Responsible Appliance Disposal (RAD) Program: Guidance Document for Foam Recovery from Appliance Disposal

Introduction

It is estimated that more than 13 million refrigerators/freezers, 9 million window air conditioning units, and 1.5 million dehumidifiers are disposed of annually in the United States. These appliances can have harmful impacts on the environment when taken out of service. To mitigate these impacts, federal law requires that all refrigerant is recovered prior to dismantling or disposal of these appliances, and universal waste (e.g., mercury, used oil, polychlorinated biphenyls [PCBs]) is properly managed and stored. However, federal law does not require the recovery of appliance foam blowing agents, which may contribute to ozone depletion and climate change if not appropriately managed and released into the atmosphere.

The U.S. Environmental Protection Agency's (EPA) Responsible Appliance Disposal (RAD) program was launched in October 2006 to protect the ozone layer, cut greenhouse gas emissions, and benefit communities. RAD is a voluntary partnership program between EPA and various partners involved in appliance collection and disposal, including utilities, state and local governments, retailers, manufacturers, waste removal service providers, affiliates, and others. RAD partners work with recyclers to ensure that used appliances are disposed of using best environmental practices. Recyclers use manual, semi-automated, or fully automated systems to dismantle and process units. While landfilling appliances results in the emission of 45% to 100% of the foam blowing agent, it is estimated that during manual recovery, only 15% of the foam blowing agent is emitted, and during fully automated recovery, only 5% of foam blowing agent is emitted (ICF, 2011).

This guidance document aims to provide recyclers interested in implementing best environmental practices for the disposal of refrigerated appliances with an overview of necessary qualifications, tools, and processes. This document summarizes available guidance on foam recovery from resources such as *Guideline on the Manual Dismantling of Refrigerators and Air Conditioners* and *Emissions of Potent Greenhouse Gases from Appliance and Building Waste in Landfills* (GIZ, 2017; Yesiller, et al., 2016), as well as EPA's website. This guidance document is for illustrative purposes only; the dismantling of refrigerated appliances is subject to applicable federal, state, and local environmental regulations.

Technician Qualifications

EPA regulations (40 CFR Part 82, Subpart F) under Section 608 of the Clean Air Act require that technicians who could be reasonably expected to violate the integrity of the refrigerant circuit during the maintenance, service, repair, or disposal of appliances containing any class I or class II refrigerant or any non-exempt substitute refrigerant (40 CFR Part 82, Subpart F, Section 154(a)) must pass a certification exam offered by an approved technician certification program. Certification exams are specific to the type of equipment the technician seeks to work on, and certification credentials do not expire. A list of approved technician certification programs can be found online at EPA's Section 608 Technician Certification Webpage.

Tools

Technicians may use several tools to dismantle refrigerated appliances. The following is a non-comprehensive list of tools commonly used by technicians:

- Personal protective equipment: gloves, steel-toed shoes, thick pants, safety goggles, dust mask, ear plugs, and headphones
- Hand tools: piercing pliers, side cutter, scraper, spanner, hammer, angle grinder, drilling machine, hydraulic shears, and cordless screwdriver
- Other tools: portable recovery unit for refrigerant extraction, dust collection system to prevent small particles from entering the lungs, containers to hold materials during dismantling, heated oil separator to separate refrigerant from oil

Process

There are multiple steps involved in the dismantling of refrigerated appliances. The following is an illustrative list of steps commonly used by technicians:

STEP 1 Remove loose parts.

1. If the refrigerator is delivered with all interior parts (e.g., drawers, shelves), remove these parts and separate the plastic, glass, and steel components. Further separate plastic components based on the recycling symbol indicating the type of plastic; if there is no recycling symbol, store plastic parts as mixed plastics in a container for later separation.
2. **Recycle** loose parts by sending to a standard recycling facility. Recyclers can be located using Earth 911's Recycling Locator at https://search.earth911.com.

STEP 2 Remove the cable.

1. Using piecing pliers or a side cutter, cut the plug-in cable at the base of the refrigerator.
2. **Recycle** the cable by sending it to a small electronics recycler. Recyclers can be located using Earth 911's Recycling Locator at https://search.earth911.com.

STEP 3 Remove mercury switches (freezers).

1. Remove the plastic box cover to check the cover plate of the freezer for mercury-containing switches.
2. Store the mercury-containing component in accordance with federal hazardous waste regulations (40 CFR Part 273). Additional guidelines can be found at https://www.epa.gov/mercury/storing-transporting-and-disposing-mercury#packaging.
3. **Recycle** mercury switches by sending them to a hazardous waste facility. Facilities can be located using Earth 911's Recycling Locator at https://search.earth911.com.

