type capacitors may be cardboard wrapped. Running capacitors are typically oval or rectangular in shape with a sealed metal casing[15] (see Figure 6).

Appliances which contain motors, such as washers and refrigerators, will usually have the motor located near the bottom and can be accessed from the rear. The capacitor, which is usually a starting capacitor, will be attached to the housing of the motor and may be covered in a protective casing[16]. If not attached to the housing, the capacitor, if any, may be located by following the wires from the motor.

Both window and central air conditioners may have a combination of starting and running capacitors, possibly up to four capacitors total. The casing of the air conditioners will have to be removed prior to inspection for capacitors. The capacitors will typically be attached to the fan motor and the compressor. For window air conditioning units in particular, the capacitor(s) will typically be located directly behind the control panel[16] (see Figure 8).



Starting Capacitor

Running Capacitor

Figure 6

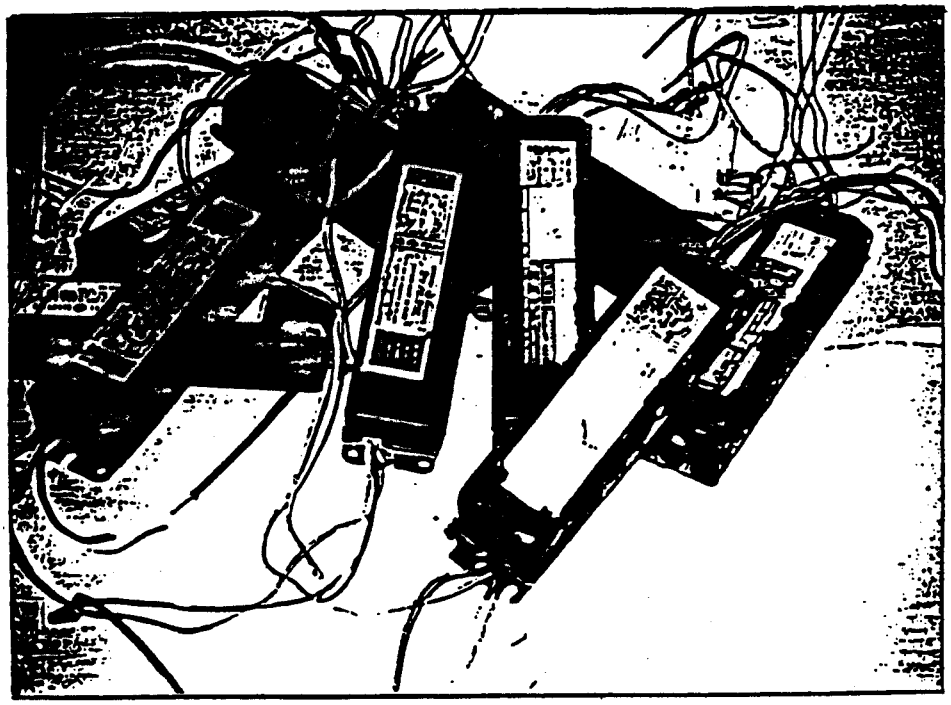


Figure 7

Fluorescent Lighting Ballasts

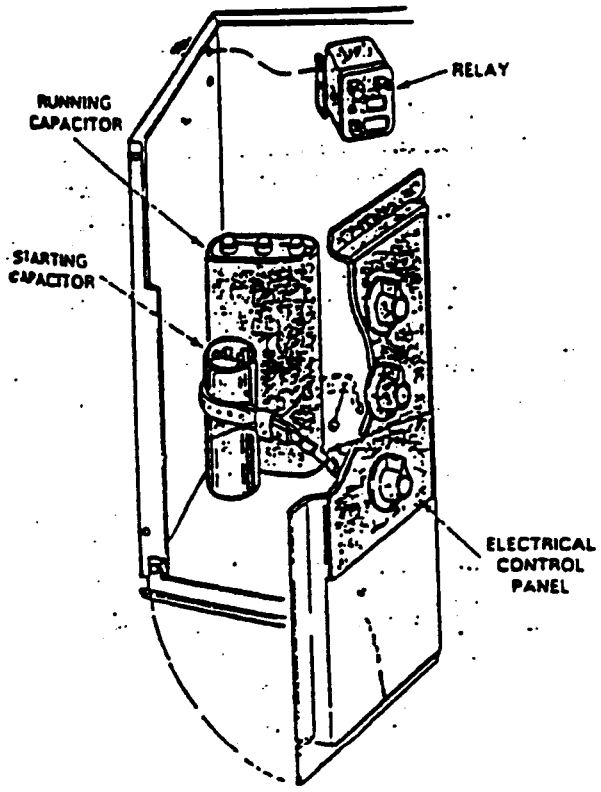


Figure 8

Window Air-Conditioning Unit Showing Location of Capacitor(s) and Control Panel

Microwave ovens have one capacitor located directly behind the control panel and attached to the transformer. The casing of the microwave or front panel will have to be removed prior to accessing the capacitor[16].

