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Civil Engineering

REFRIGERANT MANAGEMENT PROGRAM

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This manual implements Air Force Policy Directive (AFPD) 32-10, *Installations and Facilities*, and Title 40, Code of Federal Regulations (CFR), Part 82, *Protection of Stratospheric Ozone.* It describes the Air Force policy for managing refrigerants used in real property equipment and does not apply to refrigerants used in motor vehicle air conditioning (MVAC) or aircraft refrigeration systems. This manual applies to all Air Force Active, Reserve, Guard, civilian and contractor personnel who develop, acquire, deliver, use, operate, or manage refrigerants used in Air Force real property equipment. Direct questions, comments, recommended changes, or conflicts to this manual through command channels, using the AF Form 847, *Recommendation for Change of Publication*, through the appropriate functional chain of command. The authorities to waive wing/unit level requirements in this publication are identified with a Tier ("T-0, T-1, T-2, T-3") number following the compliance statement. See AFI 33-360, *Publications and Forms Management*, Table 1.1, for a description of the authorities associated with the Tier numbers. Submit requests for waivers through the chain of command to the appropriate Tier waiver approval authority, or alternately, to the publication OPR for non-tiered compliance items. Ensure that all records created as a result of processes prescribed in this publication are maintained in accordance with AFMAN 33-363, *Management of Records*, and disposed of in accordance with the Air Force Records Disposition Schedule (RDS) located in the Air Force Records Information Management System (AFRIMS).

SUMMARY OF CHANGES

This manual replaces AFPAM 32-7089, *Refrigerant Managemen*t. It has been substantially revised and must be completely reviewed. This manual identifies the Tier waiver authorities as approved by the Inspector General Advisory Board. Major changes include removing the requirement for a base refrigerant management plan and creating the Air Force Refrigerant Management Program that each installation must support. It directs the use of the Air Program Information Management System (APIMS) as the database of record for refrigerant management. It provides up-to-date guidance on refrigerant management for meeting Air Force and DOD requirements as well as managing refrigerant and equipment in accordance with Environmental Protection Agency (EPA) requirements. All civil engineering (CE) personnel and any other personnel on Air Force installations who work with or manage refrigerants must review this manual in its entirety.

Chapter 1

GENERAL INFORMATION

1.1. Introduction. The EPA initially developed regulations for the management of ozone-depleting substances (ODS) in 1990 under Title VI of the Clean Air Act (CAA). These regulations are contained within 40 CFR Part 82. These rules cover all areas of refrigerant management and use and are applicable to all Air Force, Reserve, ANG, and government-owned contractor-operated (GOCO) activities, equipment, systems, and products located within the United States and its territories.

1.2. Purpose. All Air Force installations, regardless of size, with refrigeration and/or comfort cooling equipment must manage and maintain equipment and refrigerant stockpiles in such a way as to ensure both mission success and compliance with applicable environmental regulations. The purpose of this manual is to provide direction and methodologies to assist installation personnel in managing all facets of refrigerants at their installations and function as an Air Force-wide refrigerant management plan.

1.3. Intended Audience. This manual is intended to assist installation CE personnel who work with refrigerants, perform maintenance on, or are responsible for, facility design, planning, or environmental oversight and compliance activities for equipment regulated under Title VI of the CAA (e.g., chillers, air conditioners, refrigeration units). This manual is a guide for tenant organizations who do not receive equipment service support from installation CE on how to comply with EPA and installation requirements within their native organization and meet Air Force requirements within the framework of their support agreement.

1.4. Applicability. This manual is intended to address stationary equipment containing refrigerants installed on Air Force installations used for the purposes of comfort cooling, commercial refrigeration, or industrial process cooling. Refrigerants in MVAC or aircraft refrigeration systems are managed by other programs and are not included in the scope of this manual.

1.5. Legal Drivers.

1.5.1. Legal requirements for the management of refrigerants are defined in 40 CFR Part 82. These regulations were initially published in 1990 and have been amended multiple times by the EPA. Air Force installations are subject to, and therefore must comply with, all provisions of the CAA; failure to comply can result in both civil and criminal penalties of up to $37,500 per non-compliance per day. Major sections of Title VI of the CAA are included in Table 1.1.

Table 1.1. Major Section the Clean Air Act.

CAA Section	Title
602	Listing of Class I and Class II Substances
603	Monitoring and Reporting Requirements
608	National Recycling and Emission Reduction Program
612	Safe Alternatives Policy

1.6. Air Force Refrigerant Management Program. This manual is intended to function as the Air Force-wide Refrigerant Management Plan and, to the maximum extent possible, standardize refrigerant management operations across the Air Force. All refrigerants and associated processes must follow the process authorization procedures IAW AFI 32-7086, Hazardous Materials Management. Unless otherwise required by law, each installation is no longer required to develop and maintain individual refrigerant management plans; all installations must maintain all refrigerant management records within APIMS, including current equipment inventory and document planned replacement dates. Installations must continue to plan, program, and budget for air conditioning/refrigeration (AC/R) equipment replacement using sound lifecycle engineering practices and track programs in APIMS. **(T-1).**

1.7. Scope of Requirements. Although the installation base civil engineer (BCE) is tasked with maintaining only equipment owned by CE, legal requirements and the requirements in this manual are applicable to all real property installed equipment (RPIE) or real property similar equipment (RPSE) containing refrigerant and the management of that equipment on Air Force-owned or -managed installations. As such, the BCE must ensure personnel become familiar with the requirements of host-tenant agreements and are aware of areas where support is required by those agreements. **(T-1).** Additionally, all tenant organizations must ensure that refrigerants are managed and maintained in accordance with all legal and Air Force requirements. The BCE must ensure the roles and responsibilities of all parties are recorded in appropriate support agreements. **(T-1).**

1.8. Phase-Out of Class I and Class II Refrigerants. There is no reason to make equipment replacement decisions based solely on the type of refrigerant used in an item of equipment; however, other factors must be considered when determining whether to retain or select equipment with a particular refrigerant. The most important selection criteria include equipment efficiency and condition; based on past refrigerant phase-outs, refrigerant inventory and availability should not be an issue if existing refrigerants are recovered and reused as equipment is decommissioned. Therefore, with common refrigerants still available today, selection criteria should be heavily weighted towards equipment efficiency and condition factors. Based on United Nations Environment Programme (UNEP) protocols, the refrigerant phase-outs continue. Though HCFC-22 equipment is no longer manufactured, the refrigerant itself is still available for purchase. HCFC-22 refrigerant is expected to remain relatively plentiful, though production levels will be reduced until production ends in 2020. HCFC-123 refrigerant will end production in 2030. The only remaining Class II refrigerant-containing equipment still being manufactured are HCFC-123 chillers. Manufacturing of this equipment will end in 2020. Tables 1.2 and 1.3 are comprehensive listings of Class I and II compounds that could be used as refrigerants, although some may not be used in the Air Force.

Table 1.2. Listing of Class I Compounds Used as Refrigerants.

Class I Compounds			
Name	**Chemical Formula**	**Technical Name**	**CAS Number**
CFC-11	CCl_3F	Trichlorofluoromethane	75-69-4
CFC-12	CCl_2F_2	Dichlorodifluoromethane	75-71-8
CFC-113	$C_2F_3Cl_3$	1,1,2-Trichlorotrifluoroethane	76-13-1
CFC-114	$C_2F_4Cl_2$	Dichlorotetrafluoroethane	76-14-2
CFC-115	C_2F_5Cl	Monochloropentafluoroethane	76-15-3
CFC-13	CF_3Cl	Chlorotrifluoromethane	75-72-9
CFC-111	C_2FCl_5	Pentachlorofluoroethane	354-56-3
CFC-112	$C_2F_2Cl_4$	Tetrachlorodifluoroethane	76-12-0
CFC-211	C_3FCl_7	Heptachlorofluoropropane	422-78-6
CFC-212	$C_3F_2Cl_6$	Hexachlorodifluoropropane	3182-26-1
CFC-213	$C_3F_3Cl_5$	Pentachlorotrifluoropropane	165977
CFC-214	$C_3F_4Cl_4$	Tetrachlorotetrafluoropropane	29255-31-0
CFC-215	$C_3F_5Cl_3$	Trichloropentafluoropropane	4259-43-2
CFC-216	$C_3F_6Cl_2$	Dichlorohexafluoropropane	661-97-2
CFC-217	C_3F_7Cl	Chloroheptafluoropropane	422-86-6

Table 1.3. Listing of Class II Compounds Used as Refrigerants.

Class II Compounds			
Name	**Chemical Formula**	**Technical Name**	**CAS Number**
HCFC-21	$CHFCl_2$	Dichlorofluoromethane	75-43-4
HCFC-22	CHF_2Cl	Monochlorodifluoromethane	75-43-6
HCFC-31	CH_2FCl	Monochlorofluoromethane	593-70-4
HCFC-121	C_2HFCl_4	Tetrachlorofluoroethane	354-14-3
HCFC-122	$C_2HF_2Cl_3$	Trichlorodifluoroethane	354-21-2
HCFC-123	$C_2HF_3Cl_2$	Dichlorotrifluoroethane	306-83-2
HCFC-124	C_2HF_4Cl	Monochlorotetrafluoroethane	2837-89-0
HCFC-131	$C_2H_2FCl_3$	Trichlorofluoroethane	359-28-4
HCFC-132b	$C_2H_2F_2Cl_2$	Dichlorodifluoroethane	1649-08-7
HCFC-133a	$C_2H_2F_3Cl$	Monochlorotrifluoroethane	75-88-7
HCFC-141b	$C_2H_3FCl_2$	Dichlorofluoroethane	1717-00-6
HCFC-142b	$C_2H_3F_2Cl$	Monochlorodifluoroethane	75-68-3
HCFC-221	C_3HFCl_6	Hexachlorofluoropropane	422-26-4
HCFC-222	$C_3HF_2Cl_5$	Pentachlorodifluoropropane	422-49-1
HCFC-223	$C_3HF_3Cl_4$	Tetrachlorotrifluoropropane	422-52-6
HCFC-224	$C_3HF_4Cl_3$	Trichlorotetrafluoropropane	422-54-8
HCFC-225ca	$C_3HF_5Cl_2$	Dichloropentafluoropropane	422-56-0
HCFC-225cb	$C_3HF_5Cl_2$	Dichloropentafluoropropane	507-55-1
HCFC-226	C_3HF_6Cl	Monochlorohexafluoropropane	431-87-8
HCFC-231	$C_3H_2FCl_5$	Pentachlorofluoropropane	421-94-3
HCFC-232	$C_3H_2F_2Cl_4$	Tetrachlorodifluoropropane	460-89-9
HCFC-233	$C_3H_2F_3Cl_3$	Trichlorotrifluoropropane	7125-84-0
HCFC-234	$C_3H_2F_4Cl_2$	Dichlorotetrafluoropropane	425-94-5
HCFC-235	$C_3H_2F_5Cl$	Monochloropentafluoropropane	460-92-4
HCFC-241	$C_3H_3FCl_4$	Tetrachlorofluoropropane	666-27-3
HCFC-242	$C_3H_3F_2Cl_3$	Trichlorodifluoropropane	460-63-9
HCFC-243	$C_3H_3F_3Cl_2$	Dichlorotrifluoropropane	460-69-5
HCFC-244	$C_3H_3F_4Cl$	Monochlorotetrafluoropropane	134190-50-4
HCFC-251	$C_3H_4FCl_3$	Monochlorotetrafluoropropane	421-41-0
HCFC-252	$C_3H_4F_2Cl_2$	Dichlorodifluoropropane	819-00-1
HCFC-253	$C_3H_4F_3Cl$	Monochlorotrifluoropropane	460-35-5
HCFC-261	$C_3H_5FCl_2$	Dichlorofluoropropane	420-97-3
HCFC-262	$C_3H_5F_2Cl$	Monochlorodifluoropropane	421-02-03
HCFC-271	C_3H_6FCl	Monochlorofluoropropane	430-55-7

1.9. Acceptable Substitutes for Refrigeration Equipment. The EPA Significant New Alternatives Policy (SNAP) program has a list of acceptable substitutes. This list is updated periodically as the EPA assesses further information on refrigerant alternatives, and should be reviewed regularly. The list is posted at the EPA website: **https://www.epa.gov/snap**

Chapter 2

ROLES AND RESPONSIBILITIES

2.1. AF/A4C Directorate of Civil Engineers: Publishes Air Force guidance and develops Management Internal Control Toolset (MICT) Self-Assessment Communicators as part of the oversight strategy.

2.2. Air Force Installation and Mission Support Center (AFIMSC): Provides, oversight, and guidance to major commands (MAJCOM) and installations.

2.3. Air Force Civil Engineer Center (AFCEC) AFIMSC Primary Subordinate Unit (PSU):

2.3.1. Formulates Air Force instructions and guidance for maintaining AC/R systems.

2.3.2. Directs implementation of applicable public law, safety standards, and DOD directives.

2.3.3. Provides management and technical assistance to base civil engineer organizations.

2.3.4. Approves equipment conversion proposals, including the life-cycle cost analysis.

2.4. ANG will provide supplemental guidance to ANG installations when variations from this instruction are necessary.

2.5. Base Civil Engineer (BCE): Ensures AC/R equipment is constructed, installed, operated, tested, repaired, and maintained in compliance with applicable codes, regulations, federal law, and host nation final governing standards (FGS) at overseas installations. The BCE ensures the following key functions are accomplished: **(T-1).**

2.5.1. **Planning, Programming, and Budgeting.** Plans, programs, and budgets for routine and reoccurring operations, maintenance, and environmental compliance activities.

2.5.1.1. Determines installation AC/R requirements and ensures safety and adequacy of refrigerant supplies and storage facilities through evaluation of refrigerant usage on individual systems.

2.5.1.2. Analyzes and plans the AC/R maintenance and repair workloads; recommends changes to recurring work requirements based on properly engineered short- and long-range system replacement planning; reviews refrigerant use in each system at least annually to determine any changes that may be required.

2.5.1.3. Ensures efficient management of service contracts and warranty programs for maintenance and repair of AC/R systems and equipment.