Mercury-containing parts in appliances sold in Connecticut, Louisiana, Maine, Massachusetts, Minnesota, New York, Rhode Island, Vermont, and Washington are required to be clearly labeled as containing mercury. If you do not know whether your appliance contains mercury, contact the manufacturer.

STEP 4 Extract refrigerant oil.

1. Using piercing pliers connected to a portable recovery unit or an industrial extraction system with a heating oil separator, extract the refrigerant and oil at the lowest point of the refrigerant line.
2. Oil
   a. Store the extracted oil in double-walled containers.
   b. After using the heated oil separator, the refrigerant concentration in the waste oil should be less than 2 grams of halogenated hydrocarbons per kilogram of oil.
   c. Refrigerant concentration < 2 g/kg oil: **Recycle** the oil by sending it to a recycling facility, which can be located using Earth 911's Recycling Locator at https://search.earth911.com.
   d. Refrigerant concentration > 2 g/kg oil: **Destroy** the oil by sending it to an approved ozone-depleting substances (ODS) destruction facility. Approved destruction facilities can be found in **Appendix C**.
3. Refrigerant
   a. Store the recovered refrigerant in a cylinder (see Figure 1).
   b. **Reclaim or destroy** refrigerant by sending it to an approved facility for reclamation or destruction. Approved reclamation facilities can be found online at EPA's Section 608 Reclamation Webpage. Approved destruction facilities can be found in **Appendix C**.

Figure 1. Cylinder for storing recovered refrigerant (GIZ, 2017).

Refrigerant Reclamation and Destruction

Reclamation: EPA regulations (40 CFR Part 82, Subpart F) under Section 608 of the Clean Air Act restrict the resale of used ozone-depleting and substitute refrigerant to a new owner unless it has been reclaimed by an EPA-certified refrigerant reclaimer. Refrigerant that has been recovered and/or recycled can be returned to the same system or other systems owned by the same person without being reclaimed. To be properly reclaimed, used refrigerant must be reprocessed to at least the purity level specified in Appendix A to 40 CFR Part 82, Subpart F (based on Air Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 700-2016). This purity level must be verified using the laboratory protocol set forth in this same standard.

Destruction: For the purposes of destruction, ODS can be fed into a destruction unit. Hazardous waste combustors must be compliant with the operating conditions depending on the substance being destroyed (e.g., the minimum combustion temperature, minimum residence time, maximum waste feed rates, and continuous compliance with a carbon monoxide limit, which indicates incomplete combustion). Combustion of fluorinated and brominated compounds results in the production of acidic gases, including hydrofluoric acid and hydrogen bromide, which limits the amounts of these compounds that can be combusted in hazardous waste combustors (ICF, 2018). According to EPA regulations (40 CFR Part 82, Subpart A) under Section 608 of the Clean Air Act, ODS must be destroyed using a destruction technology approved by the Parties to the Montreal Protocol, found in Annex II of the Report of the 30th Meeting of the Parties.

STEP 5 Remove capacitors.

1. Cut visually protruding parts and store them in separate containers to be recycled.
2. Confirm whether the capacitor contains mercury or PCBs.
3. Remove the capacitor from the refrigerator, using extra caution if it contains mercury or PCBs, and store it in a separate container.
   a. If the capacitor contains mercury, store and dispose of the mercury-containing component in accordance with federal hazardous waste regulations (40 CFR Part 273). Additional guidelines can be found at https://www.epa.gov/mercury/storing-transporting-and-disposing-mercury#packaging. Hazardous waste facilities can be located using Earth 911's Recycling Locator at https://search.earth911.com.
   b. If the capacitor contains PCBs, store and dispose of the PCB-containing component in accordance with federal PCB regulations (40 CFR Part 761). Approved PCB commercial storage and disposal facilities can be found at https://www.epa.gov/pcbs/list-approved-polychlorinated-biphenyl-pcb-commercial-storage-and-disposal-facilities.

4. If the capacitor does not contain mercury or PCBs, **recycle** the capacitor by sending it in the container to an electronics recycling facility. Facilities can be located using Earth 911's Recycling Locator at https://search.earth911.com.

Mercury-containing parts in appliances sold in Connecticut, Louisiana, Maine, Massachusetts, Minnesota, New York, Rhode Island, Vermont, and Washington are required to be clearly labeled as containing mercury. If you do not know whether your appliance contains mercury, contact the manufacturer.

PCBs may be present in products and materials produced before the 1979 PCB ban. If you do not know whether your capacitor contains PCBs, treat is as if it does.

STEP 6 Remove the compressor.