Fluorescent light ballasts (see Figure 7) are located in the housing of light fixtures. You may have to unscrew the back panel to access the ballast[16].

3.3 Does the Capacitor or Light Ballast Contain PCBs?

According to the United States Environmental Protection Agency (US EPA), PCB capacitors are invariably enclosed in a sheet steel jacket (a magnet can distinguish them). The soldering of the seams or a galvanized finish may also be useful in distinguishing them from the non-PCB or electrolytic capacitors which are typically encased in either a Bakelite or aluminum shell. The only appliances identified at the time of the letter with a significant likelihood of containing a PCB-type small capacitor are room and central air conditioners, heat pumps, furnace blowers, fluorescent lighting ballasts, and microwave ovens. These units represent a relatively small percentage of recycled "white goods" (approximately 5%). There is no evidence that small PCB capacitors were used in household clothes washers, clothes dryers, dishwashers, hot water heaters, garbage disposers, trash compactors, conventional ovens, ranges, or stoves. There has been suggestions that some refrigerators and freezers contain PCB small capacitors, but the use of PCB capacitors in these units were limited[17].

A capacitor may have "No PCBs" stamped on its casing, or may have a 4-digit date indicating time of manufacture. Some appliance manufacturers and repair businesses continued to use up stocks of PCB capacitors even after the 1978 ban on the production of PCBs. Some appliances manufactured after the 1978 date could therefore contain a PCB capacitor(s)[21]. It is anticipated that a majority of the stocked PCB capacitors were depleted within one year of the ban. Foreign oil-filled small capacitors may also contain PCBs despite Federal PCB restrictions[16].

3.4 Capacitor / Ballast Removal Methods

<u>Tools / Equipment Needed</u>

The basic tools needed for removing capacitors are; 1) screwdriver, 2) nut driver set, 3) crescent wrench, 4) socket set, and 5) side cutters or wire cutters.

<u>Capacitor Removal</u>

Capacitors are easily removed by loosening or removing the clamp holding the capacitor to the motor or bracket and cutting the wires from the capacitor terminals or removing the wires from the terminals if the capacitor is discharged. In some cases, the capacitor may be in a protective casing on the motor which needs to be removed first or the

capacitor may be wired to the motor bracket or other component.

Ballasts are typically fastened with screws to the light housing and would require the same tools for removal. The wires extending from the ballasts need to be cut prior to ballast removal.

3.5 Hazards / Safety Precautions

All employers must have a Material Safety Data Sheet (MSDS) for any workplace product that contains a hazardous substance(s), and must make it available to employees on request. An MSDS lists the hazardous chemical contents of a product, describes its health and safety hazards, and gives methods for using, storing and disposing of it safely. The employer may obtain an MSDS from the manufacturer of the product which contains PCBs. An MSDS for polychlorinated biphenyls is provided in appendix A.

The Hazard Evaluation System and Information Service (HESIS) produces fact sheets, booklets, and technical documents on work place chemicals. A HESIS fact sheet regarding polychlorinated biphenyls is provided in appendix B. HESIS fact sheets are designed as an aid for worker training programs and do not take the place of an MSDS. The HESIS office is located in Berkeley, California, and can be contacted at (510) 540-3138.

Employees should be trained on operational and safety aspects of any equipment used during PCB ballast and capacitor removal. Employees should also be trained in first aid.

Note: Capacitors are capable of holding an electrical charge up to several hours and have to be discharged prior to removal. Although this may not be the case for units in the disposal or recycling sectors because of the time lapse, the conservative approach is to discharge the capacitor by shorting an insulated screwdriver across the capacitor's terminals. Also, never pull on the capacitor's terminal wires when removing a capacitor (primarily oil-filled) as the terminal seal may dislodge and cause oil spillage[15].

Also, any footwear should be worn and stored in the area where capacitor removal is taking place. PCBs can be transported via foot wear[3].

4.0 Oils / Lubricants

Used oil includes any spent lubricating fluids that have been removed from vehicles, equipment, or machines. Used oil found within appliances include compressor oils contained within refrigeration and air conditioning equipment and transmission oils contained within clothes washers.