2.5.1.4. This includes tenant organizations IAW existing support agreements.

2.5.2. **Inspection, Maintenance, and Repair.**

2.5.2.1. Develops schedules for inspecting and testing AC/R equipment as required by law.

2.5.2.2. Establishes and maintains a recurring work program for AC/R equipment for maximum cost benefit through local operating procedures.

2.5.2.3. Assigns properly trained and experienced personnel; ensures AC/R equipment maintenance personnel are certified to meet state and EPA requirements or host nation FGS at overseas installations.

2.5.2.4. Ensures excess and waste refrigerants are disposed of in accordance with applicable state, federal, or host nation FGS at overseas installations.

2.5.3. **Recordkeeping and Reporting.**

2.5.3.1. Ensures all refrigerant records are kept in APIMS as the database of record, including refrigerants added, removed, or lost, and AC/R equipment in service, repaired, replaced, and decommissioned.

2.5.3.2. Ensures any leaks subject to time-sensitive requirements for repair, recordkeeping, and reporting are addressed per applicable regulations.

2.5.3.3. Ensures coordination with the Installation Support Team (IST) air quality manager to validate EPA reporting requirements. EPA reporting will be initiated by the BCE (environmental element).

2.5.4. **Support to Other Agencies.**

2.5.4.1. Determines if equipment owned or operated by tenant organizations (e.g., Army and Air Force Exchange Service [AAFES], Defense Commissary Agency [DeCA]) must be maintained by installation CE personnel based on host-tenant or other shared responsibility agreements. Ensures roles of each party are fully defined in agreement documents.

2.5.4.2. Ensures that service contracts to perform maintenance and repairs on installation AC/R equipment by outside contractors include requirements within the statement of work (SOW) to comply with all sections of 40 CFR Part 82 as well as report the quantity of refrigerant removed, recovered, recycled, or disposed of, including repair details, to the equipment owner/operator.

2.5.4.3. Ensures that when CE personnel are tasked to support RPSE, the supported equipment and refrigerant actions are tracked in APIMS, regardless of which unit funds maintenance actions. Any RPSE unit supported by the installation CE must be added to the inspection and servicing program.

2.6. Tenant- or Contractor-Operated Refrigeration Equipment. All tenant- or contractor-operated AC/R equipment is subject to the requirements of this manual. Tenants may use a different recordkeeping system as documented in the support agreement. All recordkeeping systems must be approved by the CE environmental element, and ensure it meets all requirements.

Chapter 3

REFRIGERANT MANAGEMENT PROGRAM

3.1. Technician Certification. All technicians working on AC/R equipment containing Class I or Class II refrigerants must satisfy EPA training and certification requirements imposed by Title VI of the Clean Air Act.

3.1.1. **Requirements.** A technician is any person who performs maintenance, service, repair, or system removal that could be reasonably expected to release refrigerants from appliances, except for MVAC, into the atmosphere. Apprentices are exempt from this requirement provided the apprentice is closely and continually supervised by a certified technician while performing any maintenance, service, repair, or disposal that could reasonably be expected to release refrigerant from appliances into the environment. The supervising certified technician is responsible for ensuring the apprentice complies with all EPA requirements. The EPA has proposed extending the certification requirements for technicians who work with CFC and HCFC refrigerants to technicians who work with HFCs. Technicians certified to work with CFCs and HCFCs would not have to be retested to work with HFCs, but new technicians entering the field would have to pass a test to work with CFCs, HCFCs, and/or HFCs.

3.1.2. **Certification Types.** The EPA has developed four types of certification. All refrigerant technicians must be certified by an EPA-approved technician certification program in accordance with the following classifications and types:

3.1.2.1. **Type I:** Required for servicing small appliances.

3.1.2.2. **Type II:** Required for servicing or disposing of high-pressure and very-high-pressure appliances, excluding small appliances and MVAC.

3.1.2.3. **Type III:** Required for servicing or disposing of low-pressure appliances.

3.1.2.4. **Universal:** Permits servicing all types of appliances.

3.1.3. **Documentation Requirements.**

3.1.3.1. All military and civil service technicians opening refrigerant appliances for maintenance, service, repair, or disposal must be certified as Universal technicians upon completion of the AFSC 3-level awarding technical school or upon hire into civil service. **(T-0).** Base operations support (BOS) contract personnel must be certified to the appropriate level for tasks performed prior to the BOS contract start date. **(T-0).** Documentation must be maintained in APIMS and available for inspection. **(T-0).**

3.1.3.2. Service contractors must provide copies of appropriate certification required for the type of work accomplished with a record of refrigerant service being performed on Air Force installations. This must be provided to the installation CE environmental element. Tenant units not under the purview of the installation CE, must coordinate any service contract work planned and accomplished with the installation environmental element. **(T-0).**

3.2. Refrigerant Inventory Management. Documentation and control of the refrigerant inventory is the foundation of an effective refrigerant management program. Knowing how much refrigerant is on hand, how much has been used, and what needs to be ordered ensures that enough refrigerant will be available for equipment maintenance or replacement to meet mission requirements. Class I refrigerants for facility AC/R must be supplied only from the existing CE stocks. **(T-1).** Existing equipment containing Class I refrigerants must be managed to the end of their service lives or until Class I refrigerant inventories are below critical levels. Once all Class I equipment has been decommissioned or retired, the Class I refrigerants must be transferred to the Defense Logistics Agency (DLA) through the logistics readiness squadron's hazardous materials pharmacy (LRS HAZMART). **(T-1).** Since Class II refrigerant production is being phased out, with eventual elimination by the year 2030, diminishing supplies of Class II refrigerants will require close management of refrigerant inventories to ensure adequate supplies of refrigerant are available to meet Air Force mission requirements. Additionally, managing inventories of all refrigerants will help reduce costs associated with the service and maintenance of AC/R equipment.

3.2.1. **Refrigerant Inventory List**. An inventory of all refrigerants, regardless of type, used in the maintenance of the AC/R units at an installation must be developed and maintained. **(T-1).** The inventory must be accomplished for each refrigerant. A refrigerant transaction log must be maintained for each refrigerant to determine actual consumption rates, and must follow requirements in AFI 32-7086. Inventory should be managed in EESOH-MIS, unless there is a waiver or exemption in AFI 32-7086. **(T-1).**

3.2.2. **Recording of Refrigerant Servicing**. The BCE must establish a process to ensure the refrigerant maintenance event, including the amount of refrigerant used to service an AC/R unit, is recorded in APIMS within 10 business days. **(T-1).**

3.2.3. **Leakage Rate Calculation.** The leakage rate calculation is automatically completed by APIMS after the refrigerant added data is entered into the system. There are two methods the EPA uses to calculate the leakage rate: the Annualizing Method ($LR_{\%Ann}$), which is expressed in terms of the percentage of the appliance's full charge that would be lost over a 12-month period if the current rate of loss were to continue over that period; and the Rolling Average Method ($LR_{\%Roll}$), which aggregates the amount of refrigerant added to the appliance over the past 365 days or since the last time that repairs were made if that period is less than one year. The installation can determine which one is used but the same one must be used for all AC/R on the installation and cannot be switched for convenience.

3.2.3.1. The BCE must ensure that service logs are entered into APIMS. **(T-1).** If a leak exceeds the EPA threshold, APIMS will automatically notify designated personnel to take appropriate action. Leak rates and trends must be evaluated for maintenance and programming actions at least once per year. **(T-1).**

3.2.3.2. The following is the equation used by APIMS to calculate the Annualizing Method (EPA Method #1) leakage rate ($LR_{\%Ann}$). See Figure 3.1 for a demonstration calculation.

Figure 3.1. Sample Annualized Leakage Rate Calculations.

An office building is cooled by a 200-ton rotary chiller containing a 400-pound HCFC R-22 refrigerant charge. 150 pounds of HCFC R-22 were added at the first servicing and a leak repair was made. 15 pounds of HCFC R-22 were added at the following servicing. The system was put into service 5 May 2014.

Service Records

Calendar Date	**Julian Date[1]**	**Refrigerant Added**
5 May 2014	2456782 (127)	0 lb
1 Oct 2015	2457296 (274)	150 lbs
4 Dec 2015	2457361 (338)	15 lbs

1. Determine the for the fill on 1 Oct 2015

2. Determine the for the fill on 4 Dec 2015

Notes [1]Julian date calculated by USNO Julian date converter http://aa.usno.navy.mil/data/docs/JulianDate.php. Date shown in ( ) is Julian date taken from calendar but needs to account for 365/366 days when calculating multi-calendar years.

3.2.3.3. The following is the equation used by APIMS to calculate the Rolling Average Method (EPA Method #2) leakage rate ($LR_{\%Roll}$). See Figure 3.2 for a demonstration calculation.

Figure 3.2. Sample Annualized Leakage Rate Calculations.

An office building is cooled by a 200-ton rotary chiller containing a 400-pound HCFC R-22 refrigerant charge. 150 pounds of HCFC R-22 were added at the first servicing and a leak repair was made. 5 pounds of HCFC R-22 were added at the following servicing. The system was put into service 5 May 2014.

Service Records

Calendar Date	**Julian Date[1]**	**Refrigerant Added**
5 May 2014	2456782 (127)	0 lb
1 Oct 2015	2457296 (274)	150 lbs
4 Dec 2015	2457361 (338)	5 lbs

1. Determine the for the fill on 1 Oct 2015

2. Determine the for the fill on 4 Dec 2015

Notes: [1]Julian date calculated by USNO Julian date converter http://aa.usno.navy.mil/data/docs/JulianDate.php. Date shown in ( ) is Julian date taken from calendar but needs to account for 365/366 days when calculating multi-calendar years.

3.2.4. **Determining Adequate Inventory Levels**. The determination of adequate inventory levels must be made by the BCE based on certain criteria such as mission capability, refrigerant cost and availability, and AC/R equipment phase-out timelines. One approach may be to take the average of the consumption in the past year, along with the refrigerant charge of the largest item of equipment, minus any refrigerant recovered, to determine the minimum inventory level for each refrigerant type. In determining the minimum inventory level, consider an additional safety factor equal to the amount of charge associated with the largest critical AC/R unit.

3.2.5. **Refrigerant/Equipment Replacement Planning.** Using the inventory changes recorded in APIMS, the BCE can plan for the strategic and cost-effective replacement of both ODS refrigerant-containing equipment and non-ODS systems that show an increasing trend in leak rates. Planning the phase-out of Class I and Class II refrigerant equipment will assist in meeting Air Force objectives regarding the elimination of ODS. Additionally, this process can be used to establish equipment replacement budgets and program for system replacement prior to system failure. Replacement decision criteria may include equipment age, equipment condition, refrigerant type and availability, equipment service, equipment cost, energy efficiency, and operational status.

3.2.5.1. **Equipment Condition**. Refer to past equipment service records, refrigerant leak rates, and maintenance costs. Evaluate any maintenance cost savings associated with equipment replacement. Evaluate if the leakage rate trend is increasing and approaching EPA action thresholds.

3.2.5.2. **Refrigerant Availability.** Evaluate whether current installation inventory of the required refrigerant exceeds the full charge for a particular unit. If not, determine the percentage of the equipment's full charge available and its likely or historical leakage rate. Determine the cost to replace lost refrigerant that is increasing each year. Given the limited availability of Class I refrigerants, refrigerant availability may be a primary decision criterion regarding Class I refrigerant equipment replacement. For instance, if there is one remaining item of equipment on base containing Class I refrigerant and there is little to no inventory of that refrigerant, equipment replacement would be a likely recommendation (pending other decision criteria). Equipment using HCFC-123, mostly centrifugal chillers, can be manufactured until 2020 and the refrigerant will be produced until 2030, so it is still a viable option and must be evaluated in the life-cycle cost. Class II unitary equipment consists predominantly of packaged-type, self-contained equipment using the direct expansion of a refrigerant for cooling supply airflow. Equipment types such as packaged rooftop units and split-system air-conditioners are included in this category. The predominant refrigerant utilized in this type of equipment is HCFC-22. Much of this equipment contains refrigerant charges of less than 50 pounds. Therefore, before the decision is made to replace HCFC-22 equipment, potential HCFC-22 recovery from equipment containing smaller refrigerant charges must be considered.

3.2.5.3. **Equipment Service**. Determine what impact this equipment has on the installation mission. List the consequences of the failure of this equipment.

3.2.5.4. **Equipment Cost.** The greater the replacement cost, the greater the planning horizon needed to obtain funding, procure design services, and schedule outages. The greater the replacement cost, the greater the probability the end user will have reduced operational capability in the current facility and need additional coordination planning.

3.2.5.5. **Energy Efficiency.** Compare the potential energy savings by evaluating the current equipment energy cost to a similar new high-efficiency unit. Evaluate how it affects the life-cycle cost for operation.

3.2.5.6. **Operational Status.** Determine whether the equipment serves a primary or backup function. If equipment is primary, determine if the equipment has a functional backup. The replacement priority may be lower if the equipment serves as a backup and is a tight, low-leakage unit. Determine if the equipment serves a facility that is planned for disposal or a major change in usage.

3.3. Refrigerant Recovery, Recycling, and Disposal.

3.3.1. Recovery, recycling, and reuse of Class I and Class II refrigerants will be accomplished to the maximum extent practicable to ensure responsible use and prevent losses to the atmosphere. All refrigerants must be recovered/recycled by removing the refrigerant using EPA-certified recovery equipment and storing it in an approved container. **(T-0, 40 CFR Part 82).**

3.3.2. Anyone who disposes of AC/R equipment must recover the remaining refrigerant and/or verify that the refrigerant is evacuated properly as detailed in Attachment 5. **(T-0, 40 CFR Part 82)**

3.3.3. Refrigerant may be returned to the appliance from which it is recovered or to another appliance owned by the Air Force without being recycled or reclaimed. **(T-0, 40 CFR Part 82).**

3.3.4. **Recovery Equipment.**

3.3.4.1. Base personnel who maintain, repair, or dispose of AC/R equipment must use recovery and recycling equipment certified by an EPA-approved testing organization. **(T-0).** The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) and Underwriters Laboratory (UL) are two approved organizations.

3.3.4.2. Contracts to purchase recycling and recovery equipment for use on Air Force facilities during the maintenance, service, or repair of appliances containing Class I and Class II refrigerants are to have such equipment certified by an EPA-approved equipment testing organization to meet the applicable requirements and standards of 40 CFR Part 82, Subpart F, Section 82.158. Any contractor that services heating, ventilation, and air conditioning (HVAC) equipment on Air Force-owned facilities must use certified equipment. **(T-0, 40 CFR Part 82).**

3.3.4.2.1. Each piece of equipment must have a label stating, "This equipment has been certified by an approved equipment testing organization to meet EPA's minimum requirements for recycling or recovery equipment intended for use with [appropriate category of appliance]."

3.3.4.2.2. The label must also show the date of manufacture and the serial number (if applicable) of the equipment.

3.3.4.2.3. The label must be affixed in a readily visible or accessible location, be made of a material expected to last the lifetime of the equipment, and present the required information in such a manner that it is likely to remain legible for the lifetime of the equipment. The label must be affixed in such a manner that it cannot be removed from the equipment without damaging the label.

3.3.4.2.4. The EPA has proposed standards for HFC recovery equipment that are very similar to the standards for CFC and HCFC equipment. The standards depend upon the saturation pressure of the refrigerant, the size of the appliance in which it is used, and the date of manufacture of the recovery equipment. Manufacturers of recycling and recovery equipment have stated that most recovery and recycling equipment designed for use with multiple CFC or HCFC refrigerants (e.g., 12, 22, 500, and 502) can be adapted for use with HFC refrigerants with similar saturation pressures. Thus, the EPA is proposing to allow technicians to recover HFCs using recovery or recycling equipment designed for use with at least two CFC or HCFC refrigerants of similar saturation pressure. However, recovery or recycling equipment already used for CFC or HCFC equipment should not be used for other alternate refrigerants to avoid mixing different types of refrigerants.

3.3.4.3. Use and maintain all recovery or recycling equipment in accordance with the manufacturer's directions unless such directions conflict with the requirements of the EPA.

3.3.4.4. **Equipment Certification and Registration.**

3.3.4.4.1. All refrigerant recovery and recycling equipment must be certified to meet the standards defined within 40 CFR 82.158. **(T-0).** Installations must certify to the EPA that they have obtained certified recovery and recycling equipment and that they are complying with all applicable requirements of 40 CFR subpart 82. This one-time notification is required under 40 CFR 82.162 and should be accomplished using EPA Form 7610-31 or equivalent; this form is available on the EPA's refrigerant website. **(T-0).** Installations do not need to submit subsequent notifications to the EPA when new refrigerant recovery and recycling equipment is obtained or old recovery and recycling equipment is retired.

3.3.4.4.2. A list of certified refrigerant recovery/recycling/reclaiming equipment that includes manufacturer names, evacuation certification types, the date of certification, and refrigerant type must be available on base. **(T-0).**

3.3.5. **Reallocation and Disposal of Non-required Class I and II ODS Refrigerants.**

3.3.5.1. "The installation HMMP Team is the focal point for the proper management of refrigerants. In addition, AFI 32-7086, Hazardous Materials Management, provides guidance on the disposition of unused Class I and Class II ODS. The installation EMO is the authoritative source for determining the disposition of any excess refrigerants. The non-directive process HAZMAT management playbook published on the AF CE Portal, provides additional installation-level ODS management guidance.

3.3.5.2. **Transfers.**

3.3.5.2.1. The transfer of excess Class I ODS outside the Air Force, except to the DLA ODS Defense Reserve Stockpile, is prohibited.

3.3.5.2.2. Class I or Class II refrigerant ownership cannot be sold or transferred outside of DOD. Transfers of excess refrigerant to other bases are encouraged and should be arranged through the installation HAZMART.

3.3.5.3. **DLA Turn-ins.** If the BCE identifies excess Class I refrigerants that cannot be reused on the base or reallocated within the MAJCOM, these supplies must be returned to the DLA Class I ODS Defense Reserve Stockpile through the HAZMART. **(T-1).** An example of this may be the retirement or disposal of the last item of equipment containing that refrigerant.

3.3.5.4. **Disposal.**

3.3.5.4.1. Any refrigerant contaminated by other refrigerants that cannot be reclaimed is solid waste. The solid waste refrigerant must, in turn, be characterized to determine whether it is hazardous waste. The BCE may also use process knowledge and simply declare the refrigerant to be hazardous waste and manifest it appropriately for final disposition IAW AFI 32-7042, *Waste Management*. For this reason, it is imperative that refrigerants are not mixed during recovery.

3.3.5.4.2. If a refrigerant is determined to require disposal, refrigerant evacuation must be accomplished per current EPA guidelines provided by the installation HAZMART.

3.4. Air Conditioning/Refrigeration Equipment Maintenance.

3.4.1. **Maintaining Equipment to Minimize Refrigerant Leakage**. There are several methods and procedures to minimize refrigerant leakage. The recommended methods of reducing refrigerant leakage are: follow required EPA practices, general equipment servicing and repair, leak detection methods, and AC/R equipment modifications. These methods are outlined and described below.

3.4.1.1. All persons disposing of appliances, except for small appliances, MVAC, and MVAC-like appliances, must evacuate the refrigerant, including the entire liquid refrigerant, into EPA-approved recovery or recycling equipment.

3.4.1.2. Technicians opening refrigerant appliances for maintenance, service, repair, or disposal must have the appropriate EPA certification.

3.4.1.3. Use all recovery or recycling equipment in accordance with the manufacturer's directions unless such directions conflict with the requirements of the EPA.

3.4.2. **Venting Prohibitions (All Refrigerants).**

3.4.2.1. Since July 2005, it is an EPA violation to knowingly release any Class I or Class II refrigerant or substitute refrigerant other than carbon dioxide (CO_2), ammonia, or water into the atmosphere. The knowing release of a refrigerant or non-exempt substitute subsequent to its recovery from an appliance is an EPA violation.

3.4.2.2. "De minimis" releases (as defined in 40 CFR 82.154(a)(2)) associated with good-faith attempts to recycle or recover refrigerants or non-exempt substitutes are not subject to this prohibition.

3.4.3. **Equipment Servicing and Repairs**. Detailed requirements and information about performing equipment service and repairs are in Attachment 5.

3.4.4. **Leak Detection**.

3.4.4.1. The BCE must develop a leak detection program that matches individual AC/R equipment with a specific type of leak detection. **(T-1).** The BCE should also develop an equipment leak-check schedule based on the equipment type and leak history and include it with the equipment's recurring work plan requirements. As more leaks occur, equipment checks need to be increased accordingly.

3.4.4.2. Leak-detection procedures vary from soap bubbles to sophisticated sensors. See Attachment 4 for additional detail.

3.4.4.3. All leaks must be scheduled for repair. Leaks that exceed EPA-required action levels must follow the requirements of section 3.5. **(T-0).**

3.5. EPA Repairable Leaks.

3.5.1. **Leak Identification.** The EPA requires equipment owners or operators to promptly calculate the leakage rate each time refrigerant is added to applicable equipment. The leakage rate will be calculated by APIMS automatically and automatic notification will be sent to designated personnel. If the system is leaking above the threshold, the EPA imposes strict deadlines for compliance with repairing the leaks or retrofitting/retiring the equipment. EPA notification is required when repairs or off-line actions cannot be accomplished in 30 days. **(T-0).**

3.5.2. **EPA Leakage Rate Thresholds**. The thresholds are based on three main equipment categories: comfort cooling, commercial refrigeration, and industrial process refrigeration. Comfort cooling refers to equipment designed for environmental control for occupant comfort. Commercial refrigeration refers to refrigeration appliances used in the retail food and cold storage warehouse sectors. Industrial process refrigeration refers to complex, customized appliances used in the chemical, pharmaceutical, petrochemical, and manufacturing industries. This equipment is directly linked to the industrial process. Leakage rates are calculated by APIMS and demonstrated in paragraph 3.2.3.

3.5.2.1. Comfort cooling refrigeration equipment containing 50 pounds or more of refrigerant in any single circuit must have all refrigerant leaks repaired within 30 days if the actual annual leakage rate exceeds 15 percent of the total charge.

3.5.2.2. Commercial refrigeration equipment containing 50 pounds or more of refrigerant in any single circuit must have refrigerant leaks repaired within 30 days if the actual annual leakage rate exceeds 35 percent of the total charge.

3.5.2.3. Industrial refrigeration equipment containing 50 pounds or more of refrigerant in any single circuit must have refrigerant leaks repaired within 30 days if the actual annual leakage rate exceeds 35 percent of the total charge.

3.5.3. **Leakage Repair.** Class I and Class II refrigeration equipment with leaks that exceed the leakage rate threshold must be repaired, mothballed, or have a plan to remove from service within 30 days after discovery. **(T-0).** The date of APIMS calculation will start the 30-day clock. Servicing records documenting the date and type of service, leak repair calculations, and quantity of refrigerant added must be kept for a minimum of three years. **(T-0).**

3.5.3.1. If the 30-day compliance requirement cannot be met, the leak must be reported to the EPA. **(T-0).** The EPA may grant additional time to repair leaks under certain circumstances. These circumstances include, but may not be limited to, the following:

3.5.3.1.1. If the refrigeration appliance is located in an area subject to radiological contamination or where shutting down the appliance will directly lead to radiological contamination.

3.5.3.1.2. If necessary parts are unavailable or if requirements of other applicable federal, state, or local regulations make a repair within 30 or 120 (for cases requiring industrial process shutdown) days impossible.

3.5.3.1.3. Instances where an industrial process shutdown is needed to repair leaks from industrial process refrigeration equipment.

3.5.3.1.4. Equipment is "mothballed." System mothballing means the intentional shutdown of a refrigeration appliance undertaken for an extended period by the owners or operators of that facility, where the refrigerant has been evacuated from the appliance or the affected isolated section of the appliance, to at least atmospheric pressure.

3.5.3.1.5. Equipment repair is unnecessary if a plan to retire or replace the equipment within a year is developed within 30 days after the leak is discovered. This provision also applies to a failed follow-up verification test or after making good-faith efforts to repair the leak(s).

3.5.3.1.6. If the appliance cannot be repaired or mothballed within 30 days or within 30 days of a failed follow-up verification test, or after making a good-faith effort to repair the leaks, the BCE can develop a one-year retirement or replacement plan for the leaking appliance. The plan must be entered into APIMS and a copy of the retirement or replacement plan must to be sent by the base CE environmental element to the EPA within 30 days of discovering the leak. **(T-0).** Compliance with the 30-day requirement is based on the date the report was postmarked.

3.5.4. **Verification Tests.** Verification tests include both initial and follow-up tests and have provisions with regard to leak repairs that require the evacuation of the equipment or portion of the equipment refrigerant charge.

3.5.4.1. Initial verification tests are leak tests conducted as soon as practicable after the repair is completed.

3.5.4.2. Follow-up verification tests are tests that involve checking the repairs within 30 days of the appliance returning to normal operating characteristics and conditions. Initial and follow-up verification can be done in a single service call, provided the unit is operating under normal operating conditions.

3.5.5. **Required Reports for Repairs Requiring More Than 30 Days.**

3.5.5.1. All of the following actions will be entered by the installation CE environmental element into APIMS as a record under the base-wide refrigerant management process and copy to the IST/ANGRC Air Quality Program Manager. **(T-1).**

3.5.5.2. **EPA Initial Report**. An initial report must be submitted to the EPA regarding why more than 30 days are needed to complete repairs. This report must include the following:

3.5.5.2.1. Identification of the facility;

3.5.5.2.2. Leakage rate;

3.5.5.2.3. Method used to determine the leakage rate and full charge;

3.5.5.2.4. Date a leakage rate above the applicable leakage rate was discovered;

3.5.5.2.5. Location of leak(s) to the extent determined to date;

3.5.5.2.6. Any repair work completed thus far and the date that work was completed;

3.5.5.2.7. The reasons why more than 30 days are needed to complete the work and an estimate of when the work will be completed.

3.5.5.2.8. If changes from the original estimate of when work will be completed result in extending the completion date from the date submitted to the EPA, the reasons for these changes must be documented and submitted to the EPA within 30 days of discovering the need for the change.

3.5.5.3. **Leak Repair Plans**. The BCE must submit a plan to fix leaks for which repairs are planned, but cannot be completed, to achieve a rate below the applicable allowable leakage rate prior to the 30- or 120-day point. **(T-0).** This plan is submitted only after the BCE has originally notified the EPA that the initial completion dates cannot be met.

3.5.5.4. **EPA Final Report**. The BCE must maintain records of the dates, types, and results of all initial and follow-up verification tests in APIMS. **(T-1).** Upon completion of all repairs, perform an initial verification to confirm the leak is fixed with a follow-up verification test. It there is still a leak, an interim report is sent to the EPA. The final report is due to the EPA 30 days from the date of the initial verification of the repair previously reported to the EPA. Each report must also include the following: **(T-0).**

3.5.5.4.1. Identification of the facility;

3.5.5.4.2. Leakage rate;

3.5.5.4.3. Method used to determine the leakage rate and full charge;

3.5.5.4.4. Date leakage rate above the applicable leakage rate was discovered;

3.5.5.4.5. Location of leak(s) to the extent determined to date;

3.5.5.4.6. Any repair work completed thus far and the date that work was completed.

3.6. Records Management. The following documentation pertaining to refrigerant leakage compliance is required in accordance with 40 CFR Part 82, Subpart F, Section 82.166, and all records will be maintained in APIMS. **(T-0).**

Chapter 4

AIR FORCE APIMS REFRIGERANT MANAGEMENT MODULE

4.1. APIMS Refrigerant Management Module. In order to standardize refrigerant records management and processes across the Air Force, all refrigerant records must be managed and maintained in the Air Force APIMS Refrigerant Management Module. **(T-1).** These records include documentation of AC/R equipment inventory, maintenance and repair activities, as well as any other information as required by local, state, or federal law, and host nation FGS for overseas installations.

4.2. APIMS Overview. Air Force APIMS is a centrally hosted, web-based system for managing environmental compliance data. APIMS is available to users within and outside of the Air Force network and is approved for use on all government computers. There is no software installation necessary; the only requirements are that a user has a connection to the Internet, valid CAC or External Certificate Authority (ECA), and a properly configured CAC reader installed on their computer.