1. Using a spanner or hydraulic shears, manually unscrew the compressor.
2. Using a drill, bore a hole into the bottom of the compressor.
3. Subvert the compressor and collect the oil in a container.
4. Process the collected oil using a heated oil separator.
5. Optionally, further dismantle the compressor and separate the cast alloy, copper, and iron parts.
6. **Recycle** the compressor (or its components) by sending it to a standard recycling facility or a scrap metal recycling facility.
7. **Recycle or destroy** the oil by sending it to an approved recycling or ODS destruction facility (see **Step 4** for more information).

While handling the compressor, keep oil binders nearby in case of oil spillage.

STEP 7 Remove the condensing unit.

1. Using a hammer, knock off the condensing unit's mounting brackets and remove the condensing unit.
2. Store the condensing unit in a separate container.
3. **Recycle** the condensing unit by sending the contained unit to an electronics recycling facility. Facilities can be located using Earth 911's Recycling Locator at https://search.earth911.com.

STEP 8 Remove the foam (manual process).

Use a dust mask and mobile or stationary dust collection system to prevent small particles from entering the lungs. The filter must effectively capture particles of at least 5 microns.

When removing foam, keep the foam as intact as possible to prevent the release of insulating foam blowing agent. The procedure should be done at room temperature or cooler because warm temperatures increase the release of blowing agents.

1. Using a screwdriver, remove the outer metal paneling (likely aluminum or iron sheets) from the side walls of the refrigerated appliance.
2. Using a scraper, carefully scrape the foam away from the side walls. Remove the foam in as large pieces as possible and scrape off even small adhesions to the metal walls.
3. Collect the foam pieces in sealed bags and store outer metal and polystyrene plastic paneling in separate containers.
4. **Recycle or destroy** foam by sending it to an approved facility.

Foam Recycling and Disposal

Recycling: The recycling method for insulating foam includes physical recycling and chemical recycling. Physical recycling involves crushing the foam waste and using the resulting material to make new polyurethane products. Chemical recycling is the depolymerization of polyurethane foams through heating with chemical reagents and catalysts such as alkali metal hydroxides. Distillation equipment is used to separate the products. A comprehensive list of foam recycling facilities is not available; therefore, contact local recycling facilities for information on where to recycle foam.

Disposal: In the disposal method, the foam can be combusted and used as fuel. Although this method allows for a more environmentally friendly alternative to the "business as usual" practice of landfilling, incomplete combustion of appliance foam can produce poisonous gas that also pollutes the atmosphere. A list of facilities that dispose of foam through incineration can be found in **Appendix B** and **Appendix C**.

Appendix A: Recycling and Disposal Methods for Recovered Materials

Material	Recycling Options	Facilities
Aluminum cast	Smelting	Standard recycling facility
Aluminum sheets	Smelting	Standard recycling facility
Cables	Separation in a cable recycling plant	Small electronics recycler
Capacitor	Final disposal or first separation and then smelting	Small electronics recycler
Compressor	Smelting after the separation of components	Standard recycling facility or scrap metal recycling facility
Condensing unit	Smelting	Small electronics recycler
Glass	Smelting	Standard recycling facility
Iron	Smelting	Standard recycling facility
Mercury switches	Send to a recycling plant that recovers mercury from small devices	Hazardous waste facility
PCBs	Final disposal	Approved PCB disposal facility
Plastics	Mechanical recycling, feedstock recycling, energy recovery	Standard recycling facility
Polystyrene paneling	Mechanical recycling	Standard recycling facility
Polyurethane foam	Mechanical recycling, chemical recycling, final disposal	Standard recycling facility, ODS destruction facility
Refrigerant	Reclamation or final disposal	EPA-certified refrigerant reclaimer or ODS destruction facility
Stainless steel	Smelting	Standard recycling facility

Sources: GIZ (2017), Earth 911 (2020)

Appendix B: Waste-to-Energy Facility Locations in the United States

State	Location	Facility Name
Alabama	Huntsville	Huntsville WTE Facility
California	Crows Landing	Stanislaus County Resource Recovery Facility
	Long Beach	Southeast Resource Recovery Facility
Connecticut	Bridgeport	Wheelabrator Bridgeport Company, L.P.
	Bristol	Bristol Resource Recovery Facility
	Hartford	CRRA Hartford Trash-to-Energy Plant
	Lisbon	Wheelabrator Lisbon Inc.
	Preston	Southeastern Connecticut Resource Recovery Facility
Florida	Fort Lauderdale	Wheelabrator South Broward Inc.
	Fort Myers	Lee County Resource Recovery Facility
	Miami	Miami-Dade County Resource Recovery Facility
	Okahumpka	Lake County Resource Recovery Facility
	Panama City	Bay County WTE Facility
	Spring Hill	Pasco County Solid Waste Resource Recovery Facility
	St. Petersburg	Pinellas County Resource Recovery Facility
	Tampa	Hillsborough County Resource Recovery Facility
	Tampa	McKay Bay Refuse-to-Energy Facility
	West Palm Beach	Palm Beach Renewable Energy Facility #1
	West Palm Beach	Palm Beach Renewable Energy Facility #2
Hawaii	Kapolei	Honolulu Resource Recovery Venture – HPOWER
Indiana	Indianapolis	Indianapolis Resource Recovery Facility