4.1 Lubricant Extraction Methods

The refrigerant within air conditioning and refrigeration equipment must be extracted prior to draining the oil from the compressor or removing the compressor from the appliance. If the refrigerant is not extracted, the removal of oil from the compressor or the removal of the compressor from the appliance will cause the refrigerant to vent to the atmosphere. Section 608 of the federal Clean Air Act (CAA) prohibits individuals from knowingly venting ozone depleting compounds, used as refrigerants, into the atmosphere while maintaining, servicing, repairing or disposing of air-conditioning or refrigeration equipment. The US EPA is authorized to assess fines of up to $25,000 per

day per violation of the federal CAA.

Tools / Equipment Needed

The basic tools needed for removing the compressor from the appliance are; 1) socket set, 2) side cutters or wire cutters, and 3) metal cutting saw (i.e., hack saw, reciprocating saw). For oil extraction, tools that are needed include; 1) drill and bits, 2) hammer, and 3) chisel or punch.

Compressor Removal and Oil Extraction

The compressor is typically removed from the appliance prior to oil extraction. It is recommended that metal recyclers be contacted to see if they require the compressors to be removed prior to acceptance of the unit for metals recovery. The compressor is removed by cutting the refrigerant lines and the electrical wires connected to the compressor and removal of the fasteners connecting the compressor to the unit. A method used by one recycler in California is to use a reciprocating saw to cut the refrigerant lines as well as the brackets holding the compressor to the unit.

The oil is extracted by drilling a hole in the oil reservoir of the compressor and draining the oil into a storage container. If the compressor is removed from the unit, it is usually placed on a table where it is allowed to drain into a storage container located below the table. Another method of oil extraction, for removed compressors only, is to remove the refrigerant line studs on the compressor and then place the compressor upside down to drain the oil. One recycler finds it more convenient to extract the oil by puncturing a hole through the terminal plug located on the compressor (see Figure 3). The terminal plug is accessed by removing the terminal cover, normally held on by a wire retaining clip, and removing the relay switch, overload protector, and capacitor (if any). The terminal plug on the compressor can now be punctured allowing for the oil to be extracted. This particular recycling operation uses an air chisel to puncture the compressor terminal plug.

Oil found within the transmissions of washing machines can be extracted by drilling a hole in the lubricant reservoir or by removing the gear housing.

4.2 Hazards / Safety Precautions

A person who might come into contact with used oil should wear gloves, boots, goggles or other face shield, or other protective clothing as necessary such as coveralls. Protective clothing should be made of materials that are resistant to oils[20].

Employees should be trained on operational and safety aspects of any equipment used during used oil extraction. Employees should also be trained in first aid.

5.0 Mercury

Mercury, a silver-white metal which is a liquid at room temperature, has been used in the past in consumer and industrial goods, such as thermometers, thermostats, barometers, electrical switches, and batteries. Now, due to environmental concerns, mercury is being phased out of batteries, and mercury temperature controls are being replaced with electronic devices. Current uses of mercury include thermometers and fluorescent lighting[8].

5.1 Discards Containing Mercury

Small amounts of mercury may be found in switches used in some old washing machines and chest type freezers and in temperature controls in gas stoves and water heaters[1,8,14]. The switch on the chest type freezer will be located under the lid seal and is used to turn on the interior light[14]. The switch on the washing machine is located under the lid and is used to stop the washing machine when the lid is opened during operation[5] (see Figure 9). You can determine if the switch is liquid filled by shaking it. These switches will either be encased in plastic or glass[14]. In a stove, the mercury switch is a long, thin copper tube connecting the thermostat to the gas burner control[8] (see Figure 10).

5.2 Mercury Component Removal Methods

Tools / Equipment Needed

The basic tools needed for removing the components containing mercury are; 1) screwdriver, 2) nut driver set, 3) crescent wrench, 4) socket set, and 5) side cutters or wire cutters.

Mercury Component Removal

Washing machine - the mercury switch is attached to the underside of the washer top. The washer top is held down by spring clips and can be removed by placing a screwdriver between the washer top and chassis and prying up. The mercury switch can be removed by detaching the clamp or other attaching hardware[18].

Chest type freezer - a mercury switch on some older chest type freezers may be located on the underside of the freezer door. Once located, it can be physically removed by detaching the wire from the switch. Also, this type of freezer may contain a mercury type thermostat (i.e. capillary tube) which should also be removed. It should look like a long slender tube attached to a wire.

Oven - a thermostat (i.e. capillary tube) may be present in some ovens to control temperature. It should be carefully removed from the oven and properly disposed of. Some ovens may have a mercury switch in the door which operated the internal light. This switch should also be removed from the oven.

Water heater - some water heaters may have a thermostat which contains mercury. It should be removed from the water heater.

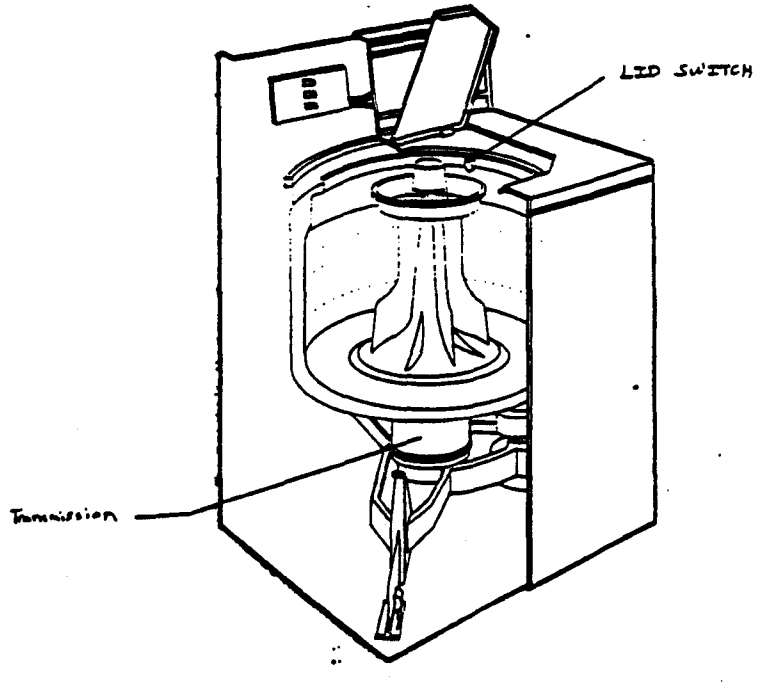


Figure 9

Washing Machine Lid Switch and Transmission

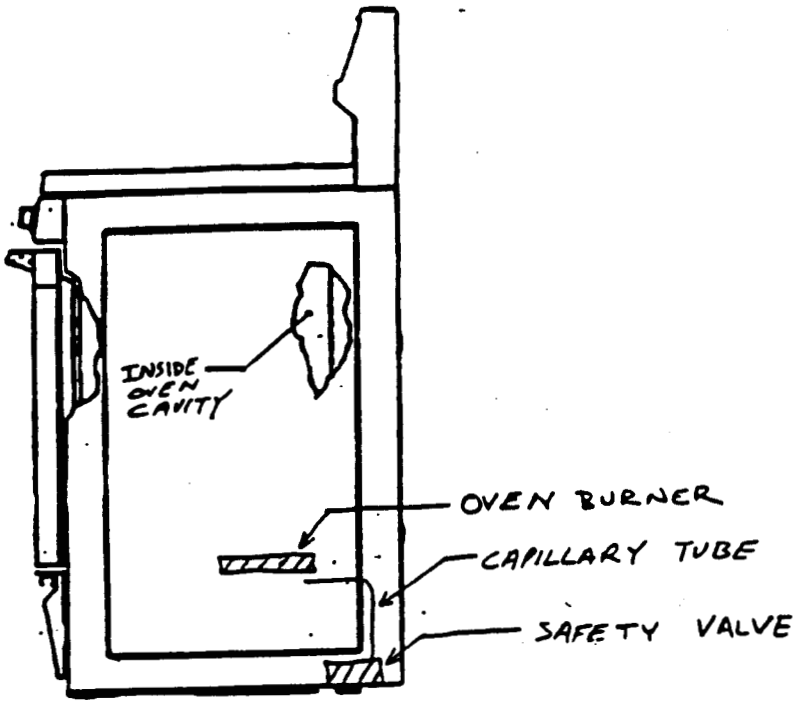


Figure 10

Capillary Tube in Gas Stove

5.3 Hazards / Safety Precautions

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The Hazard Evaluation System and Information Service (HESIS) produces fact sheets, booklets, and technical documents on work place chemicals. A HESIS fact sheet regarding mercury is provided in appendix B. HESIS fact sheets are designed as an aid for worker training programs and does not take the place of an MSDS. The HESIS office is located in Berkeley, California, and can be contacted at (510) 540-3138.

Employees should be trained on operational and safety aspects of any equipment used during mercury component removal. Employees should also be trained in first aid.