American Carbon Registry
AT WINROCK INTERNATIONAL

METHODOLOGY FOR THE QUANTIFICATION, MONITORING, REPORTING AND VERIFICATION OF GREENHOUSE GAS EMISSIONS REDUCTIONS AND REMOVALS FROM

CERTIFIED RECLAIMED HFC REFRIGERANTS

VERSION 1.1

September 2018

WINROCK INTERNATIONAL

METHODOLOGY FOR THE QUANTIFICATION, MONITORING, REPORTING AND VERIFICATION OF GREENHOUSE GAS EMISSIONS REDUCTIONS AND REMOVALS FROM CERTIFIED RECLAIMED HFC REFRIGERANTS

VERSION 1.1

September 2018

American Carbon Registry®

WASHINGTON DC OFFICE
c/o Winrock International
2451 Crystal Drive, Suite 700
Arlington, Virginia 22202 USA
ph +1 703 302 6500

ACR@winrock.org
americancarbonregistry.org

ABOUT AMERICAN CARBON REGISTRY® (ACR)

A leading carbon offset program founded in 1996 as the first private voluntary GHG registry in the world, ACR operates in the voluntary and regulated carbon markets. ACR has unparalleled experience in the development of environmentally rigorous, science-based offset methodologies as well as operational experience in the oversight of offset project verification, registration, offset issuance and retirement reporting through its online registry system.

ACKNOWLEDGEMENTS

This methodology was developed by ACR in partnership with:

EOS Climate

Financial support for the development of this methodology was provided by:

A-Gas Americas

Diversified Pure Chem

Hudson Technologies

ACRONYMS AND DEFINITIONS

If not explicitly defined here, the current definitions in the latest version of the American Carbon Registry (ACR) Standard apply.

TERM	ACRONYM (if applicable)	DEFINITION
Aerosol Product		A product pressurized by a propellant that expels its contents from a canister through a nozzle. Propellants include compressed gases and liquefied gases. Liquefied gases include HFCs, including HFC-134a, which can be recovered and reclaimed for re-use as a refrigerant, at which point it is considered a reclaimed HFC refrigerant.
Certified reclