WASHINGTON STATE
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ECOLOGY

Small-Scale Technologies to Remove and Manage Refrigerants and Compressors from Discarded Appliances

Washington State Department of Ecology
Solid Waste Services Program
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I. PROJECT OVERVIEW

In February 1994 Total Reclaim, Inc. was selected by the Washington Department of Ecology (Ecology) to evaluate commercially available refrigerant recovery equipment, to describe proper handling, processing, and management procedures for the hazardous materials found in appliances, and to conduct a survey of hazardous waste management companies and recycling services which dispose of-materials found in appliances. This paper is the result of that work.

Methodology

In developing this paper, Total Reclaim staff first attempted to compile information from other states regarding mandated processing requirements, issue papers on hazardous materials handling, and existing appliance recycling programs currently in place. Approximately twelve (12) state agencies responded to our request and that information has been incorporated into this report.

Second, Total Reclaim compiled information on current regulations, federal, state, and local, pertaining to the recovery of refrigerants and proper handling and disposal of hazardous materials contained in refrigeration equipment.

Third, Total Reclaim staff conducted a survey of businesses, both in Washington and out of state, engaged in the following activities:

- EPA approved technician certification training;
- Hazardous materials disposal;
- Heating, ventilating, and air conditioning contractors,;
- Metals recyclers;
- Manufacturers and distributors of refrigerant recovery equipment;
- Refrigerant reclaimers.

The results of these surveys are presented in both the narrative of this paper and the attached appendices.

Finally, a series of shop tests were conducted on refrigerant systems attempting to evaluate the following:

- Capabilities and efficiencies of commercially available refrigerant recovery equipment;
- Labor time required using a variety of refrigerant recovery set-ups;
- Several different methods of compressor removal;
- Several different methods of disassembling compressor motors for recycling.

II. INTRODUCTION

Appliance Disposal

Most households contain several major appliances, also called "white goods." These include: refrigerators, freezers, air conditioners, dehumidifiers, heat pumps, furnaces, stoves, ovens, washing machines, dryers, dishwashers, water heaters, trash compactors, and microwave ovens. Of these appliances, refrigerant gases are present in refrigerators, freezers, air conditioners, heat pumps, and dehumidifiers.

The Massachusetts Department of Environmental Protection estimated that the average person discards 30 pounds of white goods per year, or approximately 75 pounds per household per year. Since appliances have an average weight of about 150 lbs, this means the average household will dispose of one major appliance every other year.

Current appliance disposal options are not uniform across the state. In some jurisdictions solid waste staff or contracted businesses process appliances collected at landfills and transfer stations. In other areas, solid waste facilities refuse to accept appliances, instead referring the public to private or non-profit service providers.

Similarly, the cost of service is not consistent across the state. Charges to the public for disposal of a refrigerated appliance range from as low as $10.00 to $20.00 in the Puget Sound basin to as high as $75.00 per unit in the Okanogan valley.

Recycling Potential,

Although major appliances are composed primarily of steel, increasingly, appliances are also constructed of plastics. However, due to appearance and durability issues, it is unlikely that plastics will replace steel as the primary component in white goods in the near future. The primary result of increased use of plastics has been a decrease in the average weight of appliances (in pounds).

Materials of construction in refrigerators as a function of time - Manufacture date (Estimated retirement date)

	1972(1991)	1980(1999)	1988(2007)
Steel	147.6	138.3	129.0
Compressor	30.3	28.2	26.0
Mixed Plastics	14.0	21.6	29.0
Fiberglass	17.9	8.9	0.0
Polyurethane Foam	4.0	11.0	18.0
Aluminum	7.9	10.4	13.0
Copper	0.6	0.8	1.0
Misc.	5.7	6.8	8.0
Total	228.0	226.0	224.0

Source: "Composition, Properties, and Economic Study of Recycled Refrigerators," American Plastics Council. Nov. 1993

Although some consider the steel contained in appliances to be of "low grade" due to the presence of significant amounts of plastic, rubber, foam, and other metals, efficient use of balers and shredders by the steel recycling industry facilitates separation of the materials and make appliances a good source of steel for smelting. More than 1.6 million tons of steel were recycled from approximately 36 million appliances in the United States in 1993.

When appliances are shredded, they are turned into fist sized pieces of material. Large magnets are used to separate ferrous metals for shipment to a smelter and the remaining material is sent through an air classifier to separate non-ferrous metals (aluminum and copper) from lighter materials such as foam, rubber, and plastics. The non-ferrous metals are hand sorted and the nonmetallic residual, or shredder "fluff," is landfilled.

Hazardous Wastes in Discarded Appliances

In the regular course of decommissioning appliances, individuals or businesses will generate the following wastes that are regulated or have potential to cause harm to humans or the environment:

- Chlorofluorocarbon (CFCs) and hydrochlorofluorocarbon (HCFCs) refrigerants;
- Highly chlorinated compressor oil;
- Capacitors and ballasts containing Polychlorinated Biphenyls (PCBs);
- Mercury switches;
- Sulfur dioxide gas;
- Ammonia gas;
- Desiccant filter dryers.

To protect humans and the environment, these materials should be recovered in compliance with federal, state, and local rules and regulations; stored in appropriate containers; and transported for recycling or hazardous waste disposal at a properly permitted facility.

Additional Information

To help educate the public and promote appliance recycling, the Association of Home Appliance Manufacturers recently established the Appliance Recycling Institute Center (ARIC). ARIC has published a number of information packages and can be contacted at: 701 Pennsylvania Avenue NW, Suite 900, Washington D.C. 20004, phone number (202) 434-7492.

III. CLEAN AIR REGULATIONS

Stratospheric Ozone Layer

The Earth's stratosphere contains a layer of ozone, between 7 and 30 miles above the surface of the Earth that provides a protective barrier for the Earth's surface from ultraviolet (UV) rays emitted by the sun.

The effects on human health from increased levels of UV radiation exposure are substantial, including: increased incidence of skin cancers, cataracts, and suppression of the human immune response system. In addition, increased UV radiation is responsible for damage to crops and marine life, increases in ground level ozone and increased global warming.

Chlorofluorocarbons (CFCs) and Ozone Depletion

Chlorofluorocarbon (CFC) and hydrochlorofluorocarbon (HCFC) gases are man-made chemicals, introduced by General Motors in the early-1930's as a replacement for ammonia, sulfur dioxide, methyl acetate, and methyl formate used in refrigeration. Although these older refrigerants are inexpensive and efficient refrigerants, they are toxic, flammable, or corrosive gases. In addition, the quantity present in refrigeration equipment is sufficient to pose a significant health and safety risk to consumers and service technicians. CFC gases provided the perfect solution; cheap, efficient, and, for the most part, non hazardous to consumers and service technicians.

During the 1970's and 1980's, scientists noticed alarming fluctuations in the thickness of the ozone layer, far beyond the normal seasonal variations. These variations were eventually linked to increased levels of chlorine in the upper atmosphere.

The hypothesis linking CFCs, such as R-11 and R-12, to stratospheric ozone depletion was advanced by Professor Sherwood Rowland and Dr. Mario Molina in 1974. They hypothesized that when exposed to intense UV radiation such as found in the stratosphere, CFCs decompose, releasing free chlorine atoms. These chlorine atoms are capable of destroying thousands of ozone molecules through a series of reactions. Because CFCs do not dissolve in water or beak down naturally into materials that dissolve in water, they do not "rain" out of the atmosphere, and can continue to destroy ozone molecules for up to 120 years.

Rowland and Molina further predicted that at the current (1974) rate of CFC production and release, the ozone layer would be destroyed by the middle of the next century. In 1988, the National Aeronautics and Space Administration (NASA) reinforced this theory when high altitude probes revealed that levels of stratospheric ozone over the northern mid-latitudes had decreased by 3 to 5% annually since 1978, far more rapidly than previously thought.

Different CFCs and HCFCs have different ozone depletion potential. By international agreement, each chemical was assigned a "ozone depletion number" describing that chemical's characteristics in comparison with refrigerant R-11, which was assigned an ozone depletion number of 1.0.

During the 1960's and 1970's, the use of CFC and HCFC gases experienced dramatic growth. They were used as a propellant for aerosol cans, the blowing agent in production of foam insulation and furniture padding, in halon fire extinguishers, automotive air conditioning, and as highly evaporative cleaning solvents. The number of refrigeration and air conditioning units in service also increased dramatically.

The New Jersey Department of Environmental Protection and Energy determined that the following sources were the major sources of emissions of CFCs and related substances:

Automobile air conditioners	31.1
Refrigeration/air conditioning equipment	11.5%
Foam materials	14.2%
Sterilizing agents	12.1
Fire suppression	7.5%
Solvents	5.9%
Chemicals	3.9%
Other (mostly 1, 1, 1-trichloroethane)	13.7%

A new family of environmentally safe refrigerants that do not contain chlorine, Hydrofluorocarbons (HFCs) have been recently introduced and it is hoped they will eventually replace both CFCs and HCFCs.

A list of common CFCs, HFCs, and HCFCs and their applications are contained in Appendix 1.

Montreal Protocols

In 1987, sixty eight nations responded to the threat on the ozone layer and signed what is known as the Montreal Protocol, an agreement among nations to curtail the production and usage of CFC gases worldwide. The Protocol called for the immediate elimination of non-essential uses of CFCs, such as most aerosols, a freeze on production levels back to 1986 levels, a 20% reduction in production of CFCs by 1993, and an additional 30% reduction by 1997.

In 1990, fifty six nations signed an agreement updating the Protocol to accelerate the phase-out of production of CFCs to a 50% reduction by 1995, 85% by 1997, with a complete phase-out by 2000. The timetable for phase out of HCFCs is longer due to their lower ozone depletion potential.

On February 11, 1992, President Bush announced the US would accelerate the production phase-out, to be completed by January 1, 1996.

CFC Refrigerant Tax

The 1990 federal budged contained provisions for new federal excise taxes on the production of CFC gases, sale of existing stocks, and imports of CFCs. Tax rates are indexed for each material according to their ozone depletion potential. The excise tax rate per pound for new refrigerant R-12 is as follows:

1994-$4.35	1995-$5.35	1996-$5.80	1997 - $6.25

Recycled or reclaimed refrigerants are exempt from this tax.

1990 Amendments to the Clean Air Act

In 1990, the US Congress passed the 1990 Amendments to the Clean Air Act. Sections 604 through 608 deal with the manufacture, handling, and management of CFCs and other ozone-depleting chemicals, including time tables for production phase-out.

The objective of Section 608 was to reduce the production, use, and emissions of ozone-depleting chemicals, including CFCs and HCFCs, to the lowest possible level and to maximize the recovery and recycling of these materials. Section 608 included a ban on venting of CFC gases, reading, in part:

> *"Effective July 1, 1992, it shall be unlawful for any person in, the course of maintaining, servicing, repairing, or disposing of any appliance or industrial process refrigeration to knowingly release or dispose of any Class I or Class II substance used as a refrigerant in such appliance (or industrial process refrigeration) in a manner which permits such substance to enter the environment."*

Section 608's ban on venting was extended to include all replacements developed for CFCs and HCFCs effective January 1, 1995.

US Environmental Protection Agency Regulations

On May 14, 1993, the U.S. Environmental Protection Agency (EPA) published their final rule implementing Section 608 of the Clean Air Act. The EPA rule included the following regulations relating to the -manufacture, repair, and disposal of small appliances (high pressure equipment with a charge of less than 50 lbs of refrigerant):

- The final person in the disposal chain (scrap metal recycler or landfill owner) is responsible to ensure that CFC refrigerants are recovered or to obtain verification that refrigerants have been previously removed;
- Anyone repairing or disposing of small appliances (less than 5 pounds of refrigerant) must recover 90% of the system's refrigerant if the compressor is running, 80% of the refrigerant if not running, or evacuate the system to a minimum of 4 inches of mercury;
- Effective July 13, 1993, anyone disposing of appliances must keep records verifying that refrigerants have been recovered in accordance with EPA rules;
- Effective August 12, 1993, anyone recovering refrigerants from appliances

must certify to the EPA that they are operating equipment that meets the requirements set forth in the EPA rule;

- Beginning November 15, 1993, new refrigeration equipment must have a processing stub to facilitate recovery of refrigerants;
- Refrigerant recovery equipment manufactured after November 15, 1993, must be certified by an approved testing organization. In addition, any equipment manufactured before that date must meet the same recovery standards;
- Beginning November 14, 1994, technicians repairing small appliances must be certified by an approved testing organization.

Penalties For Illegal Venting

The EPA was authorized to impose penalties of up to $25,000 per day and a prison term of up to 5 years for anyone convicted of knowingly releasing refrigerants into the atmosphere or for making false statements in any report or application required by the EPA.

To encourage others to report violations of the Clean Air Act, the EPA is authorized to pay rewards of up to $10,000 to any person furnishing information leading to the arrest and conviction of another, person for violation of the Act's provisions.

Although EPA staff available for enforcement is limited, legal actions have been taken against individuals involved in illegal venting, sale of refrigerants in unauthorized containers, and for improper record keeping.

Washington Clean Air Act

The Washington Clean Air Act (RCW 70.94.970 - 990) regulates the handling and release of CFCs. The law is similar to the federal Clean Air Act.

In May 1992, Ecology filed an emergency rule to conditionally remove CFCs from Dangerous Wastes Regulation (Ch. 173-303 WAC) to encourage the reuse and recycling of CFCs. The intent of the rule was to curtail the illegal venting of reusable CFCs and required that CFCs be recycled on-site or sent to an EPA certified reclaimer. The impact of the rule was that all CFCs recovered and subsequently recycled or reclaimed did not need to be counted as part of a generator's hazardous wastes. CFCs that are not recycled or reclaimed are still covered under the Dangerous Wastes Regulations. The rule formally went into effect February 5, 1993.

Release of CFCs Contained in Insulating Foam

Until recently, the insulating foam most commonly used in refrigeration equipment was blown with refrigerant R-11. Since the R-11 remains trapped in the insulating foam's cells, the crushing, baling, or shredding of a refrigeration unit will invariably result in release of the R-11 to the atmosphere. To date, the EPA has not decided to regulate these releases.

Recovery equipment designed to recover R-11 from insulating foam is in operation in 17 sites in Europe and I site in North America. Unfortunately, this equipment is very

expensive and the work involved in removal and recovery of insulating foam from refrigerators is extremely labor intensive. Currently, the only appliance recycling program recovering insulating foam from refrigerators is operated by the Appliance Recovery Centers of America (ARCA) under contract with a regional power utility.

The scrap value of a refrigerator is very small compared to the costs of operating a dismantling program. Without federal or state mandates or major financial subsidies, it is unlikely programs of this type will become widespread. (A discussion of the economics of refrigerator disassembly, foam recovery, and refrigerator plastics recycling is contained in The American Plastics Council paper, "Composition, Properties, and Economic Study of Recycling Refrigerators").

Impacts of the Clean Air Act on the Refrigeration Industry

The 1990 amendments to the federal Clean Air Act dramatically changed standard operating practices in the refrigeration industry. Previously, if a system required a major re-work, the service technician would begin work by opening the service valves to the atmosphere, venting all of the CFC gases while collecting tools and equipment for the job. Once vented, the system could be serviced, checked for leaks, evacuated, recharged with new refrigerant gas, and put back on-line.

Complying with the Clean Air Act substantially increased the time required to service a refrigeration system and required service technicians to purchase recovery equipment and become proficient in the recovery of refrigerant gas. The Act also created new industries in the decommissioning and recycling of refrigeration equipment and the sale and servicing of certified recovery equipment.

Definitions

This report uses a number of terms in common usage by the refrigeration industry and the EPA, including:

- ***Recover*** - To remove refrigerant, in either liquid or vapor form, from an appliance and store it in an external container without necessarily testing or processing it in any way.

- ***Recycle*** - To clean and filter refrigerant gas for reuse without meeting all of the requirements for reclamation, most commonly by using oil separation and single or multiple passes through devices, such as replaceable core filter-dryers, to reduce moisture, acidity, and particulate matter. Some reasonably priced recovery machines have the capability to recycle refrigerants.

  Recycled refrigerant can be re-introduced into the same piece of refrigeration equipment or other refrigeration equipment under the same ownership as the original equipment. Recovered refrigerant may not be sold or re-used in any other owner's equipment unless it has been *reclaimed.*

- ***Reclaim*** - *To* reprocess used refrigerant to new product specifications according to standards developed by the American Refrigerant Institute, Standard 700-1993, Specifications for Fluorocarbon Refrigerants (known as ARI 700), and to verify this purity using the analytical methodology prescribed in the Standard.

  This term usually implies the use of a process or procedures available only through a reprocessing or manufacturing facility. Reclaimed refrigerants can be re-sold in the same manner as new product. Compressor manufacturers will accept ARI 700 tested refrigerant as meeting the terms of new equipment warranties.

- ***Technician*** - Any person who performs maintenance, service, or repair that could reasonably be expected to release class I (CFC) or class II (HCFC) substances into the atmosphere, including but not limited to installers, contractor employees, in-house service personnel, and in, some cases, owners.

- ***De minius Releases*** - Whenever refrigerant hoses are attached to refrigeration units, refrigerant lines are purged of air, or systems are pressure tested; small or "de minimus" releases of refrigerant gas occur. The 1990 Amendments stated that:

  > *"De minim us releases associated with good faith efforts attempts to recapture and recycle or* safely *dispose of any such substance shall not be subject to the prohibition..."*

  It should be noted that the terms "de minimus" and "good faith efforts" are rather loosely defined, leaving considerable ambiguity. Common "de minimus" releases of refrigerant gas include: purging of air from refrigerant cylinders and lines, venting of refrigerants from vacuum pumps, attaching refrigerant hoses and fittings, and venting of refrigerants from compressor oil prior to disposal.

IV. MANAGEMENT OF HAZARDOUS MATERIALS

Classification of Hazardous Wastes

The EPA and Ecology define "hazardous waste" as waste that could cause injury or death to humans, or pollutes land, water, or air. These wastes are regulated by federal and state public health and environmental safety laws.

There are two ways waste may be brought into the EPA's hazardous waste regulatory system, by listing of the materials specifically and through the material's identifying characteristics.

Listed Wastes - Some wastes are named specifically in one of four lists contained in the Resource Conservation and Recovery Act (RCRA) or the Washington State Dangerous Waste Regulations (173-303 WAC). These materials are listed because they contain toxic constituents that have been shown harmful to human health or the environment.

Characteristic Wastes - Wastes may be considered hazardous if they exhibit one or more of the following characteristics:

- Ignitability - wastes that are easily combustible or flammable;
- Corrosive - wastes that dissolve metals, other materials, or burns the skin;
- Reactive - wastes that are unstable or undergo rapid or violent chemical reactions with water or other materials;
- Extraction Procedure Toxic - wastes are EP Toxic if an extract of the waste is found to contain high concentrations of heavy metals that could be released into the ground water.

It is the waste generator's responsibility to determine which of their by-products are considered hazardous and to develop the best handling methods for each waste.

The Washington Department of Ecology has developed an information package called "Step by Step: Fact Sheets for Hazardous Waste Generators," to assist businesses and individuals in properly identifying, storing, and managing hazardous wastes. The guide can be obtained from any Ecology office or by calling 1-800-RECYCLE. Much of the information contained in this section derives from the Ecology information package.

For further assistance in developing procedures to minimize hazardous waste generation and to properly manage wastes generated, contact the non-profit and regulatory agencies listed in Appendix 2 and 3.

Hazardous Waste Generator Status

The EPA and Ecology have two designations of hazardous materials; Dangerous Waste (DW) and Extremely Hazardous Waste (EHW). Businesses and individuals must evaluate the materials they generate and determine if they generate either Dangerous Wastes or Extremely Hazardous Wastes.

There are three categories for individuals and businesses that generate and accumulate hazardous waste as a by-product of their operations: generators of household hazardous waste, small quantity generators, and regulated generators.

Generators of Household Hazardous Wastes

Washington state regulations regarding household generated hazardous wastes are nearly identical to federal rules.

WAC 173-303-071 (3)(c) defines "household wastes" as any waste material (including garbage, trash, and sanitary wastes in septic tanks) derived from households (including single and multiple residences, hotels and motels, bunkhouses, ranger stations, crew quarters, campgrounds, picnic grounds, and day-use recreation areas). The rule categorically excludes household wastes from regulation as "hazardous" or "dangerous" wastes.

This exemption would cover waste materials generated during the decommissioning of appliances generated by "households." It would not, however, include materials generated during the decommissioning of appliances generated by businesses of any type.

Since domestic refrigerators, freezers, and air conditioners are commonly used in business establishments and appliance processors will likely accept materials from businesses and residential customers, processors could not utilize the "household hazardous waste" exemption and would be regulated as either of the other two categories of generators.

Small Quantity Generators

Businesses or individuals are classified as Small Quantity Generators (SQG) if they generate less than a total of 220 pounds of Dangerous Waste per month or store less than a total of 220 pounds of Dangerous Waste at any time. The threshold amount for SQG generation or accumulation of Extremely Hazardous Waste is 2.2 pounds.

SQGs are required to identify and keep records of the amount of hazardous waste they accumulate each month and ensure that it remains below the allowable limits at all times. SQGs must also ensure that their hazardous wastes are disposed of properly by a facility approved in their county Local Moderate Risk Waste Plan or by Ecology. Although SQGs are not required to obtain an EPA generator number due to the small amount of hazardous materials they produce, some hazardous waste disposal companies will not accept waste from any company or individual that does not have an EPA generator number.

If possible, most businesses and individuals should attempt to maintain SQG status. SQGs can take advantage of special city and county programs not usually available to larger generators. A list of county Moderate Risk Coordinators is provided in Appendix 3. Questions regarding programs or generator status can be directed to these individuals.

All holders of EPA generator numbers are required to file an annual report Form 4, Generator Annual Dangerous Waste Report, by March 1 with the Department of Ecology listing the type and quantity of hazardous wastes generated during the previous year.

If a SQG exceeds the 220 pound limit at any time (2.2 pounds for EHW) or does not follow SQG requirements, it will become subject to the requirements for Regulated Generators.

Regulated Generators

Businesses or individuals are classified as Regulated Generators if they generate more than 220 pounds of Dangerous Waste per month or accumulate more than 220 pounds at any time. The threshold amounts for Extremely Hazardous Waste for Regulated Generators is 2.2 pounds per month or 2.2 pounds total accumulated. Regulated generators cannot accumulate more than 2,200 pounds of hazardous waste on site.

Regulated Generators must do all of the following:

- Identify hazardous wastes generated;
- Obtain an EPA/Ecology generator identification number;
- Prepare a Form 4, Annual Dangerous Waste Report;
- Perform preventative maintenance;
- Properly accumulate hazardous wastes;
- Develop an emergency plan;
- Use, manage, and label hazardous waste containers properly;
- Arrange for proper transportation and disposal;
- Manifest shipments of hazardous wastes;
- Keep records of hazardous waste activity.

Accumulation of Hazardous Materials

All generators, both SQGs and regulated generators, must properly store and label hazardous waste. Proper storage includes:

- Using approved containers for hazardous materials;
- Having secondary containment in the event of a spill;
- Acquiring spill response equipment for each type of waste stored;
- Securing lids on all containers which are not currently being filled;
- Maintaining a flammable storage area in compliance with local fire codes.

Generators must also take steps to prevent accidents such as spills, fires, or releases of toxins into the environment. The generator should identify a safety/emergency coordinator to make sure the facility is in compliance with EPA/Ecology requirements and should train all employees on emergency preparedness.

All containers must have labels stating if the contents are considered dangerous or hazardous according to Department of Transportation (DOT), EPA, and Ecology guidelines and directions for appropriate emergency response in the event of spills or leaks. Containers must properly identify the following:

- Contents;
- Date the container started being filled;
- Health risks associated with the waste;
- Flammability;
- Reactivity;
- Required personal protection.

Transportation of Hazardous Wastes

All hazardous waste must be shipped in Department of Transportation (DOT) approved storage containers and marked appropriately. Although SQGs may legally transport their own hazardous waste, regulated generators must use a certified Hazardous Waste Transporter. Most hazardous waste disposal businesses are also certified transporters.

The generator must prepare, or have prepared for them, manifests for each shipment of hazardous waste sent to a hazardous waste facility. The "Uniform Hazardous Waste Manifest," developed by the EPA, is usually completed by the hauler, with information supplied by a customer on a profile of the waste. All copies of the manifest should include:

- Name, address, and telephone number of the generator;
- Date of shipment;
- State manifest number;
- Volume of material shipped and its proper shipping description, including the hazardous class and identification number, if applicable;
- Name and address of the permitted facility to which the material will be transported; Hauler's name, address, and EPA number;
- Generator's and transporter's signature.

Hazardous waste disposal companies must return a copy of the manifest to the generator within 45 days or Ecology should be notified.

It is important to keep these manifests up to date and well organized and to keep them on record indefinitely. See Appendix 4 for a sample manifest form.

When selecting a hazardous materials transporter or disposal firm, generators should evaluate the business's record of compliance with health and safety laws and insure that the firm has adequate insurance. Regional Ecology Hazardous Waste Inspectors should be contacted to provide copies of inspection reports and to review compliance history. If possible, site visits of disposal firms should be performed to evaluate service provider's operations.

Recycling of Hazardous Wastes

Regulated generators have the option of recycling their hazardous waste on-site. Hazardous wastes which are destined for recycling are considered exempt from their original hazardous waste designation. It is still mandatory to report them, but recycling credits are given for these items and they do not need to be disposed of with a hazardous waste disposal facility.

Further Information

For more information on accumulation and handling of dangerous wastes see EPA's Understanding the Small Quantity Generator Hazardous Waste Rules, Chapter 173-303 WAC Dangerous Waste Regulations, or call your regional office of the Department of Ecology. A partial list of Washington health and safety regulations is contained in Appendix 5.

V. PROPER REMOVAL AND HANDLING OF REFRIGERANTS

Common Refrigerants

There are 5 commonly used refrigerants in domestic refrigeration equipment; R-12, most commonly used in refrigerators; R-22, found in freezers and air conditioners; R-114, originally used in refrigerators, but now mostly found in marine air conditioning; ammonia (NH_3), commonly used in cold storage applications, boats, motor homes, and propane refrigerators; and sulfur dioxide (SO_2), found in older refrigeration units. Of these, R-12 and R-114 are CFCs, R-22 is an HCFC, and NH_3 and SO_2 are exotic refrigerants, not regulated by the Clean Air Act.

In addition, HFC replacement refrigerants such as R-124, R-125, and 134a are now commonly used in new refrigerators, freezers, and air conditioners.

A list of commonly used refrigerants is contained in Appendix 1.

Certification of Technicians

Beginning November 14, 1994, the EPA requires certification of technicians involved in: maintaining or repairing appliances containing less than 5 pounds of refrigerant (Type I Certification); maintaining, repairing, or disposing of appliances containing greater than 5 pounds of refrigerant (Type II Certification); and maintaining, repairing, or disposing of low pressure appliances (Type III Certification). Although certification of technicians involved in maintaining or repairing automotive air conditioners has been required since August 13, 1992, the EPA does not require certification of individuals involved in the disposal of automotive air conditioners or small refrigerated appliances.

Critics view the lack of a requirement of technician certification for individuals involved in disposal of refrigeration units as an oversight for several reasons:

- At the time of equipment disposal, all CFC refrigerants must be removed properly or they will escape to the environment;
- Any mixing of different types of refrigerant gases will make reclaiming the gas impossible and result in a hazardous mixture that must be destroyed by high temperature incineration;
- Refrigerant recovery equipment is expensive. Improper operation or handling of recovery equipment could damage the equipment;
- Untrained technicians may not understand safety issues related to working with refrigerants;
- Finally, the cost of training and certification is modest compared to the potential fines for illegal venting or workplace injuries.

Due to these considerations, it is strongly recommended that individuals involved in the recovery of refrigerants and disposal of refrigeration equipment complete an EPA approved certification program.

A survey of EPA approved technician certification programs is contained in Appendix 6.

Refrigerant Safety and First Aid

Toxicity of CFC and HCFC Refrigerants

Although the toxicity of CFC, and HCFC refrigerants is low, injury or death could occur in unique situations or where deliberately misused.

Since refrigerant gas is heavier than air, without adequate ventilation refrigerant gas can accumulate and exclude oxygen. Concentrated refrigerant gas can cause drowsiness and there have been cases of fatal cardiac irregularities as a result of exposure to high concentrations of refrigerant gas. For this reason, refrigerant recovery and unit decommissioning should occur only in areas with adequate ventilation. If refrigerant gas is to be handled in locations where high concentrations result, commercially available refrigerant monitors should be installed and auxiliary breathing apparatus should be readily accessible.

A victim of refrigerant gas inhalation should be immediately moved to fresh air and artificial respiration applied if the victim is not breathing. Do not give adrenaline (epinephrine) or other stimulants as they can complicate effects on the heart. Contact a physician immediately.

A release of liquid refrigerant or concentrated refrigerant gas can cause frostbite if it comes in contact with skin or eyes. In the case of eye or skin contact, flush with cool water for at least 15 minutes to warm slowly. Contact a physician immediately.

If subjected to high temperatures such as an electric heater or flame, CFC and HCFC refrigerants will decompose creating hydrochloric and hydrofluoric acids. If oxygen or water is present, poisonous phosgene gas will be generated. Although phosgene gas has a sharp, stinging effect on the nose at less than toxic concentrations, severe injury or death can result from breathing concentrated phosgene gas.

At the first indication of the presence of phosgene gas, the area should be evacuated immediately and the air should be cleared of the products of decomposition. A victim of phosgene gas inhalation should be immediately moved to fresh air and artificial respiration applied if the victim is not breathing. Contact a physician immediately.

The potential for creation of phosgene gas makes any flame or torch cutting of refrigeration equipment and components potentially hazardous and should be considered in designing processing procedures.

Toxicity of HFC and HCFC Replacement Refrigerants

The short term health effects of exposure to the newer HFC and HCFC refrigerants are very similar to those of CFC refrigerants.

The long term effects of exposure are only partially known. Initial research on some replacement refrigerants has shown an increased incidence of benign tumors in lab rats. In response, manufacturers have curtailed production of certain replacement refrigerants or lowered allowable workplace exposure limits. This has caused uncertainty in the refrigeration service industry with regards to selection of new equipment and refrigerants that will not pose long term health risks to service technicians.

Additional lab testing of HFC and HCFC refrigerants is being conducted and, when available, the results will undoubtedly be released in trade publications. This testing will likely determine which replacement refrigerants find common usage in industry.

Until more is known about replacement refrigerants, individuals recovering refrigerants from systems using HFC and HCFC refrigerants should always work in areas with adequate ventilation, refrigerant monitors, or auxiliary breathing apparatus.

Toxicity of Sulfur Dioxide Refrigerant

Inhalation of concentrated sulfur dioxide gas can result in severe injury or death. If a release of sulfur dioxide occurs, the area should be immediately evacuated and the air should be allowed to clear of gas. A victim of sulfur dioxide gas inhalation should be immediately moved to fresh air and artificial respiration applied if the victim is not breathing. Contact a physician immediately.

When sulfur dioxide combines with water it produces sulfuric acid. Sulfuric acid is highly corrosive, capable of burning skin or eating through metals and other materials. If contact with the skin does occur, the area should be immediately rinsed with water. Contact a physician immediately.

Toxicity of Ammonia Refrigerant

Unlike most other refrigerants, ammonia is a non-compressible, gas. As a result, ammonia systems operate under high static pressures, but do not release a sustained amount of refrigerant gas when vented. Ammonia is somewhat flammable and, with the proper proportions of air, will form an explosive mixture.

Inhalation of ammonia can result in severe injury or death. Ammonia gas may burn the eyes and cause loss of consciousness. A victim of ammonia inhalation should be immediately moved to fresh air and artificial respiration applied if the victim is not breathing. Contact a physician immediately.

Demand for Recovered CFC Refrigerants

Considerable research and development has been done by large chemical firms attempting to develop and market a “drop-in” replacement for refrigerant R-12. Although R-134a, and on a temporary basis R-22, have been identified as the likely replacements for refrigerant R-12 in domestic appliance applications, neither of these is a “drop-in” replacement for R-12 due to incompatibility of compressor lubricating oils.

To convert a piece of equipment from one type of refrigerant to another, at a minimum, the compressor lubricating oil must be drained and replaced. In many cases, the compressor must also be replaced. Frequently, the cost of performing this conversion represents a large percentage of the cost of replacing the entire unit with a new model.

As a result, until the current stock of refrigeration equipment has been decommissioned or modified, there will be a steady demand in industry for clean, used refrigerants. Since the production of R-12 and other CFC gases is being phased out, this demand will have to be met through recovery of existing refrigerant stocks. This increasing demand will likely result in higher prices being paid for recovered refrigerants, providing a financial incentive to recover CFC gases that may have otherwise been vented.

Availability of Reclamation Services

The refrigerant reclamation business is rapidly growing and is very volatile. New reclamation businesses incorporate regularly, forcing established firms to remain competitive, or loose their customer base.

The value of recovered CFC gas is entirely dependent on purity of used gas and the current market demand for the specific type of refrigerant gas. Refrigerants that do not meet the specifications of a reclaimer must be separated or incinerated.

A relatively new development in the reclaiming industry is the emergence of businesses "laundering" refrigerant gas. Instead of sending refrigerant to a reclaimer and purchasing new refrigerant from a supply house, air conditioning and appliance service companies can have their refrigerant cleaned and returned, paying only the costs of transportation and cleaning the gas.

A survey of several EPA certified reclaimers is included in Appendix 7.

Refrigerant Disposal Options,

There are two options for disposal of recovered refrigerants; 1) segregating different types of refrigerants for shipping to an EPA certified reclaimer and, 2) commingling of refrigerants to be destroyed by high temperature incineration or separated if possible.

Segregation of Refrigerant Types for Reclamation

To ensure that used refrigerant gas is acceptable for reclamation by a certified facility, there must be minimal cross-contamination of different types of refrigerant gases (generally under 1% or 2%). In the past, refrigerant manufacturers were able to mix reclaimed gas with new refrigerant stocks to maintain purity levels. With the eventual elimination of "new" CFC refrigerants, mixing of new gas with recovered gas will discontinue and the standards for cross contamination levels may become more stringent.

If individuals or businesses recovering refrigerant gas intend it to be reclaimed rather than incinerated two alternatives exist; 1) using dedicated recovery machines for each type of refrigerant gas recovered or 2) converting recovery equipment from one refrigerant type to another each time refrigerants change.

Determining the appropriate refrigerant recovery equipment to purchase is entirely dependent on the volume of refrigeration equipment to be processed and the circumstances under which recovery will take place. For example, the most desirable equipment for an appliance repair facility processing numerous units per month in one location will be different than equipment that must be carried by a technician into a customer's kitchen or up onto a building roof.

If a large number of refrigeration units are to be decommissioned, it would be preferable to operate dedicated recovery equipment for each type of refrigerant gas to be recovered. This would speed up processing time and help ensure purity of recovered refrigerants. Unfortunately, it is expensive to purchase and maintain recovery equipment for each of the common high pressure refrigerants (R-12, R-22 and R-114), as well as exotic refrigerants (R-500, R-502, NH_3, and SO_2) and the new replacement refrigerants (R-123, R-124, R-125, R-134a).

Fewer recovery machines can be employed if recovery units are evacuated and converted each time a different type of refrigerant is recovered. Converting a recovery machine from one type of refrigerant to another requires evacuation of the recovery machine down to at least 1000 microns (29.88 inches of mercury) to eliminate residual refrigerant and ensure purity of recovered refrigerants. This process can be accomplished using a second recovery machine capable of achieving EPA mandated vacuum levels and a vacuum pump to eliminate residual refrigerants.

A second, less cumbersome option would be to purchase a recovery machine with a "pump-out" feature. Units with a pump-out feature do not hold refrigerant gas on-board, and can be converted from one refrigerant gas to another by activating the pump-out function at the completion of a recovery to eliminate the majority of refrigerant from the system. The conversion is completed by pumping the unit into a vacuum with a vacuum pump and changing filter dryers.

Regardless of the type of recovery equipment or methods employed for CFC, HCFC, and HFC refrigerants, processors of sulfur dioxide (SO_2) or ammonia (NH_3) refrigeration units will have to design and construct their own recovery equipment, due to unavailability of commercially produced recovery equipment for these refrigerants.

Commingling of Refrigerants for Incineration

Commingling all recovered refrigerants in one cylinder using a single, all purpose, recovery machine and shipping the mixed product for destruction by incineration is a feasible option. Although only one recovery machine and related support equipment would be required to accomplish all recovery, this option would likely prove to be more expensive than segregation options for the following reasons:

- It is expensive to incinerate mixed refrigerants, between $3.50 and $10.00 per pound, depending on quantities to be destroyed. In addition, any revenue normally generated by sale of recovered gas to reclamation firms, up to $4.00 per pound, would also be lost;
- If refrigerants are commingled, eventually a unit containing sulfur dioxide (SO_2) may be processed along with CFC units. When the SO_2 enters the recovery machine, it will combine with moisture to create sulfuric acid in the lubricating oil, leading to a compressor burn-out; Destruction of recovered refrigerant gas will decrease the availability of reclaimed gas, leading to higher prices and shortages of refrigerants. Shortages could, in turn, require the retirement of refrigeration equipment before the end of its normal service life;
- One of the economic incentives for complying with the Clean Air Act would-be eliminated, possibly resulting in less diligence in recovering refrigerants to mandated levels.

Most national reclamation services also offer incineration of mixed refrigerant gases. Some are also experimenting with separation of mixed refrigerants. A list of reclaimer firms can be found in Appendix 7 and a list of firms providing incineration of mixed gas can be found in Appendix 8.

VI. PROCESSING GUIDELINES

As noted above, it is strongly recommended that technicians recovering refrigerants from discarded appliances or air conditioning systems complete an EPA recognized certification course. No amount of material presented in this paper can replace the information available, and practical experience gained through a well organized certification course.

Safety Equipment

Prior to working with any refrigerants or lubricating oils, technicians should obtain current copies of manufacturer's Material Safety Data Sheet (MSDS) and follow all noted safety precautions for all materials they will handle. These sheets are available from all manufacturers or distributors of new refrigerants or lubricants.

Personnel handling refrigerants should always wear safety glasses, preferably side shield type. In addition, gloves should be worn to protect skin from chemicals and to prevent frostbite. Showers and eye wash stations should be readily accessible in case of contact with eyes or skin occurs. In addition, adequate foot protection (heavy work boots or steel toed shoes) are recommended to prevent injury as a result of dropping heavy items.

As noted above, if refrigerant gas is handled in locations where high concentrations can accumulate, refrigerant monitors should be installed and auxiliary breathing apparatus should be readily accessible.

Prior to servicing or decommissioning refrigeration equipment, all electrical power should be disconnected from the unit. Failure to do so, could cause serious injury or death.

Finally, decommissioning refrigeration equipment can be very messy work as a result of old food left in units, water spilled from defrosting freezers, oil spills from dripping refrigerant lines or compressors, and dust and dirt attached to the bottom and back sides of refrigerators. Care must be taken to keep work areas clean and clear of hazards to prevent workers from being injured by slipping on slick surfaces.

Handling of Appliances Before Refrigerant Removal to Avoid Inadvertent Releases

Refrigerators, freezers, and air conditioning units frequently have exposed refrigerant lines used to expel heat to the outside atmosphere, on the back or bottom of the unit. If these lines are broken or punctured, the refrigerant gas contained in the system will escape to the atmosphere. Some common causes of accidental discharges are:

- Using exposed refrigerant lines to move or lift an appliance;
- Dropping or dragging units on the ground;
- Appliances shifting in a transportation truck;
- Catching the blade of a two wheel hand truck on refrigerant lines;
- An unsecured compressor motor tearing loose refrigerant lines during rough handling;

- Stacking of refrigeration units in a collection container;
- Loading units in a compactor truck;
- “Defrosting” the-freezer with a knife or screwdriver;
- A technician assuming a refrigeration unit is already vented and cutting refrigerant lines.

Normally, a standard two wheel appliance dolly is adequate for moving refrigerant units, provided that care is taken to protect the exposed refrigerant lines and that they are not used for lifting or loading. Care should be taken to secure or remove power cords as they can become entangled in the dolly wheels and cause the refrigerator to be dropped, resulting in employee injury or release of refrigerants.

Occasionally, a refrigeration unit will arrive that has been crushed or severely damaged, leading one to believe that the refrigerant lines have been broken and refrigerant vented. Unless the technician can visually identify the location of the broken line precisely, it is recommended that the refrigeration unit be attached to recovery equipment and evacuated as though it is still charged with refrigerant.

Accidental Venting Procedures

Despite all precautions, accidental releases of refrigerant gases can occur. It is recommended that formal procedures, including training and disciplinary actions, be developed by any business engaged in refrigerant recovery and appliance recycling. A log of accidental releases of refrigerants, regardless of amount or cause, should be maintained to document preventative procedures and record training andd disciplinary actions taken to prevent re-occurrence. A sample accidental release form is contained in Appendix 9.

Identification and Separation of Appliances by Refrigerant Type

The most effective way to ensure purity of recovered refrigerant gas is to segregate refrigeration units by refrigerant type prior to decommissioning. Although the majority of domestic units use refrigerant R-12, each unit should be inspected to determine the refrigerant type used and whether the unit has been• converted to another refrigerant.

When manufactured, all refrigeration units have a placard installed on the compressor or in the compressor compartment naming the manufacturer, equipment model and serial numbers, and listing the type and amount of refrigerant used, and refrigerant test pressures (See below).

If the manufacturer’s placard is missing from a unit, another refrigerant identification technique can sometimes be used. At a given ambient temperature, different refrigerant gases will exhibit different pressures. System pressure can be tested by attaching a manifold gauge to a service port or refrigerant tap valve on the equipment. Deviation of

more than a small amount will indicate that either the system has a low charge or that it is charged with a different type of refrigerant gas. A pressure/temperature (PT) chart for several common refrigerants is contained in Appendix 10.

If there is no placard indicating refrigeration type and the results of pressure testing are inconclusive, the refrigerant gas in the unit should be recovered and placed in a refrigerant cylinder dedicated to mixed gas for separation or to be destroyed by high temperature incineration. Doing so will prevent the possible cross contamination of larger quantities of refrigerant gas with the unknown gas.

Frequently, technicians will segregate units by refrigerant type to allow them to concentrate on one type of refrigerant until it is convenient to convert to another gas to eliminate a backlog of units.

Refrigerant Cylinders

Two types of refrigerant cylinders are commonly used to contain refrigerant gases; disposable and reusable cylinders.

Disposable Cylinders

New refrigerants are commonly packaged in disposable cylinders. Disposal cylinders normally have thin steel walls and are designed to be filled by the refrigerant manufacturer and discarded after use. Re-filling and transporting disposable containers is against federal law and violators are subject to a penalty of up to $25,000 fine and up to 5 years imprisonment.

It should be noted that after all the liquid refrigerant in a disposable cylinder has been used to charge refrigeration systems, the “empty” cylinder still contains refrigerant gas. For that reason, “empty” disposable cylinders should be attached to recovery equipment and the refrigerant vapors recovered prior to recycling the container to prevent the release of residual gases into the atmosphere.

Re-fillable Cylinders

US Department of Transportation (DOT) approved re-fillable refrigerant cylinders have substantially stronger construction and usually have at least 2 replaceable valves, rather than only one on disposable cylinders. Recovery equipment is normally sold with at least one DOT approved refillable cylinder.

Re-fillable cylinders should always be properly labeled, including:

- A DOT label indicating shipping name and United Nations number for the specific refrigerant;
- A DOT “nonflammable gas” label (4" x 4" green diamond shaped);
- A label prepared in accordance with the American National Standard Z129.1-1982 and Compressed

Gas Association Pamphlet C-7, listing:

- Product identity;
- Antidotes;
- Signal word;
- Notes to physicians;
- Statement of hazards;
- Instructions in case of contact or exposure;
- Precautionary measures;
- Instructions in case of fire, spills or leaks;
- Instructions for container handling and storage;

Sample copies of refrigerant drum labels are contained in Appendix 11.

Refrigerant Cylinder Safety

Overfilling Cylinders

Overfilling refrigerant cylinders is very dangerous. Failure to leave adequate expansion space can result in over-pressurization. When tank temperatures exceed 130 degrees Fahrenheit, the compressed gas expands to liquid-fill the cylinder in what is known as hydrostatic condition. If this occurs, even minor increases in temperature will result in rapid increases in internal pressure. If the tank safety devises do not adequately vent this increase in pressure, the cylinder could rupture causing substantial damage, severe injury, or death.

During recovery of refrigerant gas, all refrigerant cylinders should be weighed on an accurate scale. Never fill a cylinder in excess of 80% of its water capacity (i.e. 40 lbs of refrigerant in a “50 lb” tank). If a tank will be exposed to temperatures in excess of 130 degrees Fahrenheit, fill only to 60%.

Safety - All Cylinders

- Never overfill cylinders.
- Keep caps on outlets at all times unless cylinder is in use.
- Cylinders should be stored up-right or in specially designed racks.
- Never drop or strike a cylinder with a hammer or other tool.
- Keep cylinders away from heat sources.
- Never lift cylinders by the valve.
- Protect cylinders from moisture, salt, or chemicals.
- Open cylinder valves slowly.
- Always close valves after use, even if still connected to recovery hoses or machines.
- Never tamper with a cylinder’s safety devices.

Refrigerant Recovery Equipment

Each piece of refrigerant recovery equipment has different operating procedures. Therefore, it is strongly recommended that operators of recovery equipment become thoroughly familiar with their particular piece of equipment by reading the manufacturer's operating manual and by obtaining training from the retailer or distributor of recovery equipment.

As noted above, effective November 15, 1993, all new recovery equipment must be certified by an approved testing organization, such as Underwriters Laboratory. In addition, any recovery equipment manufactured before that date must meet the same recovery standards.

Two general methods can be used to move refrigerants from one place to another, active or passive processes. An active system requires some kind of mechanical apparatus to move refrigerant, such as a compressor, hand pump, or liquid pump. A passive system may have no moving parts, operating instead using the principle that refrigerants tend to migrate to the coldest place in a system. Although the vast majority of available systems are active systems, the EPA has certified several passive systems.

The following equipment will be required to recover refrigerants in accordance with EPA and Ecology regulations:

- EPA certified refrigerant recovery equipment;
- Re-fillable DOT approved refrigerant cylinder;
- Vacuum pump;
- Line filter dryer;
- Manifold gauges;
- Recovery hoses;
- System tap valves.

In all cases the recovery support equipment should be in good condition with no leaks.

As mentioned previously, if the intent is to recover refrigerants for reclamation, additional equipment may be required to maintain gas purity and facilitate recovery of different refrigerants.

Appendix 12 contains schematic drawings of a refrigerant recovery and a refrigerant recycling machine. A survey of several different recovery units available from local refrigeration equipment distributors is contained in Appendix 13. Appendix 14 contains a comparison of 3 different tap valve set-ups.

CFC, HCFC, and HFC Recovery Procedure

Refrigerant recovery procedures are essentially the same for all high pressure refrigerants (R-12, R-114, R-22, R-500, R-502). As noted above, proper safety equipment and protective clothing should be used whenever working with refrigerants.

Whenever refrigerant hoses are attached to units or refrigerant cylinders or lines are purged of air, "di minimus" releases of refrigerant gas occur. The use of "environmental charging hoses" with valves and/or quick release connectors can substantially reduce the amount of gas released during unit servicing or decommissioning. It is strongly recommended that these type of hoses be used with all recovery set-ups.

Recovery machines and re-fillable cylinders must be completely, evacuated before initial start-up and every time a different refrigerant is used in a cylinder or recovery machine. Evacuation removes residual gases from the equipment, preventing cross-contamination of refrigerants. Evacuation can be accomplished with a vacuum pump capable of achieving a minimum of 1,000 microns, or 29.88 inches of mercury. It generally takes several hours for a vacuum pump to completely evacuate a cylinder or recovery machine.

The evacuated recovery machine, refrigerant cylinder, manifold gauges, and hoses should then be attached in accordance with the manufacturer's operating instructions and the refrigerant gas recovered according to equipment specifications.

To ensure all refrigerants are recovered from a refrigeration unit, technicians should attach recovery equipment to both the high pressure and low pressure side of the compressor. Although this may seem cumbersome, it will help prevent unintentionally venting of trapped refrigerants.

CFC refrigerants have a strong affinity for compressor oils and will remain in suspension even when the system is exposed to a deep vacuum. Refrigerant dissolved in compressor oil can be driven out of the oil by heating the bottom of the compressor with a heat gun during the final stages of recovery. In addition, striking the compressor several times with a hammer near the end of the recovery cycle will cause trapped refrigerant to boil out of the compressor oil.

When a cylinder reaches 80% of its water capacity, recovery should be terminated to prevent over-filling, and the cylinder exchanged for an empty one, even if it occurs in the middle of system recovery.

Steps to Prevent Mixing of Refrigerants

Steps that can be taken to prevent or minimize the probability of mixing refrigerants include the following:

- Always examine the equipment's nameplate and look for stickers indicating that the unit has been retrofitted with a different refrigerant;
- Properly evacuate recovery units or dedicate a recovery unit to a specific refrigerant;
- Dedicate cylinders to a specific refrigerant;
- Unknown refrigerants should be tested before consolidating into larger batches;
- Assure that cylinders are free of oil and other contaminants;
- Keep appropriate records of refrigerant inventory;

Clearly label cylinders used for recovered and/or recycled refrigerants.

It is difficult to determine the presence of mixed refrigerants without a laboratory test, therefore, every precaution should be taken to avoid mixing in the first place.

Replacement Refrigerants

As with other refrigerant types, the newly developed replacement refrigerants must be recovered according to EPA and Ecology rules. Some HCFCs and HFCs depend on synthetic lubricating oils rather than the mineral based lubricating oils that are used, with older refrigerants. This will complicate recovery because most available recovery equipment is not compatible with both the mineral oils used in CFC units and the synthetic oils used in newer HCFC and HFC units. This incompatibility has resulted in development of "oil-less" recovery systems. These machines do not use a standard, oil lubricated compressor and are compatible with various refrigerants and different compressor oils.

Low Pressure Gases

Several refrigerants in common usage (R-11, R-123, R-113) have very high boiling points and operate under low pressures. These refrigerants are usually found in very large, industrial chillers. Specialized recovery equipment, training, and certification is required to service or decommission this equipment.

"Drop-in" Replacements

Refrigerant manufacturers have been aggressively working to develop a "drop-in" replacement for the most common refrigerant, R-12. A successful "drop-in" would not require retrofitting of refrigeration equipment or changing compressor oil.

Several manufacturers have been experimenting with what are known as zeotropic blends of other refrigerants. Unlike the azeotropic refrigerants (R-500, R-502, R-503) which remain a mixture in both liquid and gaseous state, zeotropic blends such as R-406a (55% R-22, 41% R-142b, and 4% R-600a) are mixtures of refrigerants that can separate into component forms in a gaseous state.

Identification and recovery of these new products can be difficult because zeotropic blends are subject to selective leakage of one or more of the constituent refrigerants. If a leak occurs, the highest pressure fraction will escape first, leaving the lower pressure components behind. In addition, the composition of recovered refrigerant may change from the beginning of recovery to the end of recovery. Zeotropic blends can be recovered in the same fashion as other refrigerants. The major difference is that they cannot be reclaimed by anyone other than the manufacturer.

OZ-12

Effective November 15, 1992, the EPA banned the sale of one pound containers of refrigerant R-12 for recharging automobile air conditioners. Following, imposition of the ban, OZ Technology began distributing a product known as OZ-12. This product appeared on the shelves of auto parts stores in Washington, prompting a complaint from Ecology personnel.

The National Highway Safety Administration investigated OZ-12 and found propane and butane listed as primary ingredients. Although neither propane nor butane are considered ozone-depleting gases, both are extremely flammable. Washington law prohibits using flammable refrigerants in automobile air conditioners and subsequently, OZ Technology recalled OZ-12 from all Washington distributors. Nonetheless, some of the product was sold and probably introduced into air conditioning or refrigeration equipment.

Businesses recovering refrigerants, whether automobile repair shops or appliance processors, should be aware of the dangers of recovering flammable gases and that even a very small amount of OZ-12 can contaminate an entire refrigerant recovery cylinder, requiring incineration as a hazardous material.

Sulfur Dioxide (SO_2) Recovery Procedures

Several options exist for decommissioning SO_2 units including: cut and run, recovery to a dedicated SO_2 tank, conversion to sulfuric acid ($H_2 SO_4$) for disposal, and inerting SO_2 in water. Each of these methods has inherent problems.

Cut-n-run

Sulfur dioxide refrigerators contain between 1 and 2 pounds of SO_2 gas, an amount far below the amounts regulated by the EPA, Ecology, or the Puget Sound Air Pollution Control Authorities (PSAPCA). Although it would be legal to cut the refrigerant lines and dear the immediate area and wait for the gas to dissipate, this is NOT recommended for several reasons:

- The operator may be unexpectedly exposed to escaping gas, causing injury or death;
- Bystanders may be unaware of the gas and could be injured by SO_2 gas;
- Residual SO_2 still trapped in refrigeration compressors could lead to subsequent exposure and injury;
- Confusion between refrigeration units may lead to venting of CFC gases as well.

Collection for Disposal in a Dedicated SO_2 Cylinder

The SO_2 contained in refrigeration units could be collected using a SO_2 recovery machine, in a similar fashion as normal refrigerants. Unfortunately, at this time, SO_2 recovery equipment is not commercially available and must be custom fabricated. In addition, a survey of refrigerant reclaimers and incineration companies was unable to identify a disposal option for SO_2 gas.

Converting to Sulfuric Acid for Disposal

Dissolving SO_2 in water (H_2O) produces sulfuric acid (H_2SO_4). Potentially, sulfuric acid generated in this manner could be re-used by industry if it could be generated in proper concentrations. Several of the hazardous waste disposal firms listed in Appendix 16 indicated that they can accept sulfuric acid for disposal.

Inerting in Water With Soda Ash

Combining SO_2 with soda ash (Na_2CO_3) in water (H_2O) will form sodium sulfate, carbon dioxide, and water ($NaSO_4 + CO_2 + H_2O$). If properly mixed, the pH level of the solution can be brought to within the parameters of municipal water treatment facilities. Additional materials may be required by local waste water authorities to prevent additional reactions or damage to downstream waste water treatment equipment.

Required Equipment

As noted above, SO_2 refrigeration equipment presents significant hazards to service technicians and appliance dismantlers. SO_2 refrigeration equipment should only be processed in areas with adequate ventilation using full face respirators or auxiliary breathing apparatus. All skin should be covered to eliminate the potential for acid burns resulting from SO_2 coming in contact with sweat. In, addition to safety glasses, gloves, and coveralls, the following equipment is necessary:

- Properly constructed SO_2 recovery equipment;
- Manifold gauges;
- Refrigerant hoses;
- Tap valves;
- Pumping and diffusing apparatus to mix SO_2 with water.

It must be emphasized that due to the severe hazards involved in mishandling SO_2, prior to disposing of SO_2 in any of the above methods, it is strongly recommended to consult with a chemist, local hazardous waste personnel, and waste water authorities to develop a safe and effective program.

Ammonia (NH_3) Recovery Procedures

Several options exist for decommissioning ammonia (NH_3) units including: cut and run, recovery to dedicated ammonia tank, and mixing with water for disposal.

Cut-n-run

Ammonia refrigerators contain between 1 and 2 pounds of NH_3 under high static pressures. Since NH_3 is a non-compressible gas, it does not release a sustained amount of refrigerant gas when vented, but rather is released in a single, explosive burst. As with SO_2, ammonia is not present in sufficient quantities to be regulated by the EPA, Ecology, or PSAPCA and it would be legal to merely cut the refrigerant lines and clear the immediate area to allow the gas to dissipate. This is NOT recommended for several reasons:

- NH_3 is corrosive and can cause severe damage to skin, eyes, and respiratory systems;
- NH_3 gas is explosive and combustion could occur;
- NH_3 systems are under very high static pressures, and could cause serious injury if released unexpectedly;
- The operator may be sprayed by concentrated aqueous NH_3, causing injury;

- Bystanders may be injured by concentrated NH_3 gas;
- Confusion between refrigeration units may lead to venting of CFC gases as well.

Collection for Disposal in a Dedicated NH_3 Cylinder

The NH_3 contained in refrigeration units could be collected and disposed of in a similar fashion as normal refrigerants. Unfortunately, recovery equipment capable of handling NH_3 is not commercially available and would require custom fabrication.

Mixing with Water for Disposal

Diluting NH_3 in water (H_2O) through a special apparatus can produce a material that is acceptable to local waste water utilities.

NH_3 units also contain approximately 3.0% sodium chromate tetra hydrate by weight as a rust inhibitor. Hexavalent chromium (+6) such as found in sodium chromate tetra hydrate is a regulated heavy metal (D007) and may cause lung, nasal, and gastrointestinal cancer by inhalation on chronic overexposure. Metro industrial waste personnel indicated that up to 2.75 parts per million (ppm) chromium may be legally put down the drain in Seattle but strongly recommended lab testing to verify chromium concentrations.

Alternatively, chromium can be precipitated out of solution with specialized equipment using lead salt, barium salt, or barium sulfate. This material can be recovered for recycling or proper disposal.

Required Equipment

As noted above, NH_3 refrigeration equipment presents significant hazards to service technicians and appliance dismantlers. NH_3 refrigeration equipment should only be processed in areas with adequate ventilation using full face respirators or auxiliary breathing apparatus. This is especially important due to the explosive potential of NH_3. Skin should not be exposed to eliminate the possibility of burns from contacting concentrated NH_3. In addition to safety glasses, gloves, and coveralls, the following equipment is recommended:

- Liquid pump capable of pumping NH_3;
- Refrigerant hoses;
- Tap valves;
- Apparatus to mix NH_3 with water.

It must be emphasized that due to the severe hazards involved in, mishandling NH_3 and the toxic nature of chromium, prior to processing NH_3 units or disposing of their contents as municipal waste water, it is strongly recommended to consult with a chemist, local hazardous waste personnel, and waste water authorities to develop a safe and effective program.

VII. MANAGEMENT OF CAPACITORS AND BALLASTS IN APPLIANCES

Polychlorinated Biphenyls

Polychlorinated biphenyls, or PCBs, are man-made compounds developed for use in electrical equipment such as capacitors, fluorescent ballasts, and transformers because of their chemical stability and fire retardant properties. PCBs are persistent chemicals that do not biodegrade after entering the environment. Rather, they bioacummulate or biomagnify, meaning they increase in concentration at every level of the food chain.

In 1968, 1600 people were poisoned in Japan by PCB contaminated cooking oil. It was subsequently discovered that PCBs can cause kidney and liver disorders, skin lesions, nervous system and reproductive disorders. PCBs have been found in human milk and fatty tissue and have been implicated in an increased incidence of various types of cancers and birth defects.

The production of PCBs was prohibited in the U.S. in 1976 under the Toxic Substances Control Act (TSCA). This prohibition applied only to domestically produced chemical manufacturers and did not extend to electrical equipment manufactured outside of the U.S. In addition, domestic manufacturers were allowed to deplete their stock rather than dispose of the materials already produced.

In 1988 high levels of PCBs were discovered in shredder fluff in several states. One of the suspected causes of this contamination was fluorescent light ballasts and capacitors that had not been removed from appliances prior to shredding. A major trade organization, the Institute of Scrap Recycling Industries, recommended that members no longer process or handle appliances unless capacitors and ballasts had been removed.

See Appendix 15 for a list of PCB capacitor manufacturers and uses of PCBs.

Identification of Capacitors and Ballasts in Appliances

There is no way to generically identify appliances containing PCB capacitors or ballasts. In addition, capacitors are commonly added to appliances during service life. As a result, visual inspection of every appliance processed should be performed to ensure that PCB laden capacitors and ballasts are removed and segregated for proper disposal.

Two types of capacitors are commonly present in appliances; electrolyte capacitors and oil filled capacitors.

> Electrolyte capacitors, sometimes called dry or start capacitors, operate for a short time to assist in starting single phase motors. Start capacitors range between 1" in diameter x 2.5" long (approx. 1 ounce) and 2" in diameter x 4.25" long (approx. 1/2 lb) and can be easily identified by their cylindrical shape and black bakelite (plastic) or aluminum shell and porous end plug. Frequently electrolyte capacitors are mounted directly on the side of electric motors or refrigerator compressors. Start capacitors are commonly found in washers, dryers, refrigerators, freezers, and on other small electric motors.

Oil filled capacitors, commonly called run capacitors, are designed to balance electrical loads and remain in the electrical circuit throughout system operation. The capacitor oil helps dissipate heat during operation and maximizes a motor's efficiency. Run capacitors are most frequently found adjacent to electric motors or on electric panels. Oil filled capacitors used in appliances vary in size, ranging from 2" x 3" x 1" (approx. 1 /41b) to as large as 8" x 4.5" x 3" (approx. 6 lbs). They can be identified by their sealed, metal shell and oval or rectangular shape. Oil filled capacitors have been used in refrigerators, freezers, air conditioners, microwave ovens, and furnaces. Frequently air conditioners and microwaves contain multiple capacitors. Removal of run capacitors can only be performed by dismantling or opening these units.

Fluorescent ballasts are required for the proper functioning of fluorescent lights. Normally mounted to the back panel of a light fixture, fluorescent ballasts are usually rectangular in shape, varying from 2" x 2" x 4" (approx. 8 ounces) to 2.5" x 3" x 16" (approx. 15 lbs).

Potential for Containing PCBs

A study undertaken by the Scott County Sanitary Landfill Commission for the Iowa Department of Natural Resources sampled 364 appliances for the presence of capacitors and fluorescent light ballasts and developed the following generalizations:

- Oil filled capacitors are present in nearly all air conditioners and microwave ovens;
- Capacitors are present in some refrigerators, freezers, and washing machines; mostly larger, or commercial units;
- Capacitors are not present in dishwashers, clothes dryers, stoves, or water heaters.

Scott County tested 43 electrolyte capacitors, 76 oil filled capacitors, and 22 fluorescent ballasts for the presence of PCBs. PCBs were found in oil-filled capacitors from air conditioners, furnaces, microwaves, and an electric fan, as well as in fluorescent light ballasts, in concentrations of up to 100%.

Further, the study indicated that electrolyte capacitors do not contain PCBs. Instead, they contain metallic strips wrapped in either ethylene glycol or boric acid impregnated paper.

Of the capacitors and ballasts tested, the results were as follows:

Type	Number	Range of PCBs (parts per millions)
Electrolyte	43	< 20 ppm
Oil-filled	27	< 20 ppm
	50	120,000 - 960,000 ppm
Ballasts	7	< 20 ppm
	13	120,000 - 900,000 ppm

The Scott County study recommended that all capacitors be removed, inspected to determine the potential for containing PCBs, and disposed of properly.

A Wisconsin fact sheet states that oil-filled capacitors always contained PCB fluid prior to 1976. The paper went on to state that oil-filled capacitors used PCB fluid on a limited basis until 1984.

Removal of Capacitors and Ballasts

Unless properly handled, capacitors and ballasts can be punctured by equipment, crushed or cracked through rough handling, or damaged during loading and unloading of equipment.

To safely remove and handle capacitors and ballasts, the following safety equipment is recommended:

- Watertight disposable work gloves;
- Safety goggles;
- Coveralls or long sleeve shirt; Work boots that can be decontaminated or disposable booties.

The following tools are helpful in removing capacitors and ballasts safely:

- Standard and Phillips screwdrivers (with electrically insulated handles);
- Socket wrenches;
- Nut drivers;
- Wire cutters.

After locating a capacitor or ballast in a unit, the connecting wires should be cut or disconnected. The mounting screws and brackets should then be removed. Capacitors or ballasts should never be pried out of the unit. This could break the casing allowing PCB oil to leak.

Capacitors may still hold a charge after being removed from an appliance. The capacitor should be discharged immediately by placing an insulated (to prevent electric shock) screwdriver across the terminal posts or by using a discharge resistor, Caution should be used to prevent electric shock.

Segregation, Storage, and Disposal of PCB Capacitors and Ballasts

Two DOT approved containers should be available for disposal of capacitors and ballasts. One barrel should be marked "No PCBs" and be labeled in accordance with local municipal solid waste authority for non-hazardous wastes.

A second container should be lined with a 5 ml plastic drum liner and labeled in accordance with requirements for disposal of PCBs and other hazardous wastes (See Hazardous Materials section and consult your hazardous waste transporter and disposal company). Appendix 16 contains copies of proper labels for drums containing PCB capacitors.

Approximately 4 inches of dry absorbent material should be placed in the bottom of the PCB container to absorb fluids in the event of leakage of the contents. The lid on the PCB barrel should be kept sealed when it is not being filled.

Identification and Storage of PCB Capacitors

Following removal, all capacitors and ballasts should be visually inspected prior to disposal. Electrolyte capacitors should be placed in the non-hazardous, "No PCBs," container.

Oil filled capacitors and ballasts should be closely inspected for the words "No PCBs" either imprinted on the shell or printed on the label. If these words are present, the capacitor or ballast can be placed in the "No PCBs" container.

Capacitors and ballasts with no markings or labels should be assumed to contain PCBs. These capacitors and ballasts should be carefully placed in the PCB labeled container. Once deposited in the container, these materials should not be disturbed except by the company accepting the materials for hazardous waste disposal. Containers used for the transport and/or storage of PCBs cannot be used to transport and/or store any other materials without proper decontamination or reconditioning.

A capacitor storage area must be designed and maintained to prevent the release of PCBs to the environment. The storage area should:

- Have continuous, watertight concrete or other comparable flooring: Concrete floors must be sealed with concrete sealer or be lined with at least a 50-mil polyethylene liner, to prevent spilled PCB fluid from permeating the concrete;
- Have containment curbing with a minimum height of 6 inches;
- Not have floor drains, sewer lines, or other openings that would allow liquids to flow from the curbed area;
- Be located inside, or in an area protected from the weather;
- Not be located within a 100 year flood plain;
- Be protected from vehicular traffic.

Storage areas and containers should be inspected regularly for evidence of leaks.

PCB Spills

In the event of an accidental spill of fluid suspected of containing PCBs, the following equipment should be available to safely clean the material:

- Watertight disposable work gloves or Vitron gloves;
- Safety glasses;
- Oil absorbent pads;
- Oil solvent (Hexane, mineral spirits, Pentane 155, Xylene, Toluene, or diesel fuel).

Immediately place the leaking capacitor or ballast in the PCB barrel. If oil has leaked on the shop floor, clean the entire area with an oil absorbent pad containing one of the solvents listed above. All materials used for cleaning, including gloves, pads and rags should be placed in the PCB drum for disposal.

If adjacent soil becomes contaminated with PCB oil, shovel the soil to a depth of at least 4 inches and place soil in PCB barrel. Contact local hazardous waste clean-up authorities listed in Appendix 2. A soil sample of the surrounding area should be taken and analyzed for PCB contamination.

It should be noted that if PCB contamination does occurs, the generator will be held accountable for all PCB's detected in soils or ground water. The fines for PCB contamination and the future cleanup costs greatly exceed the costs of proper PCB disposal.

Transportation and Disposal of PCB Capacitors and Ballasts

Several hazardous waste disposal firms offer either incineration and landfilling options for disposing of PCB laden materials. In most cases, landfilling is cheaper than incineration and recycling of the metals.

Generators should consider the long term implications of this decision as well as any other decision regarding the "disposal" of hazardous wastes. While no recommendation on a preferred disposal option can be made in this regard, it is important to note that it is the generator's responsibility to guarantee that their wastes are properly handled and managed forever.

If landfilling is selected as the disposal option, and at some future date soil or ground water contamination is discovered, the generator of PCB materials may be included in the list of potentially liable parties, possibly resulting in being forced to share in the cost of a hazardous waste clean-up.

High temperature incineration of PCB capacitors breaks down the PCBs into simple compounds. If incineration is selected as the disposal option, a land ban is attached to the waste manifest, guaranteeing to the generator that the hazardous materials disposal company will not landfill the materials collected.

Appendix 17 contains a list of EPA certified PCB disposal companies. Most of these firms can also provide transportation of PCB capacitors and ballasts.

VIII. MANAGEMENT OF MERCURY FOUND IN APPLIANCES

Mercury Hazards

Mercury is listed in WAC 173-303-9903 as an extremely hazardous waste with high toxicity characteristics. Short term effects of mercury exposure include skin and lung irritation, fever, nausea, diarrhea, headaches, muscle pain, and kidney, liver, and nerve damage. Long term effects include lack of appetite, inability to urinate, anemia, difficulty walking, twitching, loss of memory, and hallucinations. Concentrations as low as .03 mg have induced psychiatric symptoms in humans.

Mercury in Appliances

Mercury is used in appliances in a variety of applications, including: door switches in older washing machines, fluorescent light tubes in stoves and ranges, and in temperature controls in some stoves and water heaters. Mercury is also commonly used in room thermostats.

Mercury components should be removed from all appliances prior to shipping to scrap metal recycling firms. Failure to do so could result in mercury being released to the environment when the appliance is either baled or shredded. If mercury is released, it could contaminate shredder fluff beyond federal or state limits and create a health hazard to workers at the recycling firm.

Identification of Mercury Components

In older washing machines, a mercury switch is sometimes attached to the door lid near the hinge to act as a safety shut-off switch when the lid is opened during machine operation. Mercury switches from washing machines are cylindrical in shape, one to two inches long, approximately one half inch in diameter, and have two wires protruding from one end of the plastic housing. Mercury switches in washing machines were eventually replaced by a plastic micro-switch that makes a soft clicking noise when the washing machine lid is lifted.

It has been mentioned that the temperature control thermostats containing a small amount of mercury may have been used in some natural gas stoves and water heaters. If found, these components should be carefully removed and handled in the same manner as mercury switches.

Removal of Mercury Switches

Employees removing mercury switches should be equipped with proper safety equipment, including: gloves, eye protection, and coveralls.

Although very durable, mercury switches can be broken and should be handled carefully. Mercury switches can be removed by disconnecting or cutting the wires connecting the mercury switch to the washing machine's wiring harness. The retaining clip should be gently opened and the mercury switch removed.

Handling and Storage of Mercury Switches

Since mercury is listed as an Extremely Hazardous Waste, regardless of generator status, businesses accumulating mercury must dispose of it within 14 days of collecting 2.2 lbs.

Mercury switches should be placed in a steel or poly drum that has been lined with a 5 mil poly liner. Handling, storage, and shipping for disposal should be done in accordance with DOT rules and the receiving facility's requirements. Containers and storage areas should be inspected regularly for evidence of leaks.

A list of firms accepting mercury components for recycling is contained in Appendix 18.

IX. MANAGEMENT OF COMPRESSORS FROM REFRIGERATION EQUIPMENT

Refrigerant Compressors

Most refrigeration units contain an electric compressor motor used to compress CFC refrigerant gas and circulate the refrigerant through the sealed system. The compressor also uses a high quality mineral oil used as motor lubricant and coolant. The CFC gas and compressor oil are the only materials normally found in an operational refrigeration system.

Consumers assume refrigeration equipment will operate continuously for many years without requiring maintenance. During a normal day, the compressor will cycle on and off dozens of times. To prevent compressors from making excessive noise and reduce operating wear, the motor must be internally dampened to eliminate vibration. This is accomplished by mounting the motor on springs inside the compressor housing. In addition, vibrations between the compressor body and refrigerator shell must be eliminated. Most commonly, compressors rest on rubber cushions to lessen vibration and noise generated during operation.

Difficulties in Disposing of Refrigeration Compressors

Although most ferrous metal recyclers in Washington will accept refrigerator cabinets for baling or shredding after all CFCs and PCB capacitors have been removed, the metal recyclers surveyed require that compressor motors also be removed prior to being accepted. There are several reasons, including:

- The Clean Air Act places the burden on the final handler of appliances to ensure that CFC refrigerants have been recovered. Requiring removal of compressors ensures that no CFC gas remains in the system, preventing an illegal release of refrigerants during baling or shredding;
- Compressor motors contain significant amounts of lubricating oil. Many scrap metal yards already have water run-off contamination problems. Accepting compressors, could potentially increase this liability;
- Finally, compressors are electric motors containing substantial amounts of copper. Although copper is valuable for recycling when separated, copper dissolves in molten steel and becomes a significant contaminant if not removed prior to smelting.

Compressor Removal

Prior to removing compressors from refrigeration equipment, complete recovery of refrigerants in compliance with EPA specifications must be completed.

As noted above, most compressors are mounted in refrigeration equipment with bolts and nuts. Removal of compressors can be accomplished using tools as simple as a socket set and a pair of diagonal cutters, or as capital intensive as a plasma torch or an automobile engine puller.

There are several simple methods to remove compressor motors, including:

- Simple hand tools (socket wrenches, screwdrivers, pry bar);
- Reciprocating saw;
- Pneumatic chisel;
- Acetylene torch.

Regardless of the method of removing compressor mounting bolts or brackets, copper refrigerant lines and the wiring harness must be disconnected prior to removing the compressor from the unit. This is most easily accomplished with a pair of diagonal cutters or bolt cutters.

Hand Tools

Compressor motors are most commonly installed with standard bolts and nuts. Unless the bolts have been severely damaged or permanently rusted in place, simple hand tools such as socket wrenches or open end wrenches are capable of removing most compressors. If rusted tight, compressor mounting bolts will either need to be broken with a hammer or cut out using a reciprocating saw, pneumatic chisel, or acetylene torch.

Newer refrigeration units frequently utilize spring clips to attach motors to frame members. Unless damaged, spring clips can be easily removed using screwdrivers or plyers. If frozen in place, spring clips can be cut free using a pair of diagonal cutters.

8 refrigerators were selected at random and compressor motors removed. Using hand tools, it took 34 minutes to complete the operation, an average of 4.25 minutes per compressor.

Reciprocating Saw

The processing time of removing compressors can be accelerated considerably using a reciprocating saw to cut the mounting bolts, brackets, or frame members.

10 refrigerators were selected at random and compressor motors removed. Using a reciprocating saw, it took 20 minutes to complete the operation, an average of 2.0 minutes per compressor.

The major disadvantage of using a reciprocating saw is the cost of replacing saw blades that wear out or are broken. In the test, 2 saw blades were broken during removal of the compressors. Replacement blades can be purchased for approximately $2.50 per blade.

Pneumatic Chisel

Use of a pneumatic chisel can be very effective in removing compressor motors from refrigeration units. 7 compressor units were removed in 22 minutes using this method for an average of 3.1 minutes per unit. Pneumatic chisels are durable and are subject to little wear and tear during use.

Aside from requiring a reliable supply of compressed air for operation, the most significant problem with use of a pneumatic chisel is the level of noise associated with the equipment. Pneumatic chisels generate noise levels far greater than occupational

safety limits and require hearing protection for both the operator and anyone in the surrounding area.

Acetylene Torch

Acetylene torches are commonly used in servicing and repair of refrigeration units and automobile dismantling yards. Cutting torch tips are inexpensive and relatively efficient at removing compressor motors. 10 compressor units were removed in 60 minutes using, an acetylene cutting torch for an average of 6.0 minutes per compressor.

Several problems associated with removing compressors with an acetylene torch were encountered, including:

- Some compressors are mounted on fiberglass panels, requiring alternate removal methods;
- Cutting torches consume considerable amounts or acetylene and oxygen during operation;
- Cuts have a tendency to weld themselves closed, requiring additional cutting;
- Flammable materials present in compressor compartments include: foam or fiberglass insulation, dust and dirt, paint, rubber mounting pads, electric wiring, refrigerant oil, and refrigerant gases. Unintentional burning of any of these materials will result in smoke that is potentially hazardous to employees.

Plasma Cutting Torch

Although a plasma cutting torch is effective at cutting flat plate steel, consuming only electricity and compressed air, it does not perform well when cutting steel channels or complex shapes. As a result, a plasma torch is considerably less effective in removing compressors than an acetylene torch. In addition, removing compressors with a plasma torch caused substantial burning of surrounding materials. Plasma torches are also relatively expensive ($2500 - $5000).

Compressor Disposal

Although the used lubricating oil contained in compressors is a regulated waste, compressor motors themselves are not regulated. At this time no federal or state regulations mandate specific processing or disposal methods for compressor bodies.

Three options exist for disposing of compressors removed from refrigerant equipment, disposing of compressors as solid waste, contracting with a compressor recycling firm, or disassembling compressors in-house and recycling the metals.

Landfilling Compressors

On January 1, 1994, Ecology implemented a rule aimed at promoting the recycling of used oil and discouraging disposal of the oil in environmentally damaging ways. The rule prohibited the dumping of oil bearing containers, regardless of type, in landfills. Although compressors were not specifically identified in the ban, compressors contain a significant amount of lubricating oil and, as a result of the ban, the landfilling of undrained compressors would be illegal.

It should be noted that many waste haulers do not like handling compressors due to the potential for damage to refuse collection, hauling, and compacting equipment. Acceptance standards and disposal rates for landfilling are developed on a county by county basis. Some counties may allow the landfilling of compressors that have been drained of lubricating oil. Parties interested in landfilling compressors should contact their garbage hauler and local solid waste management authority to determine acceptance standards and rates.

From a best management practices standpoint, the landfilling of compressors would not be the preferred option. Since compressors contain significant quantities of recyclable copper, steel, and aluminum, landfilling of this material is a waste of recyclable metals and valuable landfill space.

Compressor Draining

Regardless of whether compressors are to be discarded as solid waste or recycled, the lubricating oil should be drained. This can be relatively easily accomplished by drilling a hole (1 /4" to 1") in the bottom of the compressor body. The compressor can then be inverting over a catch basin, such as on a screen over a 55 gallon drum, and allowed to drain thoroughly. The compressor should be re-adjusted at least once during the draining process to allow any oil trapped in the compressor to drain.

30 compressors were selected at random and drained of lubricating oil, requiring 60 minutes to accomplish, or an average of 2.0 minutes per compressor. Draining the 30 compressors resulted in 3 gallons of lubricating oil, an average of 12.8 fluid ounces of lubricating oil per compressor.

Compressor Recycling Businesses

A number of companies accept compressors from businesses and the public for recycling. Some of these businesses perform the dismantling and segregation of metals, while others subcontract or export the compressors for disassembly.

Most compressor management firms request that measures be taken to prevent lubricating oil from leaking from compressors during storage or shipping. The most common methods used to prevent oil leaks are draining the compressors as noted above, soldering or pinching copper lines closed, or using a leak proof container to catch leaking oil, such as a 55 gallon drum.

A survey of firms providing compressor recycling services is contained in Appendix 19.

Disassembly for Domestic Recycling

Compressor cases are very durable and difficult to open. There is no commercially available compressor cutting equipment to accomplish this work. Instead, compressor recycling firms have designed and developed methods to perform the work, including:

- Cutting with an abrasive saw;
- Cutting with a acetylene cutting torch;
- Cutting with a plasma torch.

An additional challenge in processing compressors is the potential that lead was used in the black paint on compressors. Workplace exposure limits on lead require that air monitors and special air handling equipment be used if lead exposure could result from torch cutting or grinding operations.

Cutting with-an Abrasive Saw

Compressor recycling firms have designed and built two different types of abrasive saws to cut compressor shells. One firm utilizes a standard table saw with an abrasive wheel. The operator manually rotates the compressor body against the blade. A second design utilizes a motorized carriage to rotate the compressor against the abrasive blade. After the shell is cut open and one half of the shell removed, the motor retaining springs can be cut and the electric motor can be lifted out of the other half of the shell for disassembly.

An abrasive saw makes a clean cut through the shell burning only a small amount of residual oil or compressor components. Abrasive wheels are relatively expensive and would be consumed regularly with this type of operation. As noted above, lead may still be a concern.

Cutting with an Acetylene or Plasma Cutting Torch

Although both an acetylene cutting torch and a plasma cutting torch were capable of cutting compressor shells, both had significant problems.

Acetylene and plasma torches both create substantial heat and an ignition source, resulting in combustion of paint; compressor oil, and residual refrigerant. As noted above, the products of combustion of compressor oil and refrigerant include hydrofluoric acid, hydrochloric acid, and phosgene gas. The products of combustion of compressor paint are unknown.

During tests smoke was generated in sufficient quantities that air emission permits may be required from local air pollution control authorities if compressor cutting with either an acetylene or plasma torch is to be done on a regular basis.

Finally, if a compressor shell has been cut with a torch, the electric motor inside is severely burned, making disassembly and recycling of the metals significantly more difficult and potentially hazardous to workers.

Unless air handling mechanisms can be developed to control or eliminate the hazardous smoke and protect workers, neither an acetylene cutting torch nor a plasma cutting torch would be recommended for cutting large numbers of compressors.

Disassembly of Electric Motors

The electric motors contained in compressors are generally assembled with nuts and bolts or pressed together. It is relatively straight forward to disassemble and recover the metals from individual motors. Unfortunately, there are numerous different motor designs that would require different set-ups and tools to disassemble. In addition, copper electric windings are routed through the stator of the electric motor, and must be cut by hand and

pulled out of the motor. As a result, disassembly of electric motors takes significant labor time to accomplish.

Some scrap metal buyers purchase scrap electric motors for recycling, including compressor motors with their shells removed. Motors are then either sent to a metal shredder or exported for disassembly and recovery of metals.

Export Markets

Export markets exist in Asia and on the Pacific Rim for scrap motors. Several scrap brokers purchase full container loads of compressors, approximately 45,000 lbs, for shipment to foreign recycling firms. The compressors are disassembled by hand, and the copper, aluminum, and steel are recovered for reuse. To be acceptable to these markets, compressors must be drained of lubricating oil prior to loading.

Metals Recycling Firms

Currently, most metal recyclers in Washington will not accept compressor motors, regardless of how they have been handled. Several firms indicated that they will accept the metals from compressors provided the metals are clean and segregated.

Compressor recycling firms or processors must develop programs and procedures conforming with the acceptance standards of buyers of their metals. These acceptance standards will also dictate potential revenues available.

Appendix 20 contains a list of metals recycling firms around Washington state that indicated they would accept materials recovered from compressor motors.

Desiccant Filter Dryers

Desiccant filter dryers are cylindrical chambers filled with a special desiccant that removes moisture, acids and particulate matter. Due to the materials trapped **in** used filter dryers, persons servicing refrigeration equipment and refrigerant recovery equipment must properly manage filter dryers that have been removed from service.

If the filter dryer is to be discarded as solid waste, it should be handled as a hazardous material due to residual oil, acid, and particulates. Filter dryers can, however, be recycled along with other metals.

X. MANAGEMENT OF USED COMPRESSOR OIL

Chlorine Content in Used Compressor Oil

During refrigeration system operation, compressor oil is in contact with refrigerant, in both gas and liquid form. At low temperatures, as much as 1/3 of the refrigerant in a system may be mixed in the compressor oil. This can be verified visually when the oil is drained from a system. Even if the system has been subjected to EPA regulated vacuums during recovery, the oil drained out of a compressor will foam when agitated, releasing refrigerant gas.

Federal Regulation of Used Compressor Oil

The open cup flash temperature for compressor oil ranges between 335 and 405°F. These open cup flash points are well above the characteristic level of <140°F for liquid waste and compressor oil does not have be handled as a characteristic hazardous waste.

Federal rules presume, however, that any waste oil exhibiting greater than 1,000 parts per million (ppm) chlorine has been mixed with a listed hazardous waste, such as a solvent, and require that such waste be manifested and disposed of as a hazardous waste.