4.3. APIMS Record Management. Use of the APIMS application ensures that legally required AC/R records are recorded and cataloged as required by EPA regulations. APIMS is considered to be the system of record for all refrigerant activities.

4.4. APIMS Training and Support.

4.4.1. Use of APIMS is supported through a telephone help desk, recurring webinar training events, prerecorded training videos, and a series of quick guides. Contact information for the APIMS Help Desk is displayed in the lower left-hand corner of the screen: **help@apims-support.com**, 1-844-EZ-APIMS (392-7467)

4.4.2. User guides and other reference documents are contained within APIMS. To access them, scroll to the bottom of the page and click on the link on the left-hand side, "Help & System Documentation." From there, a series of PDF documents will be available for reference. Look for a document titled, *Refrigerant Compliance*.

4.5. Access to APIMS. Coordinate with your installation CE environmental element air quality manager to obtain an account in APIMS. The system is available at the following address: **https://apims.af.mil**

JOHN COOPER
Lieutenant General, USAF
DCS/Logistics, Engineering and Force Protection

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

40 CFR Part 82, Subpart F, *Recycling and Emissions Reduction*

40 CFR Part 82, *Protection of Stratospheric Ozone*, 2008

40 CFR 82.154, *Prohibitions*

40 CFR Part 82, Subpart F, Section 82.156, *Required Practices*, 2008

40 CFR Part 82, Subpart F, Section 82.158, *Standards for Recycling and Recovery Equipment*, 2008

40 CFR Part 82, Subpart F, Section 82.166, *Reporting and Record-Keeping Requirements*, 2008

40 CFR Part 82, Subpart F, Section 82.162, *Certification by Owners of Recovery and Recycling Equipment*, 200749 CFR Part 178, Subpart C, Section 178.35, *General Requirements for Specification Cylinders*, 2011

AFPD 32-70, *Environmental Quality*

AFI 32-7040, *Air Quality Compliance and Resource Management*, 4 November 2014

AFI 32-7042, *Waste Management*, 07 November 2014

AFI 32-7086, *Hazardous Materials Management*, 4 February 2015

AFI 33-360, *Publications and Forms Management*, 1 December 2015

AFMAN 33-363, *Management of Records*, 1 Mar 2008, Certified Current 9 April 2015 *Incorporating Change 2, 9 June 2016*

AFPD 32-10, *Installations and Facilities*, 4 March 2010

AHRI 700-2015, *Specification for Refrigerants*, 2015

AHRI 740-2016, *Performance Rating of Refrigerant Recovery Equipment and Recovery/Recycling Equipment*, 2016

AHRI Guideline N-2015, *Assignment of Refrigerant Container Colors*, 2015

ANSI/ASHRAE Standard 147-2013, *Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems*, 2013

ASHRAE 15-2013, *Safety Standard for Refrigeration Systems*, 2013

ASHRAE 34-2013, *Designation and Safety Classification of Refrigerant*, 2013

Clean Air Act, 40 CFR Subchapter C, Parts 50–97

Department of Defense Ozone Depleting Substances Turn-in Procedures, December 2015

DLAI 4145.25, *Storage and Handling of Liquefied and Gaseous Compressed Gasses and Their Full and Empty Cylinders*, 16 June 2000

DOT Specification 39, 49 CFR Section 178.65, *Specification 39 Non-reusable (non-refillable) cylinders*

NFPA 70, National Electrical Code (NEC), 2015

Prescribed Forms

None

Adopted Forms

EPA Form 7610-31, *Refrigerant Recovery or Recycling Device Acquisition Certification Form*,

https://www.epa.gov/sites/production/files/2016-03/documents/recoveryform.pdf

Abbreviations and Acronyms

AC/R—Air-conditioning and refrigeration

AF/A4C—The Air Force Civil Engineer

AFCEC—Air Force Civil Engineer Center

AFI—Air Force Instruction

AFIMSC—Air Force Installation and Mission Support Center

AFMAN—Air Force Manual

AFPD—Air Force Policy Directive

AHRI—Air-Conditioning, Heating, and Refrigeration Institute (formerly ARI)

ANG—Air National Guard

ANSI—American National Standards Institute

APIMS—Air Program Information Management System

ARI—Air-Conditioning and Refrigeration Institute or American Refrigeration Institute (now AHRI)

ASHRAE—American Society of Heating, Refrigerating and Air-Conditioning Engineers

BCE—Base Civil Engineer

BEE—Bioenvironmental Engineering

BOS—Base operations support

CAA—Clean Air Act

CAC—Common Access Card

CAS—Chemical Abstracts Service

CE—Civil Engineering

CFC—Chlorofluorocarbon

CFR—Code of Federal Regulations

CO_2—carbon dioxide

DLA—Defense Logistics Agency

DLAI—Defense Logistics Agency Instruction

DOD—Department of Defense

DOT—Department of Transportation

EPA—Environmental Protection Agency

FGS—Final Governing Standards

HAZMART—Hazardous Materials Pharmacy

HCFC—Hydrochlorofluorocarbon

HFC—Hydrofluorocarbon

Hg—Mercury

HVAC—heating, ventilating, and air-conditioning

IDLH—Immediately Dangerous to Life and Health

IR—Infrared

IR-PAS—Infrared-photo acoustic spectroscopy

IST—Installation Support Team

lb/yr—pound per year

lb—pound

MAJCOM—Major Command

mm—millimeter

MVAC—Motor Vehicle Air-Conditioning

NCG—non-condensable Gas

NFPA—National Fire Protection Association

ODS—ozone-depleting substances

OEL—Occupational Exposure Limit

OSHA—Occupational Safety and Health Administration

PDF—portable document format

ppm—parts per million

psia—pounds per square inch absolute

psig—pound per square inch gauge

psi—pounds per square inch

PSU—Primary Subordinate Unit

RPIE—real property installed equipment

RPSE—real property similar equipment

SNAP—Significant New Alternatives Policy

STEL—Short-Term Exposure Limit

TLV—Threshold Limit Value

TLV-TWA—Threshold Limit Value – Time-Weighted Average

UL—Underwriters' Laboratory

UNEP—United Nations Environment Programme

USNO—United States Naval Observatory

UV—ultraviolet

wt—weight

Terms

Appliance—Any device that contains and uses a refrigerant and is used for household or commercial purposes, including any air conditioner, refrigerator, chiller, or freezer.

Commercial Refrigeration—Per 40 CFR Part 82, Subpart F, Section 82.156(i), the refrigeration appliances utilized in the retail food and cold storage warehouse sectors. Retail food includes the refrigeration equipment found in supermarkets, convenience stores, restaurants, and other food service establishments. Cold storage includes the equipment used to store meat, produce, dairy products, and other perishable goods. All of the equipment contains large refrigerant charges, typically over 75 pounds.

Consumption Rate (CR)—The annual rate at which a refrigerant is lost to leaks and emissions, typically expressed in pounds per year (lb/yr).

Disposal—(1) The process leading to appliance disassembly where the appliance components are reused. (2) The disassembly of any appliance for discharge, deposit, dumping, or placing of its discarded component parts into or on any land or water. (3) The discharge, deposit, dumping, or placing of any discarded appliance into any land or water.

Follow-up Verification Test—Per 40 CFR Part 82, Subpart F, Section 82.156(i), those tests that involve checking the repairs within 30 days of the appliance's return to normal operating characteristics and conditions. Follow-up verification tests for appliances from which the refrigerant charge has been evacuated means a test conducted after the appliance or portion of the appliance has resumed operation at normal operating characteristics and conditions of temperature and pressure, except in cases where sound professional judgment dictates that these tests will be more meaningful if performed prior to the return to normal operating characteristics and conditions. A follow-up verification test with respect to repairs conducted without evacuation of the refrigerant charge means a reverification test conducted after the initial verification test and usually within 30 days of normal operating conditions. Where an appliance is not evacuated, it is only necessary to conclude any required changes in pressure, temperature or other conditions to return the appliance to normal operating characteristics and conditions.

Full Charge—The amount of refrigerant required for normal operating characteristics and conditions of the appliance as determined by using one or a combination of the following four methods: (1) Use the equipment manufacturer's determination of the correct full charge for the equipment; (2) Determine the full charge by making appropriate calculations based on component sizes, density of refrigerant, volume of piping, and other relevant considerations; (3) Use actual measurements of the amount of refrigerant added or evacuated from the appliance; and/or (4) Use an established range based on the best available data regarding the normal operating characteristics and conditions for the appliance, where the midpoint of the range will serve as the full charge and where records are maintained in APIMS.

High-Pressure Appliance—Uses a refrigerant with a liquid phase saturation pressure between 170 psia and 355 psia at 104 °F. This definition includes, but is not limited to, appliances using R-401A, R-409A, R-401B, R-411A, R-22, R-411B, R-502, R-402B, R-408A, and R-402A.

Household Refrigeration—Refrigerators and freezers intended primarily for household/small work center use. This equipment may be used outside the home and can be found in shops and work centers.

Industrial Process Refrigeration—Per 40 CFR Part 82, Subpart F, Section 82.156(i), this is complex customized appliances used in the chemical, pharmaceutical, petrochemical, and manufacturing industries. This includes industrial ice machines.

Industrial Process Shutdown—Per 40 CFR Part 82, Subpart F, Section 82.156(i), an industrial process or facility temporarily ceases to operate or manufacture whatever is being produced at that facility.

Initial Verification Test—For the purposes of 40 CFR Part 82, Subpart F, Section 82.156(i), those leak tests that are conducted as soon as practicable after the repair is completed. An initial verification test, with regard to the leak repairs that require the evacuation of the appliance or portion of the appliance, means a test conducted prior to the replacement of the full refrigerant charge and before the appliance or portion of the appliance has reached operation at normal operating characteristics and conditions of temperature and pressure. An initial verification test with regard to repairs conducted without the evacuation of the refrigerant charge means a test conducted as soon as practicable after the conclusion of the repair work.

Leak Rate—The rate at which an appliance is losing refrigerant, measured between refrigerant charges. See Chapter 3 for calculation methods.

Life-Cycle Cost (LCC)—The total cost associated with the purchase, installation, operating, and maintenance of a system or equipment over its expected life.

Low-Loss Fitting—Any device intended to establish a connection between hoses, AC/R equipment, or recovery or recycling equipment that will close automatically or must be manually closed before disconnecting, thereby minimizing the release of refrigerant to the atmosphere.

Low-Pressure Appliance—An appliance that uses a refrigerant with a liquid phase saturation pressure below 45 psia at 104 °F. This definition includes, but is not limited to, appliances using R-11, R-123, and R-113.

Major Maintenance, Service, or Repair—Maintenance, service, or repair that involves removing the compressor, evaporator, or auxiliary heat exchanger coil or any maintenance, service, or repair that involves uncovering an opening of more than 4 square inches of “flow area” for more than 15 minutes.

Medium-pressure Appliance—An appliance that uses a refrigerant with a liquid phase saturation pressure between 45 psia and 170 psia at 104 °F. This definition includes, but is not limited to, appliances using R-114, R-124, R-12, R-401C, R-406A, and R-500.

Opening an Appliance—Any service, maintenance, or repair of an appliance that could be reasonably expected to release refrigerant to the atmosphere unless the refrigerant was previously recovered from the appliance.

Reclaim Refrigerant—To reprocess refrigerant to all of the specifications in Appendix A to 40 CFR Part 82, Subpart F (based on AHRI Standard 700-2015, *Specifications for Refrigerants*), that are applicable to that refrigerant and to verify that the refrigerant meets these specifications using the analytical methodology prescribed in Section 5 of Appendix A of 40 CFR Part 82, Subpart F.

Recover Refrigerant—To remove refrigerant in any condition from an appliance and to store it in an external container without necessarily testing or processing it in any way.

Recycle Refrigerant—To extract refrigerant from an appliance and clean refrigerant for reuse without meeting all of the requirements for reclamation. In general, recycled refrigerant is refrigerant that is cleaned using oil separation and single or multiple passes through devices such as replaceable core filter-driers, which reduce moisture, acidity, and particulate matter. These procedures are usually implemented at the field job site.

Refrigerant—Any substance consisting in part or whole of a Class I or Class II ODS or an EPA-approved alternative, used in a heat cycle that undergoes a phase change between gas and liquid to allow cooling, as in refrigerators, air conditioners, etc.

Refrigerant Circuit—Parts of an appliance that are normally connected to each other (or are separated only by internal valves) and are designed to contain refrigerant.

Self-contained Recovery Equipment—Refrigerant recovery or recycling equipment that is capable of removing the refrigerant from an appliance without the assistance of components contained in the appliance.

Small Appliance—Any appliance that is fully manufactured, charged, and hermetically sealed in a factory with 5 pounds or less of a Class I or Class II substance used as a refrigerant, including, but not limited to, refrigerators and freezers (designed for home, commercial, or consumer use), medical or industrial research refrigeration equipment, room air conditioners (including window air conditioners and packaged terminal air heat pumps), dehumidifiers, under-the-counter ice makers, vending machines, and drinking water coolers.

Substitute—Any chemical or product, whether existing or new, that is used by any person as an EPA-approved replacement for a Class I or II ozone-depleting substance (ODS) in a given refrigeration or air-conditioning end-use.

Technician—Any person who maintains, services, or repairs AC/R equipment that could reasonably be expected to release refrigerants to the atmosphere. Must be certified by the EPA.

Very-High-Pressure Appliance—AC/R equipment that uses a refrigerant with a critical temperature below 104 °F or with a liquid phase saturation pressure above 355 psia at 104 °F. This definition includes, but is not limited to, appliances using R-13 or R-503.

Attachment 2

UPDATE ON REFRIGERANTS: TRANSLATING THE LAWS, REGULATIONS, AND POLICIES INTO PRACTICE

A2.1. The Montréal Protocol. Since 1974, atmospheric scientists worldwide have substantiated and refined the hypothesis confirming the long-term, negative consequences of CFC use. In response to scientists' concerns, representatives of 35 nations met in 1987 at the United Nations Environment Programme (UNEP) in Montréal and established an international protocol for restricting CFC and halon production. Representatives from 93 nations met in London in 1990 to revise the Montréal Protocol because of new information regarding ozone destruction. This meeting accelerated the CFC phase-out. UNEP's November 1992 meeting in Copenhagen accelerated the phase-out schedules. The Montréal Protocol representatives generally meet every year to assess the status of ODS reduction efforts and consider new recommendations. The 2007 meeting increased the pace of the R-22 phase-out. The 2008 meeting urged the use of natural refrigerants such as carbon dioxide (CO_2).

A2.1.1. **Phase-Out Schedules.** Under the Montreal Protocol, HCFC refrigerants were to be reduced by 90 percent from their baseline by 2015. The current schedule sets future milestones of 99.5% reduction by 2020 with use of HCFCs being phased out by 2030. By 2020, the production of all new HCFC refrigerants will cease. In addition, manufacturing new equipment using HCFC refrigerants was banned beyond January 2010. The exception is HCFC-123. Equipment designed to use HCFC-123 can be produced until January 2020. The refrigerant itself will be produced until 2030.

A2.1.2. **Applicable CFCs.** The CFC refrigerants used by the Air Force for AC/R units that are affected by the Montréal Protocol include CFC-11, CFC-12, CFC-113, CFC-500, CFC-501, CFC-502, and CFC-503.

A2.1.3. **Applicable HCFCs.** The most widely used HCFC refrigerants affected by the Montréal Protocol are HCFC-22 and HCFC-123.

A2.2. Clean Air Act Amendments. Table A2.1 shows the current phase-out schedule for HCFCs, including the change at the Montréal Protocol meeting in 2007.

Table A2.1. Current Phase-Out Schedule for HCFCs.

Montréal Protocol		United States	
Year to be implemented	**Percent reduction in consumption and production using the cap as a baseline**	**Year to be Implemented**	**Implementation of HCFCs phase-out to CAA regulations**
2004	35.0%	2003	No production and no importing of HCFC-141b
2010	75.0%	2010	No production and no importing of HCFCs R-22 or R-142b except for use in equipment made before 1 January 2010

2015	90.0**%**	2015	No production and no importing of any HCFCs except for use as refrigerants and equipment manufactured before 1 January 2010
2020	99.5**%**	2020	No production and no importing of HCFC-142b and HCFC-22
2030	100.0**%**	2030	No production and no importing any HCFCs

A2.3. EPA Regulations.

A2.3.1. **Overview.** A refrigerant recycling requirement overview of CAA, Section 608, follows. It includes the final regulations published in the 14 May 1993 Federal Register, 40 CFR Part 82 (2008). The prohibition against venting became effective 1 July 2008. These requirements directly impact base CE daily activities. For additional information visit the EPA website: **https://www.epa.gov/ozone-layer-protection**. The following summarizes these procedures:

A2.3.1.1. Require service practices that maximize ODS recovery or recycling during servicing and disposal of AC/R equipment.

A2.3.1.2. Establish certification requirements for technicians and recycling, recovery, and reclaiming equipment.

A2.3.1.3. Confine Class I and Class II ODS refrigerant sales to certified technicians.

A2.3.1.4. Require that substantial leaks in AC/R equipment with a refrigerant charge of 50 pounds or greater in a refrigerant cylinder be repaired.

A2.3.1.5. Establish safe disposal requirements for small appliances, such as home refrigerators and room air-conditioners, which typically enter the waste stream with an intact charge.

A2.3.2. **Prohibition on Venting.** Effective 13 June 2005, no person maintaining, servicing, repairing, or disposing of appliances may knowingly vent or otherwise release into the environment any appliance's refrigerant or its substitute. The exceptions include nitrogen, water, ammonia, hydrocarbons, and chlorine. Some industrial uses are not affected. This applies to HFC refrigerants, including, but not limited to, R-134a and R-410a.

A2.3.3. **Service Practice Requirements.** The EPA established requirements that must be met when servicing AC/R equipment.

A2.3.3.1. Technicians are required to evacuate AC/R equipment to established vacuum levels. If the technician's recovery or recycling equipment was manufactured before 15 November 1993, the AC/R equipment must be evacuated to the levels indicated in the first column of Table A5.1. The recovery or recycling equipment must have been certified by an EPA-approved equipment testing organization (see 40 CFR Part 82 [2008], Subpart F, 156 to 158). Technicians repairing small appliances, such as household refrigerators, household freezers, and water coolers, are required to recover 80 to 90 percent of the system refrigerant, depending on the system's compressor status.

A2.3.3.2. The EPA has established limited exceptions to its evacuation requirements for minor repairs and repairs of leaking equipment not followed by an equipment evacuation into the environment. If evacuation to the level described in Table A5.1 is not attainable, or would significantly contaminate the recovered refrigerant, persons opening the appliance must isolate the leaking components from the non-leaking components whenever possible; evacuate non-leaking components to the levels shown in Table A5.1; and evacuate leaking components to a level that will not significantly contaminate the refrigerant (≤ 0 psig).

A2.3.3.2.1. If evacuation of the equipment to the environment will not be performed when repairs are complete, and if the repair is not major, then the appliance must be evacuated to at least 0 psig before it is opened if it is a high-pressure or very-high-pressure appliance, or be pressurized to 0 psig before it is opened if it is a low-pressure appliance. Methods that require subsequent purging (e.g., nitrogen) cannot be used.

A2.3.3.2.2. Major repairs include the removal of a compressor(s), condenser, evaporator, or auxiliary heat exchanger coil.

A2.3.3.3. The EPA permits the return of recovered and/or recycled refrigerant to the same system or other systems owned by the same person without restriction. If refrigerant changes ownership, the refrigerant must be reclaimed. (It must be reclaimed according to purity standards of AHRI 700-2015, *Specification for Refrigerants*, and chemically analyzed to confirm it meets that standard.)

A2.3.4. **Equipment Certification.**

A2.3.4.1. The EPA has created a certification program for recovery/recycle equipment. Under the program, the EPA requires that equipment manufactured on or after 15 November 1993 undergo tests administered by an EPA-approved testing organization to verify it meets the EPA's requirements. Recycling and recovery equipment intended for use with AC/R equipment other than small appliances must be tested by the manufacturer according to AHRI 740-2016, *Performance Rating of Refrigerant Recovery Equipment and Recovery/Recycling Equipment*. Recovery equipment designed for small appliances must also be tested to comply with AHRI 740-2016.

A2.3.4.2. The EPA requires recovery efficiency standards that vary based on the AC/R equipment size and type being serviced. For recovery and recycling equipment designed for AC/R equipment other than small appliances, the standards are identical to those shown in the second column of Table A5.1. Recovery equipment intended for small appliances must recover 90 percent of the refrigerant in a small appliance while the appliance's compressor is operating or 80 percent if the compressor is not operating.

A2.3.5. **Grandfathering Equipment.** Equipment manufactured before 15 November 1993, including homemade equipment, will be grandfathered if it meets the standards in the first column of Table A5.1. Third-party testing is not required for equipment manufactured before 15 November 1993 (see paragraph A2.3.4).

A2.3.6. **Refrigerant Leaks.** Owners of equipment with charges of 50 pounds or more of refrigerant per refrigerant circuit must repair leaks that exceed the annual maximum leakage rate of 15 percent for comfort cooling and 35 percent for commercial refrigeration and industrial process equipment within 30 days. If the owner is unable to repair the equipment, a retirement plan must be developed within 30 days and implemented within 12 months. A copy of the plan must be present with the equipment. Upon completion of the repair, a follow-up verification must occur within 30 days. Owners must maintain records of the refrigerant quantity added to their equipment during servicing and maintenance procedures. All service records must be entered into the Air Force APIMS system in accordance with this manual. Information about APIMS is in Chapter 4 of this manual.

A2.3.7. **Mandatory Technician Certification.** The CAA of 1990, Title VI, Section 608, imposes requirements for training and certifying technicians involved in maintaining and servicing refrigeration systems with CFC or HCFC refrigerants. Technicians servicing MVAC must also be certified to work with R-134a. The best practice for the Air Force is to train and certify all technicians working with any refrigerants.

A2.3.7.1. The EPA has four types of certification:

A2.3.7.1.1. Type I: Required for servicing small appliances.

A2.3.7.1.2. Type II: Required for servicing or disposing of high-pressure or very high-pressure appliances, except small appliances and MVAC.

A2.3.7.1.3. Type III: Required for servicing or disposing of low-pressure appliances.

A2.3.7.1.4. Universal: Approved for servicing all equipment types.

A2.3.7.2. Technicians, as defined in 40 CFR 82, Subpart F, 82.15, who service or repair small appliances must have Type I certification.

A2.3.7.3. Technicians must pass an EPA-approved test administered by an EPA-approved certifying organization. Technicians must be certified to be able to maintain, service, and repair AC/R equipment. Apprentice technicians working in an approved program under the direction of a certified technician do not require certification.

A2.3.8. **Refrigerant Sales Restrictions.** Any CFC or HCFC refrigerant sold in any size container will be restricted to technicians certified by an EPA-approved program.

A2.3.9. **Registration by Owners of Recycling and Recovery Equipment.** The EPA requires that persons who service or dispose of AC/R equipment must notify (register their equipment) the EPA that they have purchased and use recovery or recycling equipment certified to meet EPA requirements and that they are complying with the applicable requirements of EPA Section 608, *Refrigerant Recycling Rule* (40 CFR Part 82, Subpart F). The initial registration form, EPA Form 7610-31, *Refrigerant Recovery or Recycling Device Acquisition Certification Form*, must be signed by the equipment's owner or another responsible officer and sent to the appropriate EPA regional office. This form serves as an initial notification only; equipment owners are not required to, and therefore should not, send in a new form each time they add or remove recycling or recovery equipment to their inventory. Although recycling and recovery equipment owners are required to list the number of trucks based at their shops, they do not need an item of recycling or recovery equipment for every truck.

A2.3.10. **Safe Disposal Requirements.**

A2.3.10.1. Under the EPA's rule, equipment that is typically dismantled onsite before disposal (e.g., retail food refrigeration, cold storage warehouse refrigeration, chillers, or industrial process refrigeration) must have its refrigerant recovered according to the EPA's servicing requirements. However, equipment that typically enters the waste stream with the charge intact (e.g., household refrigerators, freezers, room air-conditioners) is subject to special safe disposal requirements.

A2.3.10.2. Under these requirements, the final person in the disposal chain (e.g., scrap metal recycler, landfill owner) must ensure the refrigerant is recovered before final disposal of the equipment. If the final person in the disposal chain accepts appliances that no longer hold a refrigerant charge, that person is responsible for obtaining a signed statement from whom the appliance is being accepted. The signed statement must include the name and address of the person who recovered the refrigerant and the date the refrigerant was recovered, or a copy of a contract stating that the refrigerant will be removed before delivery. The signed statement or contract must be available onsite for inspection. The EPA does not mandate a sticker as a form of verification that the refrigerant has been removed prior to disposal of the appliance but such stickers do not relieve the final disposer of their responsibility to recover any remaining refrigerant in the appliance. Technician certification is not required for individuals removing refrigerant from appliances prior to disposal; however, the equipment used to recover refrigerant from appliances prior to final disposal must meet the same performance standards as EPA-certified refrigerant recovery equipment used prior to servicing.

A2.3.10.3. Per EPA Section 608 of the Clean Air Act of 1990, disposable cylinders should be emptied (recover the refrigerant until the pressure is reduced to a vacuum). The container's valve should be closed and the container itself marked as empty; the container is now ready for disposal. It is recommended, but not required, by EPA Section 608 that the cylinder valve be opened afterwards to allow air to enter. The cylinder valve is then broken off while the valve remains open and the cylinder is punctured. This will prevent cylinder misuse by untrained individuals. Once the cylinder has been rendered useless as a refrigerant container, it can be disposed of as scrap metal. For details on disposal rules, refer to Department of Transportation (DOT) Specification 39, 49 CFR 178.65, *Specification 39 Non-reusable (non-refillable) cylinders*, and Defense Logistics Agency Instruction (DLAI) 4145.25, *Storage and Handling of Liquefied and Gaseous Compressed Gasses and Their Full and Empty Cylinders*.

A2.3.11. **Major Recordkeeping Requirements.** The EPA recordkeeping requirements discussed in paragraphs A2.3.11.1 and A2.3.11.2 can be met by using APIMS. All technician certifications and service events must be entered into APIMS.

A2.3.11.1. Technicians servicing appliances containing 50 or more pounds of refrigerant in a refrigerant circuit must provide the owner with an invoice that indicates the amount of refrigerant added to the appliance/refrigerant circuit. Technicians must also keep a copy of their proof of certification at their place of business.

A2.3.11.2. Owners of appliances that contain 50 or more pounds of refrigerant in a circuit must keep service records documenting the date and type of service and the quantity of refrigerant added to the appliance/refrigerant circuit.

A2.3.12. **Hazardous Waste Disposal.** The EPA has requirements for safely disposing of refrigerants.

A2.3.12.1. If refrigerants are recycled or reclaimed, they are not considered hazardous waste under federal law. In addition, used oils contaminated with CFCs or HCFCs are not hazardous waste as long as they are not combined with other waste.

A2.3.12.1.1. CFC-contaminated oils are subject to CFC recycling or reclamation.

A2.3.12.1.2. HCFC-contaminated oils are subject to HCFC recycling or reclamation.

A2.3.12.1.3. Contaminated oils are not to be mixed with used oils from other sources.

A2.3.12.1.4. If either CFC or HCFC is not ultimately reclaimed from the oil, manage the oil under 40 CFR 279 requirements or manage as solid [and potentially hazardous] waste under 40 CFR 261.

A2.3.12.2. Used oils containing CFCs after the CFC reclamation procedure are, however, subject to specification limits for used oil fuels if they are not burned.

A2.3.13. **Enforcement.** The EPA is continually performing random inspections, responding to tips, and pursuing violators. Under the CAA, the EPA is authorized to assess fines of up to $37,500 per day, per event for any violations.

Attachment 3

REFRIGERANT HANDLING AND STORAGE RECOMMENDATIONS AND REQUIREMENTS

A3.1. Introduction. All refrigerants should be stored in a controlled environment. For safety, it is important to limit access to refrigerants; some refrigerants are very toxic, flammable, or stored in high-pressure containers. Whenever possible, store refrigerants at a single location for better control and management. This simplifies refrigerant inventory management and guarantees that essential recordkeeping practices are followed.

A3.2. Refrigerant Storage Requirements – Enclosed Space. Buildings or areas within buildings, designed or used specifically as enclosed refrigerant storage facilities, must comply with ASHRAE 15-2013, *Safety Standard for Refrigeration Systems*. To meet the refrigerant concentration limits from ASHRAE 15-2013, Section 7.2, storage areas must be designed to the requirements for refrigerating machinery rooms in Section 8.1. These requirements include, but are not limited to, refrigerant storage facility ventilation and exhaust requirements, refrigerant monitors, and alarms. ASHRAE 15-2013 limits the amount of refrigerant stored in containers without relief valves and piping to not more than 330 pounds of refrigerant. All refrigerants must be stored in approved containers.

A3.3. Refrigerant Storage Recommendations – Open Space. There are no specific code requirements for refrigerant storage in non-enclosed areas other than following safe refrigerant-handling practices. Storage areas must have limited access. The following practices are recommended:

A3.3.1. All storage areas should be roofed for protection from weather extremes and be large enough to shield the refrigerant containers from direct sunlight. At a minimum, enclose the area with a chain-link fence for security.

A3.3.2. An open enclosure should be a stand-alone entity.

A3.3.3. If an enclosure is located adjacent to a building that shares a common wall and the remaining sides are open, do not install a door in the common wall within the confines of the enclosure.

A3.4. Refrigerant Health and Safety Issues. There are many health and safety issues associated with all refrigerants and HCFC refrigerants. Technicians or anyone with the potential to be working with or around refrigerants should complete a training program that meets the minimum guidelines approved by the installation bioenvironmental engineering (BEE) flight. This training must be provided and documented per installation guidelines and policies. The following section provides general information as a guideline to these hazards and references to assist in selecting sensing devices.

A3.4.1. **Physical Properties of Refrigerants.** Table A3.1 provides an overview of the refrigerants used in AC/R applications, including the type and designation number, chemical formula, boiling point, threshold limit value (TLV), short-term exposure limit (STEL), immediately dangerous to life and health (IDLH), and occupational exposure limit (OEL) information. This information can help set alarm limits or required detection devices. For details needed to design a storage area, the designer must use the most current version of ASHRAE 15 to determine volume of mechanical ventilation required and where to set an oxygen sensor. Ventilation for the machinery room is addressed in ASHRAE 15-2013, Section 8.11.5.

A3.4.1.1. The boiling point in Table A3.1 is the temperature at which the refrigerant will boil off as a gas at atmospheric pressure.

A3.4.1.2. The various refrigerant concentration levels at which an individual can be safely exposed are usually time-dependent. In Table A3.1, these levels are indicated by the TLV, STEL, IDLH and OEL columns, and are expressed in parts per million (ppm). The levels for TLV and STEL are established and published by the American Conference of Governmental Industrial Hygienists (ACGIH). IDLH values are specified by the National Institute of Occupational Safety and Health (NIOSH). The OEL is based on the TLV or similar value from the Occupational Safety Health Administration (OSHA) or related industrial health organization. The TWA and OEL are time-weighted averages over an eight-hour work day. The STEL is an acute hazard measured with a time-weighted average to not exceed 15 minutes, four times per work day. The IDLH values represent a vapor concentration level that would cause oxygen concentrations to drop below 19.5 percent. The data and terms in this table are for general design reference. Specific questions about hazards or health implications must be submitted to the installation BEE flight for assessment, awareness, and authoritative answer.

Table A3.1. Physical Properties of Refrigerants.

Refrigerant	**Name**	**Chemical Formula**	**Boiling Point°C/°F**	**TLV (ppm)**	**STEL (ppm)**	**IDLH (ppm)**	**OEL (ppm)**
ASHRAE 34 Safety Group A1 This grouping signifies least toxic and least flammable							
CFC-11	CCI3F	CCl_3F	23.9/75	1,000	--	10,000	1,000
CFC-12	Dichlorodifluoromethane	CCl_2F_2	-30/-22	1,000	--	50,000	1,000
CFC-13	Chlorotrifluoromethane	$CClF_3$	-82/-115	--	--	50,000	1,000
R-13B1	Bromotrifluoromethane	$CBrF_3$	-57.8/-72	1,000	--	--	1,000
R-14	Tetrafluoromethane (carbon tetrafluoride)	CF_4	-128/-198	--	--	--	1,000
HCFC-22	Chlorodifluoromethane	$CHClF_2$	-40.6/-41	1,000	1,250	--	1,000
CFC-113	Trichlorotrifluoroethane	CCl_2FCClF_2	47.8/118	1,000	1,250	4,500	1,000
CFC-114	Dichlorotetrafluoroethane	$CClF_2CClF_2$	3.3/38	1,000	--	50,000	1,000
CFC-115	Chloropentafluoroethane	$CClF_2CF_3$	-38.9/-38	1,000	--	--	1,000
HFC-134a	1,1,1,2-Tetrafluoroethane	CH_2FCF_3	-26/-15.2	--	--	--	1,000
CFC-400	R-12 and R-114	$CCl_2F2/C_2Cl_2F_4$	Boiling point changes with pressure	1,000	--	50,000	1,000

HCFC-401a	R-22/R-152a/R-124 (53%/13%/34% by wt)	$CHClF_2/CH_3CHF_2/CHClFCF_3$	-32.8/-27	--	--	--	1,000
HCFC-401b	R-22/R-152a/R-124 (61%/11%/28% by wt)	$CHClF_2/CH_3CHF_2/CHClFCF_3$	-35/-30.5	--	--	--	1,000
HCFC-402a	R-22/R-125/R-290 (30%/60%/2% by wt)	$CHClF_2/C_3H_8/CHF_2CF_3C_2HF_5$	-49/-56.6	--	--	--	1,000
HCFC-402b	R-22/R-125/R-290 (60%/38%/2% by wt)	$CHClF_2/C_3H_8/CHF_2CF_3C_2HF_5$	-47/-53.3	--	--	--	1,000
HFC-404a	R-143a/R-125/R-134a (52%/44%/4% by wt)	$CH_3CF_3/CHF_2CF_3/CH_2FCF_3$	-46.7/-52	--	--	--	1,000
CFC-500	R-12/152a (73.8%/26.2% by wt)	CCl_2F_2/CH_3CHF_3	-33.3/-28	1,000	--	--	1,000
CFC-502	R-22/115 (48.8%/51.2% by wt)	$CHClF_2/CClF_2CF_3$	-45/-49.7	1,000	--	--	1,000
CFC-503	R-23/13 (40.1%/59.9% by wt)	$CHF_3/CClF_3$	-88/-126	--	--	--	1,000
HFC-507	R-125/R-143a (50%/50% by wt)	CHF_2CF_3/CH_3CF_3	-46.7/-52	--	--	--	1000
R-718	Water	H_2O	100/212	--	--	--	--
R-744	Carbon Dioxide	CO_2	-78/-109	5,000	30,000	50,000	--
ASHRAE 34 Safety Group A2 This grouping signifies least toxic but more flammable							
CFC-142b	1-Chloro-1,1,-Difluoroethane	CH_3CClF_2	-10/14	--	--	--	1000
HFC-152a	1,1-Difluoroethane	CH_3CHF_2	-25/-13	--	--	--	1000
ASHRAE 34 Safety Group A3 This group signifies least toxic but most flammable							
R-170	Ethane	C_2H_6	-89/-128	--	--	--	1000
R-290	Propane	C_3H_8	-42.2/-44	1,000	--	20,000	1000
R-600	Butane	C_4H_{10}	-0.6/31	800	--	--	1000
R-600a	2-Methylpropane (Isobutane)	$CH(CH_3)_3$	-11.7/11	--	--	--	1000
R-1150	Ethene (Ethylene)	C_2H_4	-104/-155	--	--	--	200
R-1270	Propene (Propylene)	C_3H_6	-47.8/-54	--	--	--	500
ASHRAE 34 Safety Group B1 This grouping signifies more toxicity but least flammable							
HCFC-123	2,2-Dichloro-1,1,1-Tri-fluoroethane	$CHCl_2CF_3$	27.6/81.7	--	--	--	50
R-764	Sulfur Dioxide	SO_2	-10/14	2	5	100	--

ASHRAE 34 Safety Group B2 This grouping signifies most toxic but more flammable							
R40	Chloromethane (Methyl chloride)	CH_3Cl	-24.4/-12	50	100	10,000	--
R-611	Methyl formate	$HCOOCH_3$	31.7/89	100	150	5,000	100
R-717	Ammonia	NH_3	-33.3/-28	25	35	500	25

A3.4.2. **Refrigerant Exposure.** Refrigerants handled in accordance with the manufacturer's recommended exposure limits pose no acute or chronic inhalation toxicity hazard.

A3.4.3. **Flammability Precautions.**

A3.4.3.1. Typical AC/R refrigerants are nonflammable and non-explosive. However, mixing refrigerants with flammable gases (such as air) or liquids can result in a flammable solution. Therefore, refrigerants should never be mixed with any flammable gas or liquid. Refrigerants should not be exposed to open flames or electrical heating elements. Though most refrigerants are not flammable at ambient temperatures and atmospheric pressure, tests have shown some types to be combustible at pressures as low as 5.5 psig at 351 °F when mixed with air at volumetric concentrations of generally more than 60 percent air. At lower temperatures, higher pressures are required for combustibility. Refrigerants should not be used or allowed to be present with high concentrations of air above atmospheric pressure.

A3.4.3.2. When storing Safety Group A2, B2, A3, and B3 refrigerants, the room must meet requirements of the National Fire Protection Association (NFPA) 70, National Electrical Code (NEC), Class I, Division I. Per ASHRAE 15-2013, the total of all Groups A2, B2, A3, and B3 refrigerants other than R-717 (ammonia), must not exceed 1100 pounds without approval by the authority having jurisdiction.

A3.5. Disposable and Reusable Refrigerant Cylinders. Refrigerants are contained in disposable and reusable shipping containers or cylinders. Since the refrigerant-containing cylinders can be pressurized, they are considered pressure vessels. They must comply with federal and state laws regulating transportation and usage of such containers. Specific guidance on the storage and handling of refrigerant cylinders is found in DLAI 4145.25, Storage and Handling of Liquefied and Gaseous Compressed Gasses and their Full and Empty Cylinders. Coordinate all movements with the installation HAZMART for current guidance on shipping and disposal procedures.

A3.5.1. **Identifying Containers.**

A3.5.1.1. Both disposable and reusable cylinders are painted (or otherwise marked) in a color code system. This code was voluntarily established by refrigerant manufacturers to identify their products. Common refrigerant colors and identification are set out in Table A3.2.

Table A3.2. Color Code System.

Refrigerant	Color	Refrigerant	Color
R-11	orange	R-403b	light gray
R-12	white	R-404a	orange
R-12/114	light gray	R-407c	brown
R-13	light blue	R-408a	medium purple
R-13b1	pinkish-red	R-403a	medium brown
R-22	light green	R-410a	rose
R-23	light blue-gray	R-414b	medium blue
R-113	dark purple	R-416a	yellow-green
R-114	navy blue	R-417a	green
R-123	light blue-gray	R-500	yellow
R-124	dot green	R-502	light purple
R-134a	light blue (sky)	R-503	blue-green
R-401a	pinkish-red	R-507	aqua blue
R-401b	yellow-brown	R-508b	dark blue
R-402a	light brown	R-717	silver
R-402b	green-brown	NH3	silver
R-402b	green-brown	NH3	silver

A3.5.1.2. The shade of color may vary from one manufacturer to another. Verify contents by means other than color. Every refrigerant cylinder is silk-screened with product, safety, and warning information. Manufacturer technical bulletins and Safety Data Sheets (SDS) are available upon request. Do not repaint cylinders with a different color and used with another refrigerant. Refer to AHRI Guideline N-2015, *Assignment of Refrigerant Container Colors.*

A3.5.2. **Disposable Refrigerant Cylinders.** Disposable cylinders will be stored in dry locations to prevent corrosion and transported carefully to prevent abrasion of painted surfaces. They are not to be refilled. When the cylinder is empty, ensure all pressure is released to 0 psi. The cylinders should be rendered useless for any purpose by breaking off the valve or puncturing the cylinder. After the cylinder has been rendered incapable of containing any compressed gas under pressure, it must be disposed of as scrap metal.

A3.6. Transportation, Labels, and Markings (DOT Requirements). All questions on transportation, labels, and markings of refrigerant cylinders can be answered by the installation HAZMART.

Attachment 4

REFRIGERANT LEAK DETECTION AND ROOM SENSORS

A4.1. Introduction. Refrigerant leak detection is a key component of minimizing losses to the atmosphere, which is the goal of the CAA of 1990 and subsequent amendments. In addition, ASHRAE 15-2013 requires appropriate detection in storage areas to protect the health of employees working in that mechanical space. Leaks are usually found in tubing, flanges, O-rings, and other connections. Gasket and O-ring improvements and better manufacturing techniques have significantly reduced leaks in AC/R equipment. An ongoing program for detecting leaks is the best solution for managing refrigerant losses during normal operations. This attachment provides an introduction to refrigerant leak-detection equipment and techniques.

A4.2. Detection Sensor Terminology. The following section describes electronic refrigerant sensor and detection terminology comparison criteria: sensitivity, detection limits, selectivity, and calibration stability. These are applicable to portable pinpoint detectors and permanently mounted area monitors.

A4.2.1. **Sensitivity.**

A4.2.1.1. Device sensitivity is the amount of input needed to change an output signal. For refrigerant sensors, the refrigerant vapor concentration being measured is displayed on a panel meter, a voltage output, or other display. Highly sensitive refrigerant sensors require little material to generate a large change in output signal. Low-sensitivity sensors need large amounts of material to change the output signal. The sensitivity is affected by the detection method and the material under consideration.

A4.2.1.2. An ionization sensor associated with a particular material that demonstrates high sensitivity for CFC-12 may have low sensitivity for HCFC-123 and very low sensitivity for HFC-134a. The variations in sensitivity are due to the reduction in chlorine content, which is very easily ionized and detected, from CFC- to HCFC- to HFC-class compounds. Sensitivity differences of 100x to 1000x have been reported when comparing CFC-12 to HFC-134a with some ionization-based sensors. Another example of this varying sensitivity is an infrared (IR)-based sensor. It has roughly the same sensitivity to CFC-12, HCFC-123, and HFC-134a, which is not the case for an ionization detector.