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State	Location	Facility Name
Iowa	Ames	Arnold O. Chantland Resource Recovery Plant
Maine	Auburn	Mid-Maine Waste Action Corporation
	Orrington	Penobscot Energy Recovery Company
	Portland	ecomaine
Maryland	Baltimore	Wheelabrator Baltimore, L.P.
	Dickerson	Montgomery County Resource Recovery Facility
Massachusetts	Agawan	Pioneer Valley Resource Recovery Facility
	Haverhill	Haverhill Resource Recovery Facility
	Millbury	Wheelabrator Millbury Inc.
	North Andover	Wheelabrator North Andover, Inc.
	Pittsfield	Pittsfield Resource Recovery Facility
	Saugus	Wheelabrator Saugus, Inc.
	West Wareham	SEMASS Resource Recovery Facility
Michigan	Detroit	Detroit Renewable Power
	Grand Rapids	Kent County WTE Facility
Minnesota	Alexandria	Pope/Douglas Waste-to-Energy Facility
	Elk River	Great River Energy – Elk River Station
	Fosston	Polk County Solid Waste Resource Recovery Facility
	Mankato	Xcel Energy – Wilmarth Plant

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State	Location	Facility Name
Minnesota	Minneapolis	Hennepin Energy Resource Co.
	Perham	Perham Resource Recovery Facility
	Red Wing	Xcel Energy – Red Wing Steam Plant
	Rochester	Olmsted Waste-to-Energy Facility
New Hampshire	Concord	Wheelabrator Concord Company, L.P.
New Jersey	Camden	Covanta Camden Resource Recovery Center
	Newark	Essex County Resource Recovery Facility
	Oxford	Covanta Warren Energy Resource Co. Facility
	Rahway	Union County Resource Recovery Facility
	Westville	Wheelabrator Gloucester Company, L.P.
New York	East Northport	Huntington Resource Recovery Facility
	Fulton	Oswego County Energy Recovery Facility
	Hudson Falls	Wheelabrator Hudson Falls LLC
	Jamesville	Onondaga County Resource Recovery Facility
	Niagara Falls	Niagara Resource Recovery Facility
	Peekskill	Wheelabrator Westchester, L.P.
	Poughkeepsie	Dutchess County Resource Recovery Facility
	Ronkonkoma	MacArthur WTE Facility
	West Babylon	Babylon Resource Recovery Facility
	Westbury	Covanta Hempstead
Oklahoma	Tulsa	Walter B. Hall Resource Recovery Facility

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State	Location	Facility Name
Oregon	Brooks	Marion County Solid Waste-to-Energy Facility
Pennsylvania	Bainbridge	Lancaster County Resource Recovery Facility
	Chester	Delaware Valley Resource Recovery Facility
	Conshohocken	Covanta Plymouth Renewable Energy
	Harrisburg	Susquehanna Resource Management Complex
	Morrisville	Wheelabrator Falls Inc.
	York	York County Resource Recovery Center
Virginia	Alexandria	Alexandria/Arlington Resource Recovery Facility
	Hampton	Hampton – NASA Steam Plant
	Lorton	I–95 Energy/Resource Recovery Facility
	Portsmouth	Wheelabrator Portsmouth Inc.
Washington	Spokane	Wheelabrator Spokane Inc.
Wisconsin	Almena	Barron County Waste-to-Energy & Recycling Facility
	LaCrosse	Xcel Energy French Island Generating Station

Sources: ERC (2018), EPA (2019a), ICF (2018)

Appendix C: Commercial ODS Destruction Facilities in the United States

State	Location	Facility Name
Arkansas	El Dorado	Clean Harbors El Dorado LLC*
Illinois	Sauget	Veolia ES Technical Solutions LLC*
Louisiana	Baton Rouge	Eco-Services Operations
Michigan	Belleville	Wayne Disposal Inc.
Nebraska	Kimball	Clean Harbors Environmental Services Inc.*
Ohio	Bowling Green	A-Gas Americas
	East Liverpool	Heritage Thermal Services*
	Grafton	Ross Incineration Services Inc.*
South Carolina	Graniteville	Recleim*
Texas	La Porte	Clean Harbors Deer Park LLC*
	Port Arthur	Veolia ES Technical Solutions LLC*
Utah	Grantsville	Clean Harbors Aragonite LLC*

*In addition to destroying concentrated ODS, these facilities destroy foam through incineration.
Sources: EPA (2019a), ICF (2018)

Appendix D: References

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