Recognizing that used compressor oils will exhibit higher levels than 1,000 ppm chlorine, the EPA amended their presumption to remove refrigerant oil from these regulations, on the condition that:

- The used compressor oil is not mixed with any other wastes;
- The oil is not mixed with oils from any other sources;
- The oil is destined for reuse or recycling;
- The oil contain less than 4,000 ppm total halogens.

Unfortunately, although the EPA provided an administrative exemption for compressor oils, in practical terms it is of little use because used compressor oil will normally exhibit far higher than 4,000 ppm chlorine and oil recycling firms usually mix oil from different sources. As a result, unless methods are used de-chlorinate oil below the 1,000 ppm threshold, used compressor oil must be manifested and disposed of as hazardous waste.

Testing Chlorine Content in Refrigerant Oil

Two methods are available to test the chlorine content in oils. One method is to use a propane halide leak detector and burn a small sample of oil on the copper disk. If the flame turns green, elevated levels of chlorine are present in the oil. Although a halide leak detector is a fairly inexpensive (approximately $30.00) and a relatively consistent way to determine whether elevated levels of chlorine are present, it will not provide a quantitative measure of the parts per million (ppm) of chlorine in the oil.

A more reliable, quantitative, testing method is to use a disposable chlorine detection test kit. Kits are commercially available from an environmental supply house (approximately $10.00 to $12.00 apiece). Most oil recycling companies use these kits to field test used oils for halogen, content.

Chlorine detection tests on refrigerant oil taken immediately after removal from a refrigeration system exhibited approximately 40,000 ppm chlorine (4%). Oil that is allowed to stand open in a 5 gallon drum for 3 days exhibited approximately 15,000 ppm chlorine (1.5%). It should be noted that any reduction in the amount of chlorine or CFCs in used compressor oil is due to a "di minimus" release of refrigerant gas to the atmosphere unless the escaping gas is recovered with a recovery machine or trapped in an activated carbon filter. These releases should be reduced as much as possible or eliminated altogether.

Storage of Compressor Oils

Compressor oil must be collected and stored in DOT approved shipping containers labeled "Used Compressor Oil Only." Containers should be rigid, leak proof, in good condition, and kept covered when not being filled. If the oil is destined for hazardous waste disposal, the drum should have a hazardous waste sticker noting the generator's name and address, generator number, and the date the oil began accumulating. Finally, the drum should also have a sticker noting the contents are flammable.

Precautions should be taken to minimize dangerous pressure build-up in containers due to the release of refrigerant from the oil. One method is to avoid filling containers completely and to keep containers as cool as possible.

Used oil should be stored in a bermed area, capable of containing 10% of the capacity of all stored containers or 110% of the capacity of the largest container, whichever is greatest. Bungs should be kept on drums and caps on containers when containers are not being filled or emptied to prevent accidental spills and exposure to harmful and flammable vapors.

Disposal of Compressor Oil

Decisions of how to dispose of used compressor oil will depend on the generator's hazardous materials status. Small quantity generators (SQGs) have the option of using city or county sponsored programs to collect and properly manage hazardous materials. Although most of these programs are not free, they do eliminate many of the manifesting and record keeping requirements. Information on these services is available from the Moderate Risk Coordinators listed in Appendix 3.

Regulated generators will need to work with a permitted transporter and to develop their own programs to disposal of compressor oils unless they can be recycled. The most common disposal option for used compressor oil, used by most hazardous waste management firms, is burning at high temperature in a permitted hazardous materials burner such as a cement kiln. A list of firms disposing of highly chlorinated compressor oil is contained in Appendix 21.

A second, less common option for disposing of used oil is to dechlorinate the, oil and recycle it with other used oil sources. At this time, no commercially available equipment exists capable of dechlorinating refrigerant oil.

Several methods have been suggested to reduce the chlorine content in oil, including:

- Distillation and separation;
- Heating oil and subjecting it to a vacuum.

Distillation and Separation

If compressor oil is heated above its boiling point, it could potentially be separated from impurities, including refrigerant gas and chlorine. Solvent distillation equipment is commercially available, and it is possible that this equipment could be redesigned to dechlorinate oil. Unfortunately, solvent distillation equipment costs in the range of $10,000 to $30,000, prohibitive for small scale appliance processors.

A second challenge involves fire regulations. Some fire districts restrict or prohibit use of equipment capable of heating flammable liquids above their boiling point. For example, at this time, solvent distillation equipment is not allowed by the Seattle Fire Department.

Heating and Subjecting oil to a Vacuum

The majority of chlorine in used refrigerant oil is in suspension, bound in CFC refrigerant molecules. If the oil is subjected to heat and a vacuum for a sufficient period of time, it is possible to remove enough of the refrigerant to pass a chlorine detection test at the 1000 ppm level.

When oil is subjecting to a vacuum, gas particles in suspension will escape from the surface -of the liquid. To remove sufficient refrigerant from a storage drum using a vacuum alone would require a substantial period of time. Similarly, applying heat to an oil container will excite the molecules, causing the refrigerant gas in suspension to be released over time. Neither of these methods alone were found to be adequate to reduce the chlorine level in the oil to less than 1000 ppm.

Researchers at the University of Northern Iowa have had success using readily available, low cost materials to dechlorinate oil on a small scale applying heat and vacuum simultaneously. Results of their work is contained in Appendix 22.

Burning Refrigerant Oil for Energy Recovery

Washington state regulations pertaining to the burning of used oil for energy recovery are similar to EPA rules and are found in Section 515 of the Dangerous Waste Regulations (WAC 173-303-515). These regulations specify three categories of used oil: (1) on-specification; (2) off-specification; and (3) dangerous waste fuel.

The threshold levels for other constituents in on-specification oil is shown below:

Constituent/Property	**Allowable Level**
Arsenic	5 ppm maximum
Cadmium	2 ppm maximum
Chromium	10 ppm maximum
Lead	100 ppm maximum
Flash Point	100°F minimum
Total Halogens	4000 ppm
PCBs	2 ppm

Since used compressor oil contains as much as 40,000 ppm chlorine (halogens) in suspension, unless dechlorinated for recycling, compressor oil would be considered off-specification used oil.

Off-specification oil can only be burned for space heat by the person or business that generates it. It cannot legally be sold or given away. A generator may burn his own used oil in a space heater, without testing, provided that the heater has a capacity of less than 0.5 million BTU per hour, and the products of combustion are vented to the ambient air.

Although both the EPA and Ecology provide the above exemption for the burning of off-specification oil for space heat, there are several reasons why this is NOT recommended:

- The temperatures achieved in small burners are not sufficient to provide complete destruction of the hazardous materials contained in compressor oil. Burning compressor oil at low temperatures will release phosgene gas, hydrofluoric, and hydrochloric acids. Releasing these products into ambient air would be potentially hazardous to-employees or other people in the area and exceed normal workplace exposure regulations;
- The products of combustion of used compressor are very corrosive to mechanical equipment. Greatly accelerated degradation of the burner's heat exchanger and other parts should be anticipated if compressor oil is burned for space heat;
- Finally, the EPA wants to discourage the burning of used oils with significantly elevated levels of halogens in space heaters or non-industrial furnaces or boilers.

XI. PLANNING FOR APPLIANCE RECYCLING PROGRAMS

One of the objectives of this report is to provide assistance to local solid waste agencies, appliance processors, and scrap metal firms serving smaller communities and rural areas in designing and implementing programs to properly manage discarded appliances.

Developing a single ser of recommendations is difficult due to the vastly different capabilities and infrastructures, present in government and business sectors throughout the state. Other differences include: varying distances to markets, low prices paid for recyclable materials, and the high cost of transporting large, bulky items such as appliances. This report will attempt to provide a discussion of issues to be considered when planning an appliance recycling program.

Evaluating Flow Rate of Discarded Appliances

An estimate of appliance generation rates is desirable for purposes of planning. Factors *which* impact appliance disposal generation include:

- Numbers of units currently in service;
- Life expectancy for given appliances;
- Cost of new goods as compared to costs of repairs;
- Consumer buying and disposal practices.

The EPA's "Characterization of Municipal Solid Waste in the United States: 1992 Update" estimated that appliance disposal occurs at a rate of approximately 0.14 appliances per person per year. This can, be compared with a year long study conducted by McHenry County, Illinois who determined a locally accurate number of 0.07 appliances per person per year.

Finally, the same EPA study estimated that appliances represented approximately 1.4% of the solid waste stream by weight. Multiplied by the amount of solid waste generated and by a conversion factor results in an estimate of the number of appliances generated in a planning area per year:

$$1.4\% \times \frac{\text{solid waste generated}}{\text{year}} \times \frac{600 \text{ lbs}}{\text{yd}^3} \times \frac{\text{appliances}}{200 \text{ lbs}} = \frac{\text{number of appliances}}{\text{year}}$$

These estimates of discarded appliance generation rates are applied to Washington state in Appendix 23.

Current Appliance Disposal Methods and Local Processing Capabilities

Despite the valuable steel contained in appliances, due to decommissioning costs and distances from scrap markets, appliances are still landfilled in Washington. In addition, the increased costs associated with the proper recovery of refrigerants and management of hazardous materials act as a negative incentive to proper disposal of appliances and, as a result, the improper disposal of refrigeration equipment continues to occur in spite of the Clean Air Act.

In determining an appropriate strategy to properly dealing with the flow of discarded appliances in a given jurisdiction, it is necessary to evaluate the existing infrastructure and processing capabilities.

Questions to be answered for a given solid waste planning district include:

- What are estimated appliance generation rates?
- What are the current appliance disposal practices in the area?
- Is illegal dumping a primary disposal option?
- Is stockpiling of appliances occurring? How widespread is it and in what quantities? Are local businesses in the area involved in refrigerant recovery and metals recycling?
- How far away are they?
- How much does it cost to properly dispose of an appliance at local businesses?
- Are other businesses or non-profit organizations interested in initiating service?
- Is a government agency involved in providing service? Is one interested in doing so?
- How far from a population center with appliance recycling capabilities does the majority of the population live?
- Are out of area resources available to perform services on a mobile basis or at special collection events? Can material be stockpiled locally to facilitate mobile service?
- How far is it to the nearest scrap metal buyer?

Local Appliance Processing Capabilities

It is also desirable to know what the capabilities and interests of local public, private, and non-profit organizations are with regards to appliance recycling. Numerous organizations and businesses are involved in appliance recycling in different jurisdictions around the country, including:

- Public works or solid waste agencies;
- Moderate risk waste agencies;
- Correctional facilities;
- Non-profit charitable organizations;
- Thrift stores;
- New and used appliance retailers;
- Scrap metals recyclers;
- Automobile dismantlers;
- Automobile repair facilities.
- Air conditioning service technicians;

Local planners may wish to look to these organizations for support and information in planning and implementing programs and in assessing current processing capacity.

APPENDIX 1

COMMON REFRIGERANTS AND THEIR APPLICATIONS

Common Name	Chemical Name	Chemical Symbol	Partial List of Applications	Toxicity[1]	Refrig-rant Class	Ozone Depletion Potential[1,2]	Approximate Atmospheric Lifetime (years)[1]
R-11	Trichloromonofluoromethane	CCI_3F	Large air conditioners, chillers, solvents, blowing agents for polymeric foams.	Low	I	1.0	60.0
R-12	Dichlorodifluormethane	CCl_2F_2	Refrigerators, auto air conditioners, commercial fishing boats, chillers, freezers, ice makers, soda dispensers	Low	I	1.0	120.0
R-22	Monochlorodifluoromethane	$CHCIF_2$	Air conditioners, Frozen-food plants and storage units, many medium and low-pressure applications.	Low	II	0.05	2.1
R-113	Trichlorotrifluoroethane	$C_2Cl_3F_3$	Small to medium air conditioners and Industrial coolers.	Low	I	0.8	90.0
R-114	Dichlorotetrafluoroethane	$CCIF_2CCIF_2$	Older refrigerators and marine air conditioners	Low	I	1.0	200.0
R-123	Dichlorotrifluoroethane	$CHC1_2CF_3$	Replaces R-11 in large chillers		II	0.02	
R-124	Chlorotetrafluoroethane	$CHCIFCF_3$	Replaces R-12 and 114 In air conditioners and marine chillers		II	0.02	
R-125	Pentafluoroethane	CHF_2CF_3	Replaces R-502 in low temp. food storage units and commercial food transportation.		II		
R-134a	Tetrafluoroethane	CH_2FCF	Replaces R-12 in refrigerators, auto air conditioners, and centrifugal and reciprocating chillers	Low		0.0	
R-500	73.8%R-12, 26.2% R-152a	CCl_2F_2/ CH_3CHF_2	Shipping refrigeration, chillers, water coolers	Low			
R-502	48.8% R-22, 51.2% R-115	$CHC1F_2$/ $CCIF_2CF_3$	Shipping refrigeration, commercial refrigerators, ice makers, and cold storage	Low			
R-717	Ammonia	NH_3	Industrial cold storage and RV refrigerators	High		0.0	0.0
R-764	Sulfur Dioxide	SO_2	Older refrigerators	High		0.0	0.0

[1]Missing table entries are unknown

[2]Chemical's ability to destroy ozone in relation to the destruction potential of CFC-11.

APPENDIX 2

REGULATORY AND NON-PROFIT AGENCIES

The Clean Washington Center

Department of Trade and Economic Development
2001 Sixth Avenue, Suite 2700
Seattle, WA 98121

EPA Region 10

Waste Management Branch - MS-530
1200 Sixth Avenue
Seattle, WA 98101
206-442-2777

Alaska, Idaho, Oregon, Washington

EPA Region 10 Library

800-424-4EPA

EPA CFC Hotline

800-296-1996

Department of Ecology (Ecology)

Solid and Hazardous Waste Program
Mail Stop PV-11
Olympia, WA 98504-8711
206-407-6700
800-633-7585

Ecology Hazardous Substance Info Hotline

800-633-7585
(provides Community Right-To-Know Info)

Regional Department of Ecology Offices

See Appendix 3

Department of Ecology

Recycling Hotline
1-800-RECYCLE

King County Business Waste Line

206-296-3976

Municipality of Metropolitan Seattle (METRO)

Hazardous Waste Management
130 Nickerson St., Suite 100
Seattle, WA 98109-1658
206-689-3050

Industrial Materials Exchange (IMEX)

506 2nd Ave. Room 201
Seattle, WA 98104
206-296-3976
206-296-3997 (FAX)

Refrigeration Service Engineering Society (RSES)

PO Box 84841
Seattle, WA 98124-6141
206-344-5749

Resource Conservation and Recovery Act (RCRA) Hotline

800-424-9346

Toxic Substance Control Act (TSCA)

202-554-1404

Washington Citizens for Recycling

157 Yesler Way, Suite 309
Seattle, WA 98104
206-343-5171

Washington State Recycling Association (WSRA)

203 East Fourth Ave., Suite 422
Olympia, WA 98501
206-352-8737
206-352-8426 (FAX)

APPENDIX 3

COUNTY MODERATE RISK WASTE COORDINATORS

Eastern Washington Counties

Eastern Regional Dept of Ecology Office

North 4601 Monroe, Suite 200
Spokane, WA 99205-1295
509-456-2926

Adams County

Kami Snowden
Adams County Public Works
210 Broadway
Ritzville, WA 99169
509-448-9441

Asotin County

Steve Becker
Asotin County Public Works
PO Box 160
Asotin, WA 99402
509-243-4174

Columbia County

Roger Trump
Columbia County Planning
341 East Main
Dayton, WA 99238
509-382-4676

Ferry County

Bill Chamberlain
Ferry County Public Works Dept.
PO Box 305
Republic, WA 99166
509-775-5225

Franklin County

Mike Davis
Franklin County Public Works
3540 North Ave. "C"
Pasco, WA 99301
509-545-3551

Garfield County

Nancy Waldron
Garfield County Engineer
PO Box 67
Pomeroy, WA 99347
509-843-1301

Lincoln County

Terry Goodman
Lincoln County Planning Dept.
303 Sixth Street
Davenport, WA 99122
509-725-7911

Pend Orielle County

Sid Straus
Pend Orielle County Public Works
PO Box 5040
Newport, WA 99156
509-447-4573

Spokane County

Monica Hariston
City of Spokane
Solid Waste Management
1225 East Marietta Ave.
Spokane, WA 99207

Stevens County

Jeffrey Johnston
Stevens County Hazardous Waste/
Recycling Coord.
PO Box 109
Colville, WA 99114

Walla Walla County

Gretchen Lowe
Walla Walla Recycling and Waste Management
310 West Poplar, Room 007
Walla Walla, WA 99362

Whitman County

Thomas Moore
Whitman County Public Works
404 North Main Street
Colfax, WA 99111

Central Washington Counties

Central Regional Office
Department of Ecology

106 S. Sixth Avenue
Yakima, WA 98902-3387
509-575-24-90

Benton County

Bill Henager
Benton County Solid Waste Man.
PO Box 110
Prosser, WA 99350-0110
509-786-5611

Chelan County

Kirk Bradford
Chelan/Douglas County
Health & Solid Waste Office
411 Washington Street
Wenatchee, WA 98801
509-664-2624

Brenda Harn
Chelan County Public Works
350 Orondo Street
Wenatchee, WA 98801
509-664-2631

Douglas County

Ron Draggoo
Solid Waste Coordinator
93 Eastmont Ave.
East Wenatchee, WA 98802
509-886-0899

Kittitas County

Bill Ramsdell
Kittitas County Solid Waste Div.
507 Nanum Street
Ellensburg, WA 98926
509-962-7698

Suzanne Tarr
Kittitas County Solid Waste Div.
507 Nanum Street
Ellensburg, WA 98926
509-962-7577

Klickitat County

Tom Moughon/John. Longfellow
Solid Waste Department
205 S Columbus, Room 103
Goldendale, WA 98620-9288
509-773-4616

Okanogan County

Richard Sele
Dept. of Public Works
PO Box 711
Okanogan, WA 98840
509-422-7300

Yakima County

Mark Nedrow
Yakima County Public Works
128 N 2nd Street Room 408
Yakima, WA 98901
509-575-4076

Chris Coffin
Yakima Health District
104 N. First Street
Yakima, WA 98901
509-575-4258

Northwest Counties,

Northwest Regional Department of Ecology
3190 160th Ave. SE
Bellevue, WA 98008-5452
206-649-7000

Island County

Jerry Mingo
Recycling/Hazardous Waste Coord.
PO Box 5000
Coupeville, WA 98239-5000
206-679-7386

Bambi Brown
Small Quantity Generator Coord.
PO Box 5000
Coupeville, WA 98239-5000
206-678-5111

King County

Todd Yerkes - Rosemary Byrnes
Local Hazardous Waste Management
Seattle-King County Health Dept.
110 Prefontaine Place South, Suite 210
Seattle, WA 98104
206-296-3974

Shirley Axelrod - MRW Facilities
Seattle Solid Waste Utility
710 Second Ave., Suite 505
Seattle, WA 98104-1713
206-684-7804

Dave Galvin - Hazardous Waste Section
King County Dept. of Metropolitan Services
130 Nickerson St., Suite 100
Seattle, WA 98109-1658
206-689-3054

Donna Cassano, MRW Project Manager
King County Solid Waste Division
400 Yesler Way, Room 600
Seattle, WA 98104-2637
206-296-8456

Kitsap County

Gretchen Olsen/Paula Price
Kitsap/County Public Works
MS-26, 614 Division Street
Port Orchard, WA 93366-4699
206-895-3931

San Juan County

Helen Venada - MRW Coordinator
San Juan County Public Works
PO Box 2992
Friday Harbor, WA 98250-0729
206-378-3421

Ed Stuhr
Solid Waste Manager
San Juan County Public Works
PO Box 2992
Friday Harbor, WA 98250-0729
206-378-2114

Skagit County

Jeff Hegedus
Skagit County Public Works
County Admin. Bldg., Room 203
700 South Second St.
Mount Vernon, WA 98273-3864
206-424-9532

Snohomish County

Suellen Mele - Recycling/MRW Coordinator
Snohomish County Solid Waste Division
Wall Street Building
2930 Wetmore Ave, Third Floor
Everett, WA 98201-4045
206-388-6484

Freda Tepfer
Small Quantity Generator Specialist
Snohomish County Solid Waste Division
Wall Street Building
2930 Wetmore Ave., Third Floor
Everett, WA 98201-4045
206-388-6473

Whatcom County

Jack Weiss - Solid Waste Division
Whatcom County Public Works
5256 Northwest Drive
Bellingham, WA 98226-9040
206-676-6707

Bill Englander - Program Manager
Solid Waste Program - City of Bellingham
5256 Northwest Drive
Bellingham, WA 98226
206-676-6850

Southwest Counties

Southwest Regional Department of Ecology
5751 6th Ave SE
Lacey, WA 98502
206-407-6300

APPENDIX 4

OMB burden disclosure statement:

Public reporting burden for this collection of information is estimated to average: 37 minutes for generators, 15 minutes for transporters, and 10 minutes for treatment, storage and disposal facilities. This includes time for reviewing instructions, gathering data, and completing and reviewing the form. Send comments regarding the burden estimate, including suggestions for reducing the burden to: Chief, Information Policy Branch, PM-223, U.S. Environmental Protection Agency, 401 M Street SW., Washington DC 20460; and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Washington DC 20503.

Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form Approved. OMB No. 2050-0039 Expires 9-30-94

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. | Manifest Document No. | 2. Page 1 of | Information in the shaded areas is not required by Federal law

3. Generator's Name and Mailing Address | A. State Manifest Document Number

4. Generator's Phone ( ) | B. State Generator's ID

5. Transporter 1 Company Name | 6. US EPA ID Number | C. State Transporter's ID

7. Transporter 2 Company Name | 8. US EPA ID Number | D. Transporter's Phone | E. State Transporter's ID

9. Designated Facility Name and Site Address | 10. US EPA ID Number | F. Transporter's Phone | G. State Facility's ID

H. Facility's Phone

GENERATOR

11. US DOT Description (Including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt./Vol.	I. Waste No.
a.					
b.					
c.					
d.					

J. Additional Descriptions for Materials Listed Above | K. Handling Codes for Wastes Listed Above

15. Special Handling Instructions and Additional Information

16. **GENERATOR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations.

If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.

Printed/Typed Name | Signature | Month Day Year

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials

Printed/Typed Name | Signature | Month Day Year

18. Transporter 2 Acknowledgement of Receipt of Materials

Printed/Typed Name | Signature | Month Day Year

19. Discrepancy Indication Space

FACILITY

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19

Printed/Typed Name | Signature | Month Day Year

EPA Form 8700-22 (Rev. 7-89) Previous editions are obsolete

Distribution: White - Return to Generator Green - Transporter #1
Yellow - Transporter #2 Pink - Generator's Copy, Gold - Transporter 2

APPENDIX 5

SELECTED WASHINGTON REGULATIONS AND REFERENCES

Washington Regulations	Subject(s)	Technical Assistance and Interpretation
Chapter 173-304 WAC, Minimum Functional Standards for Solid Waste Handling	Applied to MRW Fixed Facilities	Local Health Authority, Ecology Regional Office
Chapter 173-303 WAC, Dangerous Waste Regulations	Generator Status EPA/State ID # and reporting requirements	Ecology Regional Office
Chapter 296-24 WAC, General Safety and Health Standards	Part A-1 Education, Medical and First -Aid Requirements Part A-2 Personal Protective Equipment (PPE) Part E Hazardous materials, Flammable and Combustible Liquids; storage, design, ventilation, container requirements, wiring Part G-2 Fire Protection Part G-3 Fire Suppression Equipment Part L Electrical	Department of Labor and Industries Division of Industrial Health and Safety, Voluntary Service
Chapter 296-62 WAC, General Occupational Health Standards, Volumes I and II	Parts A, B, C General, Records, Hazard Communication Respiratory Protection (classification, selection, use, etc.) Part E Respiratory Protection (classification, selection, use, etc.) Part H, I Air Contaminants (Permissible Exposure limits, PELs, etc.) Part K Hearing Conservation Part L Ventilation and Emergency Washing Part P Hazardous Waste Operations and Emergency Response Part Q Hazardous Chemicals in Laboratories	Department of Labor and Industries Division of Industrial Health and Safety, Voluntary Services

SOURCE: "Moderate Risk Waste Fixed Facility Guidelines". Washington State Department of Ecology. Revised May 1993.

APPENDIX 6

TECHNICIAN CERTIFICATION CLASSES AVAILABLE

Beginning November 14, 1994, all technicians maintaining and repairing refrigeration equipment must be certified (Federal Register Title 40 Part 161). The EPA does not require that technicians involved in the disposal of small appliances be certified. **It is strongly recommended that all technicians become certified.**

A study performed by Ferris State University in Michigan found that certification training can:

- Save 30-40% of the time required to complete service jobs by familiarizing technicians with appropriate procedures;
- Improve productivity by approximately one hour per service job;
- Improve leak detection in operating systems;
- Help improve existing refrigerant stocks;
- Preserve equipment by familiarizing technicians with proper compressor oil applications.

The technician certification programs listed below are all EPA certified. The majority offer Type I (small appliances and automotive air conditioners), Type II (larger air conditioning systems), and Type III (low pressure applications) training of technicians and a proctored certification test. The only exception is the AHAM/NARDA test which is a mail-in test that only covers recovery of gas from refrigeration and air conditioning units containing less than five pounds or less refrigerant (Type I).

The materials commonly covered in certification training programs include:

- Refrigerant chemistry and applications;
- Refrigerant oil and waste oil disposal;
- Ozone depletion ;
- The Montreal Protocol;
- Federal legislation;
- Discussion of the concepts of recovery, recycle, and reclaim;
- Safe handling and transport of refrigerant gas;
- High and low pressure industrial chillers.

None of the programs require prior training, but all recommend background in low and high pressure recovery and general knowledge of refrigeration technology.

AHAM/NARDA Refrigerant Recovery Certification Program

800-394-8378

COST OF TRAINING: $22.00 includes study booklet, test booklet, and forms.
(To be completed and mailed back for certification.)

LOCATION AND SCHEDULING: At your convenience.

B. R. Engelking Co., Inc.

ACT Training

206-778-2510

COST OF TRAINING: $150.00 includes testing, manuals, and lunch.

LOCATION AND SCHEDULING: Classes are held quarterly on Saturdays at the Silver Cloud Inn, 19332 36th Ave. W., Lynnwood, WA.

I.M./Thrifty Distribution

800-747-0824

COST OF TRAINING: $75.00 includes testing and manuals.

LOCATIONS AND SCHEDULING: On an as-needed basis throughout the Northwest at each of their distribution centers.

Johnson Controls

206-827-7810

COST OF TRAINING: $90.00 includes manual and test

LOCATIONS AND SCHEDULING: Classes held on an as-needed basis.

Johnstone Supply of Seattle

206-575-0755

COST OF TRAINING: $100.00 includes manual and test.

LOCATIONS AND SCHEDULING: Sessions vary, call for information.

Refrigeration Service Engineering Society (RSES)

206-344-5749

RSES supplies a referral service for certification programs.

Trane Company

206-643-4310

COST OF TRAINING: $140.00 for manuals, testing and lunch.

LOCATION AND SCHEDULING: Available every three weeks, held all day on Saturdays.

Note: A complete list of addresses for companies is included in Appendix 24.

APPENDIX 7

AVAILABILITY OF RECLAMATION SERVICES

As manufacturers phase-out production of virgin refrigerant gas, the demand for reclaimed gas will continue to rise, making it important for the industry to have a steady supply of recovered, non-contaminated refrigerant which can be reclaimed and brought back to the marketplace. The market value of recovered CFCs depends on the quality of recovered refrigerants and the demand for each CFC.

HVAC/R company's also have the option of "laundering" their recovered refrigerant. The companies listed below will launder refrigerant. Prices for laundering are quoted on a case-by-case basis.

The refrigerant reclamation industry is highly volatile, therefore prices paid for refrigerant gas change on a regular basis. The prices listed below were good as of 6/30/94. For current prices contact each company.

All of the following companies accept refrigerant shipped from the Northwest. None of these companies accept Sulphur Dioxide or Ammonia refrigerants.

Name	Location	Shipping	Gas Specifications	Buy-Back Value*	
Appliance Recycling Centers of America Inc. (ARCA) 612-930-1738	Minneapolis, MN	Customer pays	Max. 2% cross-contam.	R-12 R-22	$4.10/lb. $.025/lb
Omega Refrigerant Reclamation Corp. 310-698-0991	Whittier, CA	Customer pays	100 lbs. minimum Max. 2% cross-contam.	R-11 R-12 R-113 R-114 R-22 R-500 R-502	$2.00/lb. $2.00/lb. $1.90/lb. $1.65/lb. $0.20/lb. $1.65/lb. $1.6511b.
Refron, Inc. 800-4REFRON	Long Island City, NY	Refron pays	Max. 2% cross-contam.	call for quote	
Total Reclaim, Inc. 206-343-7443	Seattle, WA	Customer pays	Max. 2% cross-contam.	call for quote	

A number of other reclaimers indicated an interest in used refrigerant but did not send specific details, including:

Refrigerant Recovery Corp. of America (RRCA)	800-488-7722
Rocky Mountain Reclamation, Inc.	303-455-1226
National Refrigerants	609-455-4555
New Era Environmental	703-904-7570

Note: A complete list of addresses for companies is included in Appendix 24.

APPENDIX 8

INCINERATION OF MIXED OR CONTAMINATED REFRIGERANT

Incineration of refrigerant that has been contaminated with other types of refrigerant is an important aspect of the refrigerant recovery business. If refrigerant is more than 2% cross-contaminated, most reclaiming facilities will not accept the gas for reclamation. The companies listed below offer incineration service. Included is information regarding their disposal specifications, methods, and cost of disposal. Most of these companies work on a case-by-case basis with quotes prepared for each generator and waste stream.

Most reclamation businesses also offer incineration of cross-contaminated refrigerant for a fee.

NAME	SPECIFICATIONS	DISPOSAL	COSTS
Burlington Environmental 206-223-0500/800-228-7872	liquid refrigerant only	Incineration	disposal: $350.00155 gallon drum transport: $75.00 (limited range)
Ecological Industries 206-926-3011	none given	Incineration	call for quote
Northwest EnviroService, Inc. 800-441-1090	manifested & profiled	Incineration	$300.00/ cylinder transportation cost depends on location
Omega Refrigerant Reclamation Corp. 310-698-0991	none given	mixed refrigerants are separated	$3.35/ lb less than 100 lbs.
Rollins Environmental Services, Inc. (Rolllns-Chempak, Inc.) 800-X-WASTES	Individual proposals, site visit by Rollins personnel, transported via CHEMPAK	Incineration	Individual proposals prepared, call for quote
Total Reclaim, Inc. 206-343-7443	call for Information	incineration	call for quote
US Ecology 415-736-6180	none given	Incineration	call for quote

Note: A complete list of addresses for companies is included in Appendix 24.

APPENDIX 9

TOTAL RECLAIM INC.

REFRIGERANT SERVICES
P.O BOX 24996, SEATTLE, WA. 98124 (206) 343-7443

Release No. _____

ACCIDENTAL OR UNINTENTIONAL RELEASE REPORT

Date _____

Employee Name _____

Type of Refrigerant Vented _____ Approx. How Many Pounds Were Vented? _____

Unit Refrigerant Vented From _____ Job/Invoice No. _____

Description of What Happened _____

Why Did It Happen. _____

Supervisor Venting Was Reported To: _____

Was Anyone Else Aware Of This Situation? _____

Corrective Measures Taken: _____

Disciplinary Action Taken (if necessary): _____

Employee Signature _____ Date _____

Supervisor Signature _____ Date _____

SAMPLE

"Working to keep the ozone whole."

APPENDIX 10

PRESSURE-TEMPERATURE CHART

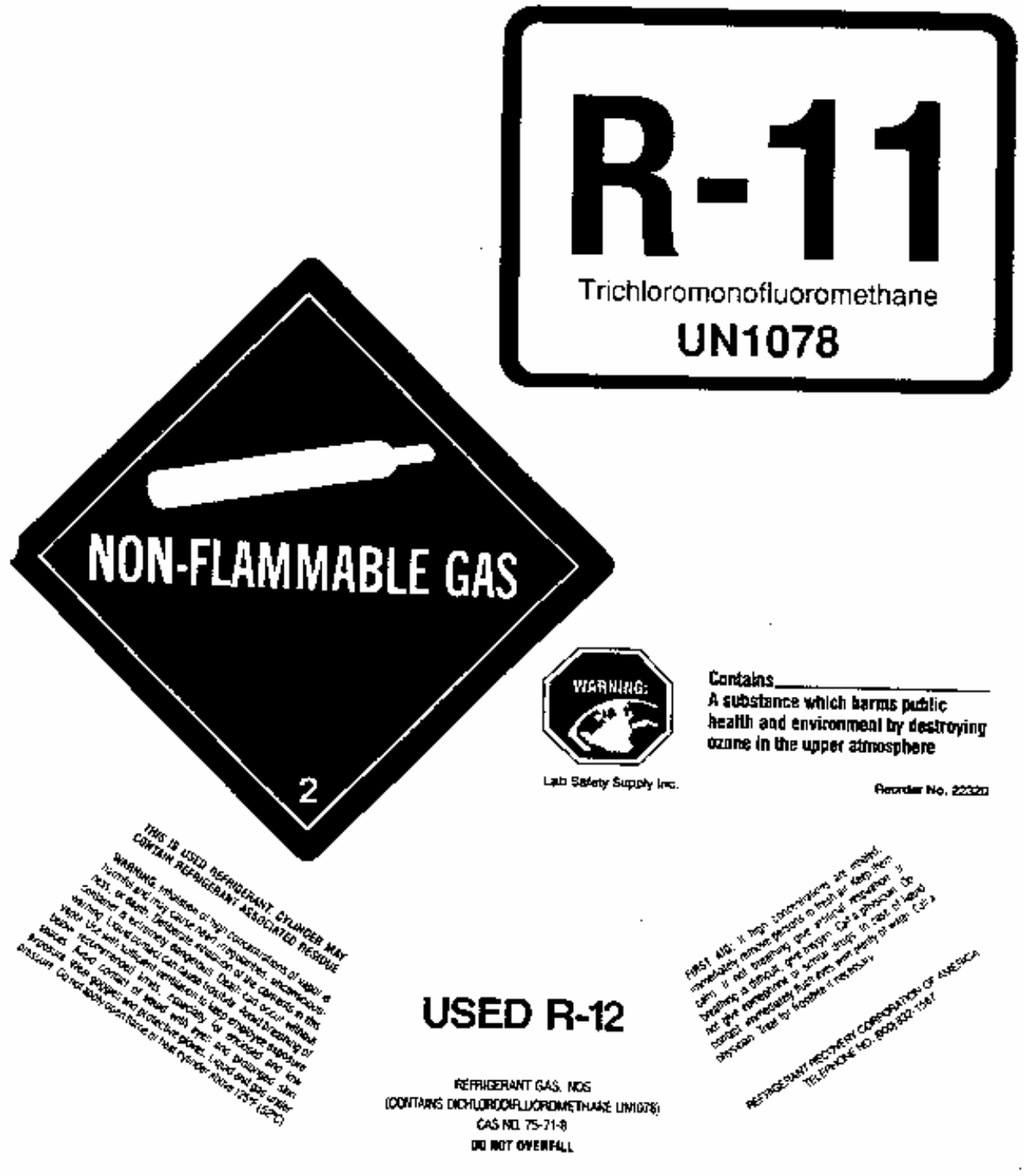
PRESSURE / TEMPERATURE RELATIONSHIP OF COMMON REFRIGERANTS

Vapor Pressure, PSIG						Vapor Pressure, PSIG					
°F	R-11	R-12	R-22	R-134a	R-500	°F	R-11	R-12	R-22	R-134a	R-500
-50		15.4*	6.0*	18.5*	12.8*	48	12.8*	44.7	81.4	43.4	55.1
-48		14.6*	4.7*	17.8*	11.9*	50	12.0*	46.7	84.7	45.5	57.6
-46		13.8*	3.3*	17.0*	10.9*	52	11.2*	48.8	88.1	47.6	60.0
-44		12.9*	1.8*	16.3*	9.8*	54	10.4*	51.0	91.5	49.7	62.6
-42		11.9'	0.3*	15.5*	8.8*	55	10.0*	52.0	93.3	50.5	63.9
-40	28.4*	11.0*	0.6	14.9*	7.6*	56	9.5*	53.2	95.1	51.8	65.2
-38	28.3*	10.0*	1.4	13.9*	6.4*	58	8.7*	55.4	98.8	55.0	67.9
-36	28.2*	8.9*	2.3	12.9*	5.2*	60	7.7*	57.7	102.5	56.8	70.6
-34	28.1*	7.8*	3.2	11.9*	3.9*	62	6.8*	60.1	106.3	60.0	73.5
-32	28.0*	6.7*	4.1	10.9*	2.6*	64	5.8*	62.5	110.2	63.0	76.3
-30	27.8*	5.5*	5.0	10.0*	1.2*	65	5.3*	63.8	112.2	64.0	77.8
-28	27.7*	4.3*	6.0	9.2*	0.1	66	4.8*	65.0	114.2	65.0	79.3
-26	27.5*	3.0*	7.0	8.0*	0.9	68	3.7*	67.6	118.3	67.8	82.3
-24	27.4*	1.6*	8.1	6.8*	1.6	70	2.6*	70.2	122.5	70.6	85.4
-22	27.2*	0.3*	9.2	5.6*	2.4	72	1.5*	72.9	126.8	73.4	88.6
-20	27.0*	0.6	10.3	4.5*	3.2	74	0.4*	75.6	131.2	77.0	91.8
-18	26.9*	1.3	11.5	3.5*	4.1	75	0.1	77.0	133.5	78.5	93.5
-16	26.7*	2.1	12.7	2.4*	5.0	76	0.4	78.4	135.7	80.0	95.1
-14	26.5*	2.8	13.9	0.3	5.9	78	1.0	81.3	140.3	83.0	98.5
-12	26.2*	3.7	15.2	1.2	6.8	80	1.6	84.2	145.0	87.0	102.0
-10	26.0*	4.5	16.6	2.1	7.8	82	2.2	87.2	149.8	90.0	105.6
-8	25.8*	5.4	18.9	2.4	8.8	84	2.9	90.2	154.7	94.0	109.2
-6	25.5*	6.3	19.4	3.2	9.9	85	3.3	91.8	157.3	95.5	110.5
-4	25.3*	7.2	20.9	4.0	11.0	86	3.6	93.3	159.8	97.0	112.9
-2	25.0*	8.2	22.5	5.0	12.1	88	4.3	96.5	164.9	100.0	116.7
0	24.7*	9.2	24.1	6.0	13.3	90	5.0	99.8	170.1	103.0	120.6
2	24.4*	10.2	25.7	7.0	14.5	92	5.7	103.1	175.4	107.5	124.5
4	24.1*	11.2	27.4	8.0	15.7	94	6.5	106.5	180.9	109.0	128.6
5	24.0*	11.8	28.3	8.7	16.2	95	6.9	108.3	183.6	112.0	130.6
6	23.8*	12.3	29.2	9.2	17.0	96	7.3	110.0	186.5	115.1	132.7
8	23.5*	13.5	31.0	10.5	18.4	98	8.1	113.5	192.1	120.0	136.9
10	23.1*	14.6	32.9	11.5	19.7	100	8.9	117.2	197.9	123.0	141.2
12	22.7*	15.8	34.9	12.8	21.2	102	9.8	120.9	203.8	127.0	145.6
14	22.3*	17.1	36.9	14.0	22.6	104	10.6	124.6	209.9	133.0	150.1
16	21.9*	18.4	39.0	15.2	24.1	105	11.1	126.6	213.0	135.0	152.4
18	21.5*	19.7	41.1	16.8	25.7	106	11.5	128.5	216.0	137.0	154.7
20	21.1*	21.0	43.3	18.0	27.3	108	12.5	132.4	222.3	143.0	159.4
22	20.6*	22.4	45.5	20.0	28.9	110	13.4	136.4	228.7	147.0	164.1
24	20.2*	23.9	47.9	21.8	30.6	112	14.4	140.5	235.2	152.0	169.0
26	19.7*	25.4	50.2	22.8	32.4	114	15.3	144.7	241.9	155.0	173.9
28	19.1*	26.9	52.7	24.2	34.3	115	15.9	146.8	245.3	157.5	176.5
30	18.6*	28.5	55.2	26.1	36.0	116	16.4	148.9	247.8	160.0	179.0
32	18.1*	30.1	57.8	28.6	37.9	118	17.4	153.2	255.6	165.0	184.2
34	17.5*	31.7	60.5	29.5	39.9	120	18.5	157.7	262.6	170.0	189.4
36	16.9*	33.4	63.3	35.5	41.9	122	19.6	162.2	269.7	177.0	194.8
38	16.3*	35.2	66.1	33.5	43.9	124	20.7	166.7	277.0	183.0	200.2
40	15.6*	37.0	69.0	35.6	46.1	125	21.3	169.1	280.7	185.0	203.0
42	14.9*	38.8	72.0	37.5	48.2	126	21.9	171.4	284.4	187.0	205.8
44	14.2*	40.7	75.0	39.4	50.5	128	23.0	176.2	291.8	193.0	211.5
46	13.5*	42.7	78.2	41.3	52.8	130	42.3	181.0	299.3	200.0	217.2