A4.2.2. **Detection Limit.** Sensitivity values are well defined but refrigerant sensor sensitivity values do not exist. The most common measure of sensor performance is the detection limit. It is the minimum amount of material a unit can sense that returns a signal at least two times stronger than the background noise level. A sensitive device does not necessarily have a low-detection limit, but that is usually the case. Area-monitoring application detection limits are measured in ppm. Area monitors have detection limits as low as 1 ppm but are typically 3 ppm to 4 ppm for most compounds. A highly sensitive detector may be able to accurately record vapor concentration levels ranging from 1 ppm to 2 ppm, while a low-sensitivity detector may record the same vapor using increments of 20 ppm or higher. A refrigerant sensor must match the intended application. For example, an ionization detector that claims a 2-ppm CFC-12 detection limit will not work as well when detecting HFC-134a. Conversely, an ionization detector designed specifically for HFC-134a may be too sensitive to monitor CFC-12.

A4.2.3. **Selectivity.** Selectivity is the ability to detect only one refrigerant of interest without interference from other compounds. Area monitoring selectivity requirements vary with specific installations. This is an important issue because monitors must work continuously and they become exposed to refrigerants with potentially more interference in a wider concentration range over a long period of time.

A4.2.4. **Calibration Stability**. Calibration stability is very important for long-term monitoring. Stability is provided by electronics that read the sensor output. In general, the electronics should be able to correctly interpret sensor output under all equipment room conditions, such as those involving temperature and humidity changes.

A4.3. Leak Detection Tools. There are several methods available to pinpoint refrigerant leaks, ranging from simple fluorescent dyes to more complex electronic detectors.

A4.3.1. **Fluorescent Dyes.** Fluorescent dyes are used in refrigeration systems to detect leaks visible under ultraviolet (UV) light. Fluorescent dyes are available for all refrigerants in use today. The dyes are placed in the refrigeration lubricant when the system is serviced. Select a dye compound compatible with the lubricating oil in the refrigeration system. Contact the refrigerant supplier for recommendations on appropriate dyes to ensure compatibility with the refrigerant. Leaks are detected by using a UV light to search for dye that has escaped from the system. The color of the dye when subjected to UV light is normally an easily visible bright green or yellow. Fluorescent dyes work very well because large areas can be rapidly checked by a single individual.

A4.3.2. **Electronic Detection Equipment.** Electronic detection equipment belongs in one of the following categories according to selectivity criteria: (1) nonselective; (2) halogen-selective; (3) compound-specific.

A4.3.2.1. **Nonselective Sensors**. These equipment sensors can detect any emission or vapor present, regardless of its chemical composition. Detectors in this category are based on electrical ionization, thermal conductivity, ultrasonic, or metal-oxide semiconductors. These detectors are simple to use, very rugged, and typically inexpensive. Nonselective sensors excel at pinpointing leak locations.

A4.3.2.2. **Halogen-Selective Sensors.** Halogen-selective sensors use a specialized sensor that allows the monitor to detect compounds containing fluoride, chloride, bromide, and iodide without interference from other chemicals. These sensors reduce the number of false alarms generated by non-refrigerant compounds such as paint or gas fumes. These durable detectors are easy to use and have a higher sensitivity than nonselective detectors (detection limits are typically less than 5 ppm). The detector’s partial specificity makes calibration easy.

A4.3.2.3. **Compound-Specific Sensors**. Compound-specific sensors are complex and expensive. They can detect a single variety without suffering interference from other compounds. Compound-specific sensors are IR-based. Newer types are based on infrared-photo acoustic spectroscopy (IR-PAS). These have detection limits around 1 ppm, depending upon the compound detected.

A4.3.2.4. **Sensitivity**. Most monitors will detect all halogen-based refrigerants, but their sensitivity varies with the specific refrigerant type. Choose the refrigerant for which the detector has the lowest sensitivity. For example, if the unit is monitoring a room that has both R-12 and R-22, choose R-12 when calibrating. Commonly used refrigerants can be divided into four groups based on their sensitivity levels:

A4.3.2.4.1. Highest sensitivity: R-11, -22, -123

A4.3.2.4.2. Moderate sensitivity: R-502

A4.3.2.4.3. Low sensitivity: R-12, -500, -114

A4.3.2.4.4. Lowest sensitivity: R-134a

A4.3.3. **Comparing Sensors and Fluorescent Dyes.** Table A4.1 provides considerations when comparing sensors and fluorescent dyes for selecting leak detection options.

Table A4.1. Comparison of Refrigerant Sensors and Fluorescent Dyes.

Comments	Nonselective	Halogen-Selective	Compound-Specific	Fluorescent Dyes
Advantages	•Simplicity •Ruggedness	•Simple/rugged •Can be calibrated •Good sensitivity •Low maintenance	•Low interference level •Can be calibrated •Good sensitivity	•Low price •Rapid detection
Disadvantages	•Low detection limits •Cross-sensitive •Limited calibrated	•Not compound-specific •Detector lifetime •Stability	•Complex maintenance •Stability questionable •High price	•Lube compatibility •No sunlight use •Not for area monitoring
Refrigerants detected	•All CFCs •HCFCs •HFCs •Blends (410a, 406, 407C)	•All CFCs •HCFCs •HFCs •Blends (410a, 406, 407C)	•All CFCs •HCFCs •HFCs •Blends (410a, 406, 407C)	•All currently available refrigerants
Other	•None	•For single refrigerant use •In moderately clean equipment rooms	•Degraded in dirty environments •Preferred type for multi-refrigerant environments	•Potential lubrican compatibility issues

A4.4. Continuous Duty Area Monitors. Electronic detection equipment, used as area monitors, check the refrigerant vapor level continuously in an equipment room or other locations where exposure is possible. Monitoring happens for several reasons: to protect personnel health and safety, conserve refrigerant, and protect valuable refrigeration equipment.

A4.4.1. **Monitor Characteristics.** If a monitor continuously samples air inside an equipment room, it should have several capabilities that short-term or leak-checking monitors do not require. These include low 0-drift or an auto-zeroing capability and outputs for triggering external alarms that alert appropriate personnel. Long-term monitoring devices should remain stable inside the temperature, voltage, humidity, and barometric pressure ranges they will encounter. Continuous monitors should be refrigerant-specific to prevent nuisance alarms generated by untargeted compounds. Monitors with poor selectivity will react to compounds other than refrigerants, including cleaning agents or paints. They should require minimal maintenance.

A4.4.2. **Considerations for Sensors Selection.** Typically, sensors last approximately two to five years from the installation date before a new sensor is required. As refrigerant detection takes place, the sensor loses some of its ability to detect refrigerant again. Sensor life is mostly determined by how much refrigerant it senses over time. Choose a sensor with a built-in calibration leak detector (a pre-programmed leak for a large selection of gases) to quickly verify the unit's calibration status. Recalibrate when necessary. To ensure accuracy, the calibrated leak is adjusted with unique electronics programmed into the sensor that correct for leak rate changes created by temperature fluctuations. Several sensor types are used in refrigerant-detection devices, but they can generally detect a wide range of refrigerants. Monitor sensitivity is tuned best for detecting a specific refrigerant. Even after tuning, a monitor will be sensitive to other common refrigerants. Manufacturers often publish cross-sensitivity charts that show how the monitor will react to various chemicals, including other refrigerants, if it is tuned to a specific refrigerant. If you know which refrigerants will be inside the equipment room, it is possible to choose a monitor calibration that will generate alarms at or below those refrigerants' threshold limit value – time-weighted average (TLV-TWA). If a proper calibration setting cannot be found, multiple detectors are needed. For example, a monitor set that detects R-123 would also detect R-134a at a level that would generate alarms for both refrigerants below their respective TLV-TWA.

A4.4.3. **Monitor Alarm Outputs.** ASHRAE 15-2013 requires monitors to activate an alarm signal if the TLV-TWA limit is reached. Monitors are capable of detecting failures that occur as they operate and should report sensor failures.

A4.5. High-Pressure Leak Test Methods. There are several methods available for leak-testing equipment containing high-pressure refrigerants. These methods depend on the refrigerant charge and the equipment's operational status. The following paragraphs describe these methods.

A4.5.1. **Operating Equipment With Refrigerant Charge.** A positive-pressure refrigerant has sufficient pressure within all components of the system to make most external leaks detectable using leak detectors. Use caution whenever leak-testing equipment is operating; moving and rotating parts present hazards.

A4.5.2. **Idle Equipment With Refrigerant Charge.** A positive-pressure refrigerant can be found using leak detectors if the mechanical room or air pressures are under normal ambient conditions. There is only one method to check for evaporator or condenser tube leaks that use water to transfer heat. The equipment must be isolated from the water piping with the tubes drained and tube sheet access plate removed. Use an eddy current analysis or leak detector (electronic or ultrasonic) to locate leaks.

A4.5.3. **Equipment Without Refrigerant Charge.** There are situations in which leak-testing needs to take place after all refrigerant is lost. Do not pressurize the system with refrigerant to see if the leaks were repaired. There are also situations where using system refrigerant alone may be inadequate to detect leaks. The refrigerant charge may have to be evacuated from the entire system or a single component. When leak-testing a system or component where refrigerant has been removed, refer to the guidelines below.

A4.5.3.1. Do not use a refrigerant as a tracer gas.

A4.5.3.2. Use compressed dry nitrogen to pressurize the system. **WARNING: Never use compressed air, oxygen, or a flammable gas to pressurize the system! This could cause an explosion.** Always use a regulator when adding nitrogen to a system. Add nitrogen slowly for better mixing with the tracer gas and prevent sweeping the tracer gas away from the access port. To ensure that the rating of the relief valve is not exceeded, a maximum test pressure of 200 psig is recommended.

A4.5.3.3. Whenever possible, isolate and pressure-test only that part of the system that requires testing.

A4.5.3.4. After a system is pressurized with nitrogen, allow it to stand for 12 to 24 hours, if possible, to allow the tracer gas to disperse uniformly throughout the system. Once the gas is fully dispersed, check for leaks.

A4.6. Low-Pressure Leak Test Methods. Leak-testing equipment containing low-pressure refrigerants is more difficult than high-pressure refrigerants. The methods available are discussed in the following paragraphs.

A4.6.1. **Operating Equipment.** There is no way to completely leak-test a low-pressure refrigerant system during operation because a large part of the system is under a vacuum. The compressor discharge pipe, condenser, and piping leading to the refrigerant flow control valve are all slightly above atmospheric pressure and can be checked using leak detectors. Use caution when leak-testing operating equipment; be aware of moving and rotating parts. Evaporator and condenser tube leaks typically include water leaking into the refrigerant rather than the reverse. This happens because refrigerant pressure is lower compared to chilled and condenser water system pressures.

A4.6.2. **Offline Equipment Testing.** A thorough leak check can be performed on a low-pressure refrigerant system only if the system is not operating. Installation CE personnel should schedule a maintenance shut-down period of at least 48 hours before a leak test. The test should be timed to negate the test's impact on the facility. A leak check is not a simple process even when the equipment is offline. The refrigerant pressure will usually be under a vacuum at room temperature. With CFC-11, equipment is under a vacuum when the refrigerant temperature drops below 74 °F. With HCFC-123 and CFC-113, equipment is under a vacuum below 82 °F and 117 °F, respectively.

A4.6.2.1. The refrigerant pressure must be increased above atmospheric pressure to detect leaks. Equipment containing refrigerant can no longer be pressurized using a non-condensable gas such as dry nitrogen. The only method to increase the refrigerant pressure above atmospheric pressure is to increase the temperature of the refrigerant. In a constant-volume system this will create a corresponding pressure increase. Increasing the temperature of CFC-11 to 100 °F will produce system pressure of 9 psig.

A4.6.2.2. There are two pressure equalization system types used to increase refrigerant temperature to achieve the desired pressure: the blanket heater and the water heater/pump.

A4.6.2.3. Use caution when heating the refrigerant charge. The pressure cannot exceed the pressure relief valve and/or rupture disk setting, which is normally set at 15 psig, or refrigerant will escape to the atmosphere. Stop adding heat when 8 to 10 psig is reached.

A4.6.2.4. Leak-check all gaskets, fittings, and penetrations using appropriate leak detection methods.

A4.6.3. **Idle/Standby Equipment.** A low-pressure system will usually be in a vacuum at typical room or ambient temperature when it is not operating. Any leaks will be due to air and water vapor entering the chiller instead of refrigerant. An integral pressure equalization system, blanket heater, or water heater/pump can be used for refrigeration equipment that operates intermittently, especially if the equipment remains on standby. Use these two methods for either pressure equalization or leak testing. It will control the pressure automatically; its internal pressure is always equal to atmospheric pressure when the chiller is idle. This reduces or eliminates refrigerant loss. Another option involves removing the chiller's refrigerant charge when chillers are idle for long periods. Store the refrigerant in an appropriate, certified tank. While idle, the chiller should be charged with dry nitrogen to a pressure of 1 to 2 psig to prevent moisture accumulation inside the chiller vessels.

A4.6.4. **Equipment Without Refrigerant Charge.** Two steps are involved in leak-testing a low-pressure chiller without its charge. The first step involves pressurizing the system to pinpoint leaks. Once completed, a vacuum is applied to ensure the equipment does not leak under its normal negative-pressure operating conditions. Follow these two steps:

A4.6.4.1. **Step 1.** Pressurize the chiller to 10 to 13 psig with dry nitrogen and use a soap-and-water solution to check all joints. Leaks will appear when the soap solution bubbles.

A4.6.4.2. **Step 2**. Evacuate the chiller, using a vacuum pump and gauge to 500 microns of mercury absolute. Once that level is reached, allow the chiller to stand idle for 12 hours. There are no leaks if vacuum remains at 800 microns or below. If the reading is at 1200 microns or greater the unit's condition is unacceptable and further leak-testing is required. Repeat until no leakage is demonstrated.

A4.7. Potential Refrigerant Leak Areas.