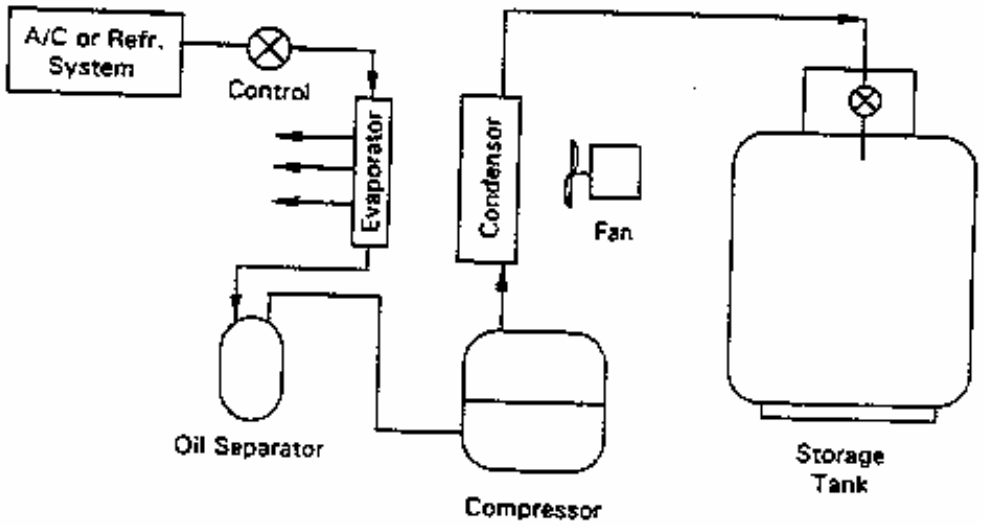
** Inches mercury below one atmosphere.*

APPENDIX 11

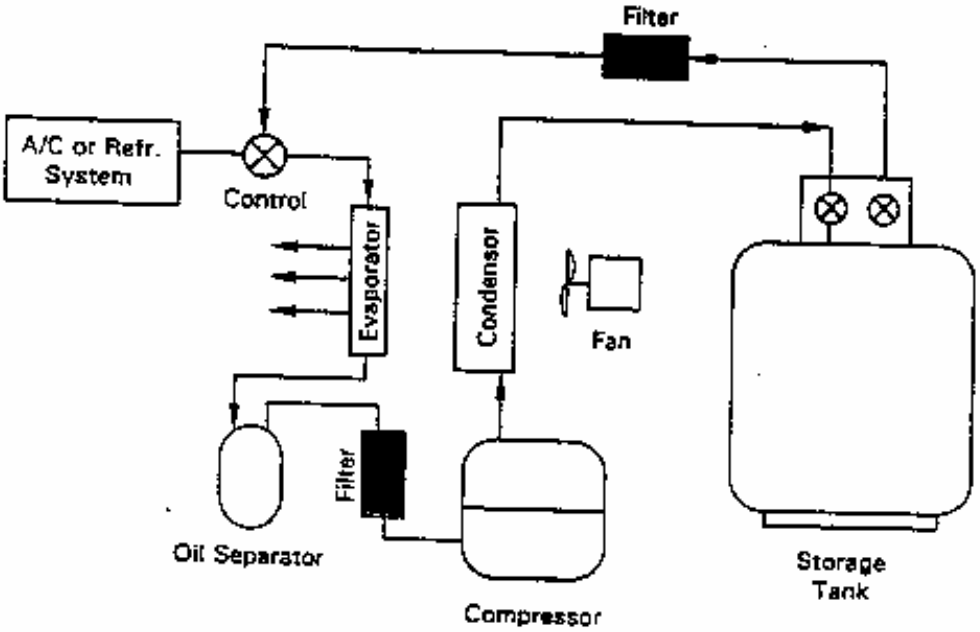
Refrigerant Cylinder Labels



APPENDIX 12



Refrigerant recovery machine [RSES 1991]



Refrigerant recycling machine [ACCA 1992]

Source: "Managing Discarded Major Appliances," The University of Illinois at Chicago-Public Service Report, July 1993

APPENDIX 13

REFRIGERANT RECOVERY EQUIPMENT SURVEY

EQUIPMENT*	Equipment Applications	Size Operating Temp. Weight	Retail Cost	Required Support Equipment (6)	Training Required To Operate (1)	Potential Pitfalls	Employee Safety issues (3X8X12)	Efficiency (Speed & Vacuum levels)	On-board Storage Capacity	Additional features information
Oz Saver Light	R-12, R-22, R-500, R-502, R-134a, & R-125 (4)	12"x11 "x13" 0' to 120' F 30 lbs.	$1500.00	Manifold gauges Storage tanks	phone support avail.	noisy	auto shut-off	14.4 lbs liquid/min. 1.1 lbs. vapor/min.r 20" vacuum	None (5)	Safety chamber, sub-cool feature, self-evacuating oil-less compressor (18)(7)
Spooter II	R-12, R-22, R-502, R-134a unit avail.	0' to 150' F 3 lbs.	$250.00	Manifold gauges Storage bottle	simple operation	small unit recovery only	incorporates a hand pump, physically demanding	1 lb. liquid/min. 25 lbs. vapor/min. 29 * of vacuum	None.	can be used as oil pump, (21X2)
Robinair 17650	R-12, R-22, R-500, R-502 (4)	9.25"x20.5"x8.25" 0' to 120' F 55 lbs.	$1699.00	Manifold gauges Hoses	phone support avail	Inerting liquid (7) vapor only	auto shutoff	.5 Ib/min vapor	Yes	single switch operations. (9)(21)(18)
Arctic Freeze Model 7300	R-12, R-22, R-500, R-502	(21) 30 lbs.	$730.00	Storage tank, Manifold gauges Hoses, tank scale(12)	simple operation, (10)	decreased efficiency in high temps. (20)	no auto shutoff	5 lbs liquid/min. & .30 lbs. vapor/min. 17 " of vacuum (11)	None	consumes 2.5 lbs. carbon dioxide per lb. refrigerant, no power required.
Roger I RG 3300	R-12, R-22, R-500, R-502	38 lbs.	N/A	Manifold gauges, Hoses			auto shutoff	N/A	N/A	incorporates heat exchanger (13)
Katie model K 3330-BD	R-12, R-22, R-500, R-502, R-11, R-13, R-134a, R-125	45"x20"x 16" 0' to 120' F 170 lbs.	$4000.00	Storage tanks, Manifold gauges, Hoses	operational video supplied	heavy power requirements, large on-board capacity	fragile safety glass, no auto shutoff (16)	10 lbs. liquid/min. 4 lbs. vapor/min. 10-15 " vacuum	7 lbs.	high cap. filter dryers, oil separator, (18) open drive compr.(19)(l6)
Total Claim	R-12, R-22, R-500, R-502, R-134a upgrade avail.	16"x10.5"x35"' 0' to 120' F 75 lbs.	$3200.00	Manifold gauges	study manual unit is user friendly	additional oil must be drained, can't run long cords	auto shutoff, (16)	2 lb vapor/min. 5 lbs liquid/min. 20 " vacuum	N/A	protective cover, adequate for outdoor. (17)(18)
Rigid RS 200	R-12, R-22, R-500, R-502, R-134a, R-125	22"xl0"xl5"' 0' to 120' 53 lbs.	$1600.00	Manifold gauges		requires manually switching from liquid to vapor	auto shutoff	.67 lb vapor/min. 3.85 lbs. liquid/min. 10 * vacuum	None	insulated tank (18)(19)

Notes:

(1) Basic Technician Certification -Should be completed before using this equipment.

(2) Capable of 250 lb. head.

(3) Standard Safety - Hearing protection, eye protection, and gloves should be worn at all times.

(4) Oil-less system - This system has multiple refrigerant capacity.

(5) When in operation the unit incorporates a safety chamber but doesn't pump itself out.

(6) A pre-filter should be used with all equipment and changed every 200 lbs. of refrigerant transfer.

(7) Inerting liquid to the system could cause damage.

(8) Always use with DOT approved refillable cylinders.

(9) Unit uses a small compressor and will operate under most power conditions.

(10) Set-up involves cooling a tank and transferring refrigerant through migration..

(11) Vacuum will be 26" for low pressure gases (R-11, 113).

(12) Never fill bottles over 80% water capacity.

(13) Unit incorporates a temperature controlled oil separator.

(14) Unit incorporates a large sight glass and care should be taken to prevent breakage.

(15) Unit is relatively large and heavy but moves easily on the shop floor.

(16) Open drive compressors have greater longevity since particulates cannot imbed in t

(17) System has a built in moisture and acid test kit. Test kits are available at a cost of $38.00 per 5 and are designed for one time usage.

(18) Unit has on-board oil separator.

(19) Unit has a sight glass to help maintain proper oil level.

(20) Carbon dioxide must be kept under 87.5^{o} F.

(21) Unit has 3 check valves; operator can stop pumping and won't loose gas.

- All units tested are EPA certified and UL/ARI listed.

APPENDIX 14

REFRIGERANT RECOVERY SET-UPS

A variety of different manifold gauges and tap valve set-ups are commercially available to recover refrigerants from discarded appliances. Three different arrangements are discussed below. It should be noted that refrigeration technicians who regularly operate recovery equipment often design and build support equipment to speed up refrigerant recovery for their particular application.

Braze-on "saddle" valves were not tested because installation of these valves is very slow and they are normally used with equipment that will be returned to service rather than be dismantled.

To ensure equipment availability for all users of this document, equipment readily available from several nationwide parts houses was evaluated.

Recovery Set-ups

All recovery set-ups require the following equipment:

- EPA certified recovery machine;
- DOT approved re-fillable refrigerant cylinder;
- Manifold gauges;
- Charging hoses.

It is recommended that "environmental charging hoses" or "quick connect couplers" be used in conjunction with or in place of standard refrigerant charging hoses. Environmental charging hoses utilize a ball valve near one end of the hose enabling the technician to turn off the flow of gas and disconnect the hose from equipment with a minimum release of refrigerant gas. "Quick connect" couplers are also commercially available that accomplish the same thing.

As with all tap valves, failure may occur as tips become dull from piercing copper or steel tubes numerous times and seals may. eventually fail from being compressed repetitively.

"Bullet" Type Tap Valves

"Bullet" type tap valves are easily available at any refrigeration supply houses or appliance supply retailers (approx. $2.75 each). These valves are effective at breaking into refrigerant lines with minimal leakage.

Difficulties encountered using Bullet valves include: Bullet valves are constructed in a "one size fits all" manner. Adapters to allow them to fit various line sizes must be installed requiring additional installation time. Bullet valves are not intended for repeated use and the schrader fittings may leak refrigerant gas as a result of wear and tear of the threads. Finally, an allen wrench is required to install Bullet valves and occasionally problems are encountered working with allen wrenches in confined spaces.

Clamp Type Tap Valves

Somewhat less commonly available than Bullet tap valves are clamp type tap valves (approx. $5.00 each). Although these valves are also intended for single use in a similar fashion as Bullet valves, clamp tap valves are constructed of brass, rather than pot metal and are more durable for multiple uses. Clamp valves are significantly faster to install than Bullet tap valves. It is also easier to assemble clamp valves as they utilize a single 13 /16" nut rather than 2 or 3 Allen screws.

Unfortunately, after numerous uses, the 13/16" nut on the base of the clamp tap valve can become worn or stripped, and may not tighten properly.

Quick Release Tap Valves

A relatively new development on recovery set-ups, quick release tap valves that use a Vise grip type handle (approx. $30.00 each) have a reusable tip for piercing copper or steel lines quickly to recover refrigerants. These tools can quickly break into refrigerant lines, requiring under a minute to install.

Most of the commercially available Vise grip type tools are designed for larger refrigeration line sizes than are used on domestic refrigerators and do not seal well on small tubes. In addition, if improperly installed, the replaceable tip (approx. $2.95 each) may be damaged.

A partial list of Washington state refrigeration supply distributors includes:

Johnstone Supply - 5 locations in Washington - (800) 962-9732

Pameco Corp. - 4 locations in Western Washington - (206) 281-1122

Refrigeration Supply Distributors - 4 locations in Washington - (206) 623-8005 or (509) 838-0593

Grainger Industrial Equipment - 6 locations in Washington - (206) 467-7270 or (509) 545-5065

APPENDIX 15a

PCB Trade Names and US Capacitor Manufacturers that used PCB's.

PCB TRADE NAMES

Aroclor	Chlorphen	Inerteen
Aroclor B	Diaclor	No. Flamol
Abestol	Dykanol	Pyranol
Askarel	Elemex	Pyrochlor
Adkarel	Eucarel	Saf-t-kuhl
Chlorextol	Hyvol	Sanotherm
Chlorinol		

US CAPACITOR MANUFACTURERS THAT USED PCBs

Aeorvox	McGraw-Edison
Axel Electronic	P.R. Mallory & Co.
Capacitor Specialists	RF Interonics
Cine-Chrome Lab	Sangarno Electric
Cornell Dublier	Sprague Electric
Electric Utility	Tobe Deutschmann Labs
General Electric	Universal Manufacturing
JARD	Westinghouse Electric
	York Electronics

APPENDIX 15b

Common Uses for Polychlorinated Biphenyls (PCBs)

An EPA survey in 1977 found 1.2 billion pounds of PCBs have been produced since 1929. The EPA estimated that 758 million pounds are still in use; 250 million pounds have been dumped in the landfills and 150 million pounds were "free in the environment."

In July 1985 it was reported that nearly 400 million pounds of PCBs still remained in large electrical equipment including transformers and capacitors. Also still in use are an estimated 275 million small capacitors, weighing on average of one-half pound each, in household appliances and light fixtures.

Materials and uses for PCBs since 1929:

Electrical equipment (transformers and capacitors)

Small capacitors for microwave ovens, air conditioners, refrigerators, washing machines and television sets

Transformers for fluorescent light fixtures

Materials and uses for PCBs until 1971:

Diffusion pump oil
Hydraulic fluids
Heat transfer applications
Plasticisers
Adhesives in brake linings, clutch faces and grinding wheels
Laminate for ceramics and metals
In washable wall coverings and upholstering materials
Adhesives in envelopes and tapes
Coating for ironing board covers
Flame-proofer for synthetic yarns
Waterproofing for canvas
Additives to paints and varnishes
Fan shrouds
In insulating tapes
In protective lacquers
In the making of plastic bottles
Epoxy resins for coating metals.

SOURCE: "Secrets in the Scrap Yard," The Providence Sunday Journal, August 28, 1988.

APPENDIX 16

PCB Drum Labels

POLYCHLORINATED BIPHENYL

PCB S. AROCHLOR

POISON! DANGER!

MAY BE FATAL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN. CANCER HAZARD.

Keep container closed. Use with adequate ventilation. Avoid contact with eyes, skin, and clothing. Wash thoroughly after handling. Do not breathe mist or vapor.

PRECAUTIONARY STATEMENTS: Contact may cause burns to skin and eyes. Vapors cause severe irritation of eyes and throat and cause eye and lung injury.

FIRST AID PROCEDURES: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact with eyes or skin, immediately flush with plenty of water for at least 15 minutes, while removing contaminated clothing and shoes. Discard contaminated clothing and shoes. In case of contact, call a physician.

Consult MSDS for further health and safety information. CAS NO. [1336-36-3]

HAZARDOUS WASTE

FEDERAL LAW PROHIBITS IMPROPER DISPOSAL

IF FOUND CONTACT THE NEAREST POLICE OR PUBLIC SAFETY AUTHORITY OR THE U.S. ENVIRONMENTAL PROTECTION AGENCY

PROPER D.O.T. SHIPPING NAME _____ UN OR NA NO. _____

GENERATOR INFORMATION

NAME _____

ADDRESS _____ PHONE _____

CITY _____ STATE _____ ZIP _____

EPA ID. NO. _____ EPA WASTE NO. _____

ACCUMULATION START DATE _____ MANIFEST DOCUMENT NO. _____

CONTAINS HAZARDOUS OR TOXIC WASTES

PROPER SHIPPING NAME _____

TECHNICAL CHEMICAL NAME _____

UN OR NA ID. NO. _____

D.O.T. PROPER SHIPPING NAME AND UN OR NA ID. NO. WITH PHRASE

HANDLE WITH CARE!

CAUTION

CONTAINS

PCBs

(Polychlorinated Biphenyls)

A toxic environmental contaminant requiring special handling and disposal in accordance with U.S. Environmental Protection Agency Regulations 40 CFR 761. For Disposal Information contact the nearest U.S. E.P.A. Office.

In case of accident or spill, call toll free the U.S. Coast Guard National Response Center: 800-424-8802

Also Contact _____

Tel. No. _____

Published by J. J. KELLER & ASSOCIATES, INC., Neenah, WI 54957-0368 49-NBL-G

APPENDIX 17

MANAGEMENT OF CAPACITORS HAVING PCB POTENTIAL

Waste PCBs are regulated by the EPA and the DOE as a hazardous waste (40 CFR part 761 and RCW 70.105.105). The EPA also lists PCBs as a toxic substance under the Toxic Substances Control Act (TSCA). Since capacitors containing PCBs are not labeled as such, all capacitors suspected of containing PCBs should be segregated and manifested for disposal. PCBs must be stored and transported in a properly labeled, DOT approved, poly-lined drum with a sealed lid.

PCB capacitors must be transported by a hazardous waste transporter for either incineration or landfilling at a permitted hazardous waste site. Listed below are hazardous waste facilities that dispose of PCB capacitors. The list includes location, cost of disposal, disposal methods, and manifesting requirements. It is recommended that generators contact these facilities to get a bid and handling requirements for disposal. Many companies offer reduced prices for larger quantities or multiple disposal projects.

Burlington Environmental

206-223-7872
800-228-7872 (national)
LOCATION: throughout the United States, headquartered in Seattle
OPTIONS: Capacitors can either be landfilled or incinerated
MANIFESTING REQUIREMENTS: Profile of waste content, manifest disposal of waste
COSTS: PROFILE FEE: $200.00
DISPOSAL: $250.00/drum for incineration, call for quote for landfill options
TRANSPORTATION: $75.00 +, depending on location

Ecologic Industries

206-926-3011
LOCATION: Headquartered in Fife, pick-up throughout the state
OPTIONS: Capacitors can either be landfilled or incinerated and metals recycled
MANIFESTING REQUIREMENTS: Profile of waste content, manifest disposal of waste
COSTS: PROFILE FEE: $200.00
DISPOSAL: landfill $200.00/55 gallon drum incineration or recycle $350.00/55 gallon drum
TRANSPORTATION: call for quote

FulCircle Ballast Recyclers

617-876-2229
LOCATION: Massachusetts, New York (send to incinerators throughout the country)
OPTIONS: PCBs are incinerated, metals recycled when possible
MANIFESTING REQUIREMENTS: They manifest for disposal depending on state regulations
COSTS: PROFILE FEE: none
DISPOSAL: $1.50/lb (less for large volumes)
TRANSPORTATION: call for quote

Northwest EnviroService, Inc.

800-441-1090
LOCATION: headquartered in Seattle, pick-up throughout the state
OPTIONS: Capacitors are incinerated (may be landfilled in some circumstances)
MANIFESTING REQUIREMENTS: Profile of waste content, manifest disposal of waste
COSTS: PROFILE FEE: $200.00
DISPOSAL: $750.00/drum (price will be lower for landfilling)
TRANSPORTATION: call for quote

Note: AA complete list of addresses for companies is included in Appendix 24.

APPENDIX 18

MERCURY SWITCH DISPOSAL

Mercury is a recyclable material. Mercury recycling companies will accept mercury switches, as well as other mercury-containing materials, for a fee, break down the switches, and collect and resell the recovered mercury. The list includes costs and processing methods.

Bethleham Apparatus

610-838-7034

COSTS: PROFILE: none

DISPOSAL: $924.00/ 5 gallons

TRANSPORTATION: generator pays

PROCESSING : place drum in furnace, evaporate mercury and condense back to liquid, recycle steel from drum. Prefer steel drums, surcharge for plastic drums.

Quicksilver Products

415-468-2000

COSTS: PROFILE: none

DISPOSAL: $595.00/ 5 gallon kit

TRANSPORTATION: generator pays

PROCESSING : mercury is reclaimed and recycled

Mercury Refining Company

800-833-3505

COSTS: PROFILE: $145.00/year

DISPOSAL: $275.00/ 5 gallon

TRANSPORTATION: generator pays

PROCESSING: mercury is stored until needed, then reclaimed and recycled

Require mercury is shipped in a steel drum with a 5 mil. poly liner. Will ,accept mercury in small quantities.

Note: A complete list of addresses for companies is included in Appendix 24.

APPENDIX 19

AVAILABILITY AND COST OF COMPRESSOR REMOVAL/PICK-UP SERVICE

Domestic refrigeration units contain a compressor ranging in weight from 5 to 40 lbs. (average). The compressors are made up of steel, copper, and aluminum and contain highly chlorinated compressor oil, whether drained or not. The metals contained in compressors have recycling value, but most metal recycling firms will not take whole compressors. Frequently they will not accept metals from compressors even after the oil has been drained and the metals cleaned. The following firms accept compressors from individuals and businesses.