A4.7.1. During inspections, leak-check the leak-prone system areas for integrity. These areas include all area penetrations where refrigerant is used and all non-welded connections. Inspect the following areas:

A4.7.1.1. Motor terminals;

A4.7.1.2. Sight glasses;

A4.7.1.3. Shaft seals;

A4.7.1.4. Schrader cores;

A4.7.1.5. Service, solenoid, and relief valves;

A4.7.1.6. Flare fittings;

A4.7.1.7. Gasket joints;

A4.7.1.8. Filter dryers.

A4.7.2. Oil stains on positive-pressure equipment or components indicate leak paths.

A4.8. Additional References. Additional references are provided as suggested sources where more in-depth information can be found: ANSI/ASHRAE Standard 147-2013, *Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems*.

Attachment 5

MAINTENANCE PRACTICES AND EQUIPMENT TO MINIMIZE REFRIGERANT LEAKAGES FROM AIR-CONDITIONING AND REFRIGERATION SYSTEMS

A5.1. Introduction. Refrigeration service and maintenance practices commonly used in the past resulted in the routine release of significant amounts of refrigerant to the atmosphere. The Clean Air Act of 1990, Section 608, and subsequent amendments require the minimization of refrigerant losses. The EPA established regulations to implement the law under 40 CFR Part 82, Subpart F. This attachment provides key concepts and ideas to assist installations to comply with current EPA regulations.

A5.2. Definitions, Common Terminology, and Requirements.

A5.2.1. **Certified Equipment.** Equipment used to handle refrigerants during servicing must be capable of meeting the evacuations levels listed in Table A5.1 and must have a visible label that demonstrates it has been tested and certified by a third-party EPA-approved testing organization to meet the requirements of 40 CFR Part 82, Subpart F, Section 82.158.

A5.2.2. **Certified Technician.** All individuals who maintain, install, service, or repair AC/R equipment must be certified as described in Chapter 3.

A5.2.3. **Low-Loss Fitting.** Any device meant to establish a connection between hoses, AC/R equipment, and recovery/recycling machines. They are designed to close automatically or manually after being disconnected to reduce refrigerant loss from hoses, AC/R equipment, and recovery/recycling machines. Low-loss fittings should have been added to refrigeration equipment connection points and service equipment hoses.

A5.2.4. **Non-condensable Gas (NCG).** Gases, which are primarily air, other than the refrigerant in the cooling system. Air Force cooling equipment uses purge units to automatically purge NCGs when the acceptable level is exceeded.

A5.2.5. **Purge Units.** Purge units are used with low-pressure chillers and refrigerant recovery equipment to remove non-condensable material that entered the system. All low-pressure chillers (R-11 or R-123) should have high-efficiency purges, with capability to process discharges of 0.7 to 1 pound-refrigerant per pound-NCG. High-efficiency purge units allow non-condensable material to be vented while leaking very little refrigerant.

A5.2.6. **Recovery.** Recovery is the removal of refrigerant from a system to store it in an external container without necessarily testing or processing it in any way. Recovery is mandatory if the system will be opened to the atmosphere. If an equipment component that requires service is isolated, only the isolated equipment section needs to be evacuated.

A5.2.7. **Recycling.** Recycling extracts refrigerant from a system and cleans refrigerant for reuse without meeting all of the requirements for reclamation. In general, recycled refrigerant is refrigerant that is cleaned using oil separation and single or multiple passes through devices, such as replaceable core filter-driers, which reduce moisture, acidity, and particulate matter. Recycling can be useful for drying refrigerants that contain moisture instead of water or for removing particulate matter.

A5.2.8. **Reclamation.** Reclamation purifies, tests, and certifies used refrigerant to all of the specifications in Appendix A to 40 CFR Part 82, Subpart F (based on AHRI Standard 700-

2015, *Specifications for Refrigerants*), that are applicable to that refrigerant and to verify the refrigerant meets these specifications using the prescribed analytical methodology. Refrigerant reclamation from a system undergoing repairs is not required in most cases. Reclamation is required if, for example, free water stands in the system due to a tube failure or because a motor burned out. Recovered refrigerants from the equipment must be reclaimed if ownership is transferred outside of the Air Force. The Air Force is considered a single owner so reclamation is not necessary given inter-base transfers. If reclamation is required, the installation HAZMART will provide guidance on proper handling.

A5.3. Recovery Equipment. Appropriate recovery equipment must be utilized to meet the requirements of the inspection or maintenance task. Equipment must be certified and capable of meeting the levels of evacuation in Table A5.1.

Table A5.1. Required Levels of Evacuation for Appliances[1].

Type of Appliance	Inches of Hg Vacuum[2]	
	Equipment[3] Manufactured Before 15 Nov 93	Equipment[3] Manufactured After 15 Nov 93
Very high-pressure appliance	0	0
High-pressure appliance or isolated component, normally containing 200 pounds refrigerant	0	0
High-pressure appliance or isolated component, normally containing 200 pounds or more refrigerant	4	10
Medium-pressure appliance or isolated component normally containing less than 200 pounds refrigerant	4	10
Medium-pressure appliance or isolated component normally containing 200 pounds or more refrigerant	4	15
Low-pressure appliance	25 [4]	25 [4]

Notes: 1. Data from Table 1, 40 CFR §82.156
2. Relative to standard atmospheric pressure of 29.9 inches Hg
3. Recovery/reclamation equipment must be certified per 40 CFR §82.158 requirements
4. Measurement in mm Hg absolute, not relative to standard atmospheric pressure

A5.3.1. **New Equipment Evaluation Criteria.** If the equipment cannot reach required evacuation levels or maintain purge-loss limits of less than 3 percent refrigerant/NCG for the total amount being recycled, it should be replaced with new equipment and the following criteria should be evaluated to acquire the appropriate item.

A5.3.1.1. UL or AHRI certification.

A5.3.1.2. Safety. Look for high-pressure, low-pressure, and high-temperature sensors for system safety shutdowns or lockouts.

A5.3.1.3. Job function versatility.

A5.3.1.4. Capacity of the container that holds the refrigerant during servicing.

A5.3.1.5. Recovery rate (one hour maximum).

A5.3.1.6. Fitting designed for low-loss.

A5.3.1.7. Tanks: proprietary or non-proprietary.

A5.3.1.8. Filter replacement prices.

A5.4. Inspection and Maintenance Concepts.

A5.4.1. **Service Practices.**

A5.4.1.1. Before opening a system, certified technicians should clearly understand the type of service work required. Previous service records should be part of the work order package but can be obtained from the service records or operating logs. This information should be used to develop a work plan that ensures refrigerant losses are minimal and identifies areas to check for possible leaks.

A5.4.1.2. Proper servicing practices require that refrigerants be isolated from the environment to the greatest extent possible. The following actions must happen at every servicing:

A5.4.1.2.1. Evacuate the unit to the amounts shown in Table A5.1 to either the system's integral receiver or recovery unit.

A5.4.1.2.2. Do not knowingly vent any refrigerants during the maintaining, servicing, repairing, or disposing of AC/R equipment.

A5.4.1.2.3. Upon completion of servicing and maintenance, return the unit to proper operating charge level.

A5.4.1.3. Because low-pressure systems can be under a vacuum when they are not in operation, the EPA requires those systems undergoing minor servicing, such as oil changes, to be pressurized to atmospheric pressure. One of the following systems must be utilized to achieve proper pressure.

A5.4.1.3.1. **Blanket Heater.** The most common pressurization system is an electric-resistant blanket heater installed between the evaporator's outer shell and its insulation jacket. Because it is mounted on the underside of the shell, it is commonly known as a belly heater. Typically, temperature or pressure sensors monitor the condenser conditions and control the blanket heater. To prevent system over-pressurization and refrigerant loss, temperature and pressure sensors should be checked before energizing the blanket heater.

A5.4.1.3.2. **Water Heater/Pump.** This system type uses a small electric water heater and circulating pump package. It heats and circulates water through the evaporator tubes to raise the refrigerant temperature and system pressure. Before beginning the heating process, isolate the evaporator from the distribution piping system. The heat added to the water is typically controlled by monitoring the water temperature once it has left the evaporator. To prevent system over-pressurization and any resulting refrigerant loss, the temperature sensor should be checked before starting the water heater/pump system.

A5.4.1.4. **Servicing Purge Systems.**

A5.4.1.4.1. Most purge systems require regular service: purge tanks and oil separators must be cleaned; gasket materials must be renewed; purge compressors must be overhauled. Servicing should be performed according to the purge system manufacturer's guidelines. To open the purge system for service, isolate it from the chiller refrigeration system and recover the refrigerant from the purge unit. To provide a convenient, efficient means of accomplishing this on an ongoing basis, permanent access and isolation valves should be installed in the system whenever a new high-efficiency unit is introduced.

A5.4.1.4.2. Purge runtime should be monitored and recorded. Many manufacturers suggest that purge systems operating in excess of one hour of runtime per week indicate excessive loss.

A5.4.1.5. Isolate equipment subcomponents for service and repair by installing isolation valves. Replace missing system connections and refrigerant cylinder caps.

A5.4.1.6. Oil should not be changed arbitrarily; instead, oil samples should be checked for contamination on a regular, scheduled basis. If contamination is present, it may indicate the need for oil and filter change. These tasks must be completed with minimal refrigerant loss. An oil sample port and isolation valves should be installed around the filter when the unit is first serviced. Change oil filters at intervals more frequently than required by manufacturers' recommendations or as indicated by spectrographic oil analyses.

A5.4.1.7. Refrigeration gauge sets should be rebuilt, if necessary, with new seals, valve seats, and packing to reduce refrigerant losses. Additional features that reduce refrigerant loss include:

A5.4.1.7.1. Quick-connect hose fittings.

A5.4.1.7.2. Four-valve manifolds to reduce hose and manifold refrigerant purging amounts.

A5.4.1.7.3. Quality, high-strength hoses to prevent ruptures.

A5.4.1.7.4. Separate refrigeration gauge sets for each refrigerant that will prevent cross-contamination.

A5.4.1.8. A vital element of a successful preventive maintenance program that minimizes emissions is a regularly scheduled chiller tube-testing program. It ensures tube integrity and efficiency and can provide early warnings.

A5.4.2. **Inspection Practices and Techniques.**

A5.4.2.1. **Particulate Evaluation.** The oil filter is an important source of information. Technicians can spot debris trapped on the filter material, remove it, and send it to the spectrographic oil analysis laboratory to identify the sediments and further evaluate the system's condition. This evaluation can be just as important as testing the liquid oil sample. When laboratory analysis of chiller oil is required, select a qualified laboratory that can perform a full range of tests.

A5.4.2.1.1. Dielectric strength measures a fluid's insulating ability. A low value can indicate water or other conducting compounds.

A5.4.2.1.2. A fluid's color can indicate contaminants and system operating conditions.

A5.4.2.1.3. The interfacial tension analysis indicates whether compounds with a strong affinity for water are present.

A5.4.2.2. **Spectrographic Oil Analysis.** Laboratory analysis of chiller oil is a method of analyzing the mechanical condition of equipment and pinpoints locations when tear-down and visual inspections are required. A spectrographic oil analysis is inexpensive and typically has a quick turn-around time. Before obtaining an oil sample for analysis, a chiller must operate for at least one hour; otherwise, any metals in the oil will not have enough time to be re-entrained from the machine bottom and will go undetected during analysis. With a complete and accurate laboratory oil analysis, testing system correction recommendations will become more reliable.

A5.4.2.2.1. **Analysis of Metal Content.** Chiller oil spectrographic analysis shows the oil's metal content and should indicate the possible source of the metal. Elements typically discovered during analyses and available sources are listed in Table A5.2.

A5.4.2.2.2. **Recording Analysis Results.** Oil analysis results should be included in the maintenance history. In many cases, rapid changes in values may indicate more problems than the value's magnitude at any given point in time. In fact, the real strength of spectrographic analysis is the ability to spot excessive wear rates indicated by rapidly increasing concentrations of the elements listed in Table A5.2 relative to the number of operating hours between samples. To properly spot these trends, the analytical laboratory performing the tests must have historical test data.

A5.4.2.3. **Eddy Current Tube-Testing.** Eddy current tube testing measures the thickness of the tube as the probe passes from one end to the other. This method can identify potential leak areas before they occur. It can prevent unscheduled chiller downtime, lost production, lost cooling, major chiller damage, and refrigerant charge contamination. Refrigerant contaminated with water in-leakage requires reclamation. To protect the refrigerant charge, a chiller requires eddy current tube-testing at least once every three years.

Table A5.2. Elements and Sources.

Element	Possible Sources
Iron	Shell/supports/cylinder/tube sheet
Chromium	Rings/cylinder/crankshaft
Nickel	Tubes/crankshaft
Aluminum	Pistons/bearings/impeller
Lead/tin	Bearings
Copper	Bearings/tubes/oil lines
Silver	Solder/cooler
Silicon	Dirt/sealant/coolant
Boron	Additive/coolant
Sodium	Brine/coolant
Potassium	Additive
Zinc	Anti-wear additive
Calcium/Magnesium	Brine/detergent additive
Barium	Detergent additive

A5.4.3. **Disposal of Unusable Fluids.**

A5.4.3.1. **Oil Replacement.** When oil analysis indicates that the refrigerant oil should be replaced, use the appropriate recovery system to remove the refrigerant for reuse. The remainder oil may or may not require disposal as a hazardous waste, depending on its mixture characteristics. Coordinate all disposal actions with the guidance of the installation HAZMART.

A5.4.3.2. **Refrigerant Replacement.** Non-contaminated refrigerant remaining on the installation can be returned to any AC/R equipment on the installation with no other action. Any contaminated refrigerants must be coordinated through the installation HAZMART for proper recycling, reclamation, or disposal, as appropriate for the level of contamination.

A5.5. Documentation. During and after service and inspections of equipment technicians must record all data required for the work order, including the amount of refrigerant serviced, amount reused, amount of refrigerant added, observations of the overall condition of system equipment, and potential leak areas. Ensure all refrigerant actions are properly documented and entered into APIMS.

A5.6. Additional References. Additional references are provided as suggested sources where more in-depth information can be found: AHRI 740-2016, *Performance Rating of Refrigerant Recovery Equipment and Recovery/Recycling Equipment*; 40 CFR Part 82, Subpart F, *Recycling and Emissions Reduction;* ANSI/ASHRAE Standard 147-2013, *Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems*.