NAME	ACCEPTANCE COST (per unit)	POLICY	REGION SERVED	PROCESSING
EADM (Environmental Appliance De-Manufacturing Co.) 206-734-4112	$10.00-20.00	no policy	Whatcom & northern Skagit counties	drains oil, separate metals for recycling
HVAC Recovery 509-783-9789	$15.00 (more than 10)	prefer whole units all sizes okay	Tri-cities region	drains oil, separate metals for recycling
Johnstone Supply 206-575-0755	$15.00	tubes must be pinched off	Seattle/Bothell areas	ship to processing facility
Total Reclaim, Inc. 206-343-7443	$10.00-$35.00	prefer tubes pinched prefer	Western Washington	drains oil, metals prepared for recycling
Certified Compressor Disposal 206-672-1684	$8.00-$25.00	tubes pinched and brazed unit clean	Seattle area	unknown

A number of other companies also recycle compressors, but did not send specific information, including:

AeroStar Heating	206-893-6596
Compressor Recycling	206-672-1684

Note: A complete list of addresses for companies is Included in Appendix 24.

APPENDIX 20

FERROUS AND NON-FERROUS METALS RECYCLERS ACCEPTING COMPRESSORS

Listed below is a survey of scrap metal buyers and their current rates for appliance grade scrap steel, #2 copper, and aluminum, and any specifications they may have for taking metals. These prices are subject to change on a daily basis. Companies listed below may also accept refrigerator carcasses for recycling.

Currently, most regional scrap metal recyclers refuse whole compressors from refrigeration units. Firms engaged in dismantling and recycling compressors must therefore prepare these materials to meet specifications of the receiving vendor. Usually this entails draining the compressor oil, possibly rinsing compressors with solvents, and separating the metals.

NAME	STEEL PRICES	COPPER #2 PRICES	ALUMINUM PRICES	SPECIFICATIONS
Dickson Iron and Metal 509-535-6146	$40.00-$50.00 / ton	$0.60 lb.	$0.32 / lb.	Compressors must be dismantled, oil drained.
General Metals of Tacoma 800-562-9876	$33.00 / ton	$0.55 / lb.	$0.23 / lb.	Compressor must be dismantled, oil drained.
Northwest Recycling 206-733-0100	N/A	N/A	N/A	Do not pay, accept compressors as a service to local contractors.
Pacific Steel 509-535-1673	$20.00 / ton	$0.60 / lb.	$0.30 / lb.	No whole compressors, must be free of hazardous materials. Do take whole accepts refrigerators for fee.
Schnitzer Steel Products Co. 503-286-5771	$40.00 / ton	$0.70 - 0.751 lb.	$0.40 - 0.50 / lb.	Compressors must be dismantled and separated.
Skagit River and Steel Recycling 206-757-6096	$10.00-20.00/ton	$0.45 / lb.	$0.25 / lb.	Will accept refrigeration and air conditioning units for a fee.

Below is a list of scrap metal recycling companies that were contacted but stated they do not accept metals from compressors.

American Recycling Corp., Spokane
Arrow Metals, Woodinville
Bloch Steel, Seattle
Butcher's Scrap and Metal, Hoquim
Cliffs Koppe Metals, Inc., Vancouver
Glen's Metal Recycling, Pasco
LTJ Recycling
Navy City Metals, Gorst
Seattle Iron and Metals, Seattle
Twin City Metals, Kennewick

APPENDIX 21

USED COMPRESSOR OIL DISPOSAL FIRMS

As of January 1, 1994, disposing of oil in a landfill is prohibited in Washington State (RCW 70.951). Used oil may either be recycled, incinerated, or burned for space heat. Highly chlorinated oils, such as compressor oils must be de-chlorinated or manifested and incinerated as hazardous waste.

Listed below are processors of refrigerant oil detailing their location, acceptance standards, disposal methods, and costs.

Burlington Environmental

206-223-0500

800-228-7872 (national)

LOCATION: throughout the United States (headquartered in Seattle)

ACCEPTANCE STANDARDS: accepts all oils, cost will depend on contaminants.

DISPOSAL METHODS: burn as bunker fuel or, if highly contaminated, will be incinerated

COSTS: PROFILE FEE: $200.00

PICK-UP $75.00 within centralized geographic region (costs vary depending on distance and amount to be disposed)

DISPOSAL: $350.00 drum (unless unusually high amounts of contaminants)

Ecological Industries

206-926-3011

LOCATION: located in Fife, Pick-up throughout the state

ACCEPTANCE STANDARDS: will accept all oils

DISPOSAL METHODS: reblended for use in cement kilns, recycled if contaminant levels are low enough

COSTS: PROFILE FEE: $100.00

TRANSPORTATION: $55.00

DISPOSAL: $100.00 drum

Johnstone Supply

206-575-0755

LOCATION: Throughout Washington

ACCEPTANCE STANDARDS: Supplies 1 gallon container to store and transport oil. Compressor oil must not be mixed with other oils. Container must be not be leaking.

DISPOSAL METHODS: Sends to Omega Refrigerant Reclamation in Las Vegas, NV.

COSTS: PROFILE FEE: none

TRANSPORTATION: Customer pays UPS charges.

DISPOSAL: $25.00 - Original purchase of container

Northwest EnviroService Inc.

800-441-1090

LOCATION: located in Seattle, pick-up state-wide

ACCEPTANCE STANDARDS: will accept all oils

DISPOSAL METHODS: Oil is reclaimed or fuel blended for energy recovery

COSTS: PROFILE FEE: $200.00

TRANSPORTATION: Depends on location, call for quote

DISPOSAL: $140.00-240.00/drum

Safety Clean

800-669-5902

800-669-5740 (national)

LOCATION: Spokane, Pasco, Lynnwood, Auburn (and throughout the United States)

ACCEPTANCE STANDARDS: will accept all oils, charge will depend on contaminants

DISPOSAL METHODS: Oil is re-refined or recycled when appropriate, otherwise blended with other fuels. If too contaminated it goes for incineration.

COSTS: PROFILE FEE : $395.00 (good indefinitely)

PICK-UP & DISPOSAL: $200.00 - 55 gallon drum (unless highly contaminated)

The companies listed below accept oils, but only if chlorine level is below 1000 parts per million.

Harbor Oil (service Spokane and Wenatchee areas)

N. 26th Artie's Court
Greenacres, WA 99016
509-926-4255

Basin Oil

P.O. Box 24906
Seattle, WA 98124
206-763-2948
800-439-2948

Shultz Distributing, Inc.

P.O. Box 24845
Seattle, WA 98124
206-682-8427

Washington cement companies were surveyed, but none permitted to burn highly chlorinated oils in production.

Oil re-refiners contacted indicated compressor oil represents too small an oil source to process separately from other used oil sources.

Note: A complete list of addresses for companies is included in Appendix 24.

APPENDIX 22

POINT SOURCE

Helping Small Businesses Find Practical Ways to Meet Air Emission Standards Vol. 1 No. 3

Project Tests Refrigerant Oil Recycling

by Jim Olson, Waste Management Specialist

Refrigeration and HVAC (heating, ventilation, and air conditioning) system lubricating oils entrain refrigerants. In systems that use halogenated hydrocarbon refrigerants (CFC and HCFC), oils are in contact with chlorine and fluorine com-pounds (total halogens). Initial screening has found total halogen levels as high as 50,000 parts per million (ppm) in representative samples of used refrigerant oil. At these elevated levels, conventional used oil recycling options are not available.

Federal regulations (40 CFR 266, Subpart E) classify used oil into two categories, specification and off specification, based on the criteria in table 1:

Used oil that exceeds any of the allowable levels is termed off-specification oil and, because of increased regulatory restriction, is undesirable for used oil recycling companies and burners. While on-specification used oil can be recycled at no or very low cost, off specification used oil must be disposed of by a hazardous waste management company at a significantly greater expense.

Furthermore, as a hazardous waste, off-specification used oil must be stored and inventoried in compliance with established EPA regulations. If more than 220 pounds (approximately 25 gallons) is generated during one month, it may only be stored for 180 days prior to off-site disposal.

Table 1

Oil Constituents

Constituent/property	Allowable level
Arsenic	5 ppm maximum
Cadmium	2 ppm maximum
Chromium	10 ppm maximum
Lead	100 ppm maximum
Flash Point	100°F minimum
Total Halogen	4,000 ppm maximum

*Used oil containing more than 1,000 ppm total halogens is presumed to be a hazardous waste unless the generator can prove the oil was not mixed with a hazardous waste (i.e. halogens are present as ingredients or from using oil rather than intentionally mixing used oil with a hazardous waste.) Table 1

The Refrigerant Oil Recycling Demonstration Project was initiated to develop a simple, cost effective method to reduce the total halogen concentration in used refrigerant oil to levels less than 4,000 ppm (ideally 1,000 ppm).

Based on EPA parameters, treated oil that meets these action levels should be acceptable for recycling through conventional, low cost, and available used oil recycling companies and drop-off locations. If successful, this method will allow the HVAC technicians to transport used refrigerant oil from the repair site to the shop for treatment.

The following criteria were considered when developing the halogen reduction methodology described in this study:

- Low set-up cost by using existing technologies.
- Containment and recovery of the halogens released from the used oil (i.e. eliminate atmospheric release of ozone depleting chemicals).
- Employee safety.

In order to accomplish all three goals, the project team selected a variation of vacuum distillation. Used refrigerant is contained in a 2.5 gallon, thick-

continued on page 2

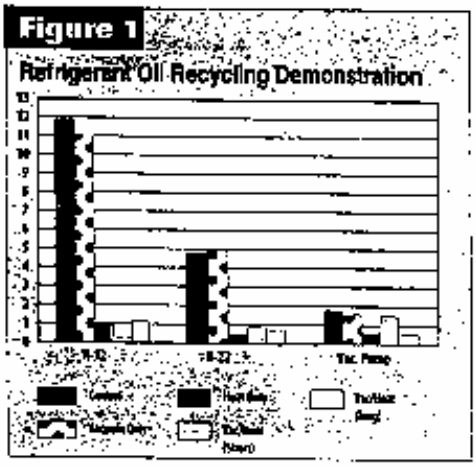
walled gasoline can. A refrigerant fitting was brazed into the can lid and sealed with a rubber gasket to create an air tight container. The container is connected to refrigerant recovery/recycling equipment with a conventional gage set. The oil is heated by placing the container on a common electric hot plate. With the exception of the container and hot plate, all of the above system components are standard equipment already avail-able to the HVAC technician.

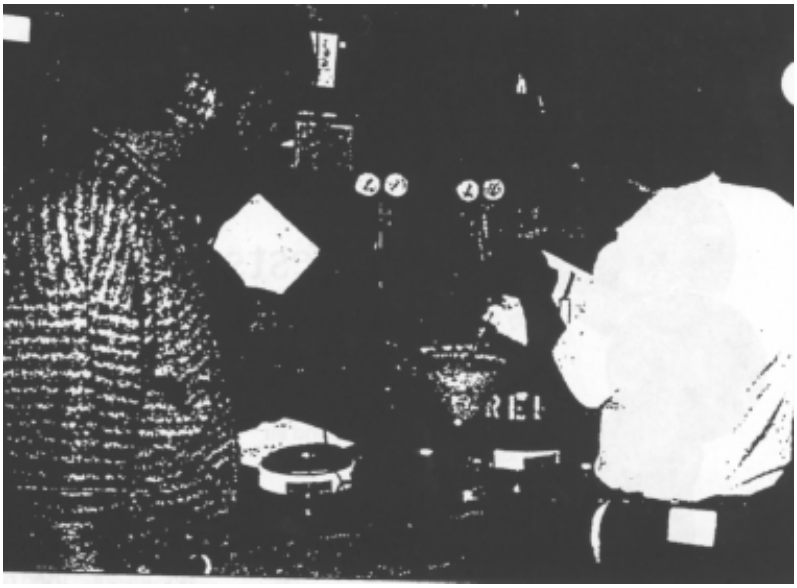
Test runs were set up using representative samples of used refrigerant oil subjected to the following conditions (modes):

- Vacuum only, at ambient temperatures of approximately 20° C, for 2.0 to 4.0 hours.
- Heating only, within a temperature range of 60° to 100° C, for 2.0 to 4.0 hours.
- A combination of heat (60° to 100°) and vacuum (10 to 25 " Hg) for 0.5 to 1.0 hour (vac/heat, short).
- A combination of heat (60° to 1000) and vacuum (10 to 25 ° Hg) for 2.0 to 4.0 hour (vac/heat, long).

An oil sample was analyzed for total halogen concentration at the conclusion of each run and compared with a control sample to establish effectiveness of each test mode.

Figure 1 shows the analytical results for R-12 and R-22 used refrigerant oil and one composite sample of used vacuum pump





Jim Olson and Rick Klein prepare a refrigerant oil sample for treatment.

Control samples from all three oil types exceeded the total halogen action level concentration of 1,000 ppm. Halogen concentration reduction in the vacuum-only mode showed little success.

Heat-only modes of operation accomplished 75 percent to 90 percent

halogen reduction efficiency. In all three cases, concentrations below the project action level of 1,000 ppm were obtained. (The minimum level of detectability for total halogen analysis ranges from 500 to 1,000 ppm. As a result, halogen levels below the detectable range were reported as "less than" values.)

While the heat-only mode proved adequate in terms of halogen reduction goals, this method does not allow recovery of released halogen compounds.

Halogen recovery was accomplished by using refrigerant recovery/recycling equipment to pull a partial vacuum on the heated used oil container. The recovered gases were then condensed and. collected in a refrigerant tank. While the vacuum/heat mode accomplishes better overall environmental control by eliminating halogen release to the environment, it provided no better halogen reduction effectiveness than the heat-only mode.

Initial study results indicate that halogen reduction effectiveness is dependent primarily on temperature. Temperatures of 60° to 100° C for time periods of up to four hours, reduced initial used oil halogen levels to less than 1,000 ppm in all test samples. The effect of partial vacuum on halogen reduction was not significant, but is recommended as a means to capture the released halogen gases.

Additional tests are planned to verify the above results and to test the process effectiveness on other refrigerant oils such as R-11, R-113 and R-502.

Upon testing completion, the project team will prepare a guide to refrigerant oil recycling. The guide will explain, in clear terms, how technicians can recover refrigerant from oils, and successfully recycle the oil.

This project is being conducted through the Small Business Pollution Prevention Center at the University of Northern Iowa. The SBPPC is also conducting applied research in other areas. For a complete list of applied research activities, please call the Iowa Waste Reduction Center at 800/422-3109.

APPENDIX 23

APPLIANCE DISCARD ESTIMATES

COUNTY	Population	Discard Rate @ 0.14 Appliances/ Year (EPA92)	Discard Rate @ 0.07 Appliances/ Year (McHenry County)	Solid Waste Generated/year (Cubic yards)	1.4% of Waste Stream by Volume
Adams	13,603	1,904	952		
Asotin	17,605	2,465	1,232		
Benton	112,560	15,758	7,879		
Chelan	52,250	7,315	3,658		
Clallam	56,464	7,905	3,952		
Clark	238,053	33,327	16,664		
Columbia	4,024	563	282		
Cowlitz	82,119	11,497	5,748		
Douglas	26,205	3,669	1,834		
Ferry	6,295	881	441		
Franklin	37,473	5,246	2,623		
Garfield	2,248	315	157		
Grant	54,758	7,666	3,833		
Grays Harbor	64,175	8,985	4,492		
Island	60,195	8,427	4,214		
Jefferson	20,146	2,820	1,410		
King	1,507,319	211,025	105,512		
Kitsap	189,731	26,562	13,281		
Kittitas	26,725	3,742	1,871		
Klickitat	16,616	2.326	1,163		
Lewis	59.359	8,310	4,155		
Lincoln	8,864	1,241	620		
Mason	38,341	5,368	2,684		
Okanogan	33,350	4,669	2,335		
Pacific	18,882	2,643	1,322		
Pend Oreille	8,915	1,248	624		
Pierce	586,203	82,068	41,034		
San Juan	10,035	1,405	702		
Skagit	79,555	11,138	5,569		
Skamania	8,289	1,160	580		
Snohomish	465,642	65,190	32,595		
Spokane	361,364	50,591	25,295		
Stevens	30,948	4,333	2,166		
Thurston	161,238	22,573	11,287		
Wahklakum	3,327	466	233		
Walla Walla	48,439	6,781	3,391		
Whatcom	127,780	17,889	8,945		
Whitman	38,775	5,429	2,714		
Yakima	188,823	26,435	13,218		
Washington State	**4,866,692**	**681,337**	**340,668**	**4,978,113**	**209,080**

New Appliance Sales In Washington State in 1993 Households - 1,872

Washers/Dryers	Dishwashers	Stoves/Ranges	Air Conditioners	Refrigerators	Freezers
231,200	112,800	107,000	20,200	137,700	34,100

Source: Refrigeration Estimated Distributor Sales by State - 1993, Association of Home Appliance Manufacturers, Chicago, Illinois.

APPENDIX 24

COMPANY ADDRESSES

AHAM/NARDA Refrigerant
Recovery Certification Program
10 East 22nd St.
Lombard, IL 60148
800-394-8378

Appliance Recycling Centers of
America (ARCA)
7400 Excelsior Blvd.
Minneapolis, MN 55426
612-930-1738

Basin Off Co., Inc.
PO Box 24906
Seattle, WA 98124
206-763-2948
800-439-2948

Bethleham Apparatus
890 Front St.
PO Box Y
Hellertown, PA 18055
610-838-7034

B.R. Engelking, Co., Inc.
ACR Training
23024 Brier Rd.
Brier, WA 98036
206-778-2510

Burlington Environmental
Waterfront Place One, Suite 700
1011 Western Ave.
Seattle, WA 98104
206-223-0500
800-228-7872 (national)

Commercial Refrigeration
5920 NE Gleason
Portland, OR 97213
800-452-2510

Dickson Iron and Metals
N. 907 Dyer Road
Spokane, WA 99207
509-535-6146

EADM
(Environmental Appliance De-
Manufacturing Company)
1500 Iowa Street
Bellingham, WA 98226
(206) 734-4112
contact: Ray Hiller

Ecological Industries
5007 Pacific Highway East
Fife, WA 98424
206-926-3011

Emerald Aire
239 SW 41st Bldg. 11
Renton, WA 98055
206-251-6676

FulCircle Ballast Recyclers
180 Fawcett St.
Cambridge, MA 02138
617-876-2229

General Metals of Tacoma
800-562-9876

Harbor Oil
N. 26th Artie's Court
Greenacres, WA 99016
509-926-4255

HVAC Recovery
4131 West Hood
Kennewick, WA 99336 *
(do not print address)
509-783-9789

I. M. /Thrifty Distribution
PO Box 301337 (main office)
Portland, OR 97220
800-747-0824

Johnson Controls, Inc.
3003 Northup Way
Bellevue, WA 98004
206-827-7810

Johnstone Supply of Seattle
18205 Andover Park
Seattle, WA 98188
206-575-0755

11715 North Creek Parkway
Suite 101
Bothell, WA 98011
206-487-6-3939
800-962-9732

Lehmann's Appliance
1920 Iowa St.
Bellingham, WA
98226 206-733-7722

LTJ Recycling, Inc.
258010 Highway 101
Port Angeles, WA 98362
206-457-1120

MacDonald Miller Services, Inc.
7704 Detroit SW
Seattle, WA 98106-1903
206-767-7995

Mercury Refining Company
1218 Central Ave.
Albany, NY 12205
800-833-3505

Northwest EnviroService, Inc.
1700 Airport Way South
Seattle, WA 98134

PO Box 24443
Seattle, WA 98124
800-441-1090

Northwest Recycling
1419 "C" Street
Bellingham, WA 98225
206-733-0100

Omega Refrigerant Reclamation
Corp.
12504 East Whittier Blvd.
Whittier, CA 90602
310-698-0991

Pacific Steel
N. 1114 Ralph
Spokane, WA 99207
509-535-1673

Puget Sound Refrigeration
3132 NE 133rd
PO Box 27073
Seattle, WA 98125
206-367-2500

Quicksilver Products
200 Valley Dr., Suite 2
Brisbane, CA 94005
415-468-2000

Refrigerant Service Engineering Society (RSES)
certification referral service
800-423-7843

REFRON, Inc.
38-18 33rd Street
Long Island City, NY 11101
800-4REFRON

Rollins Environmental Svcs, Inc.
(Rollins Chempak, Inc.)
One Rollins Plaza
PO Box 2349
Wilmington, DE 19899
800-X WASTES

Safety Clean
9516 E. Montgomery #19
Spokane, WA 99206
800-669-5902
800-669-5740 (national)
Located in Spokane, Pasco, Lynnwood, and Auburn

Schnitzer Steel Products Co.
12005 N. Burgard Road
Portland, OR 97203

Seattle Iron and Metals
2955 11th Ave SW
Seattle, WA 98134
206-682-0040

Skagit River Steel & Recycling
1265 S. Anacortes
Burlington, WA 98233
206-757-6096

Spender Environmental
PO Box 1321
Sumner, WA 98390
800-286-0896

Total Reclaim, Inc.
PO Box 24996
Seattle, WA 98124
206-343-7443

Trane Company
2021 152nd Ave NE
Redmond, WA 98052
206-643-4310

United System
1021 SW Klickitat, Suite 104
Seattle, WA 98124
206-442-9454

Universal Technical Institute
3002 N 27th Ave.
Pheonix, AR 85017

US Ecology
301 Durham Court
Danville, CA 94526
415-736-6180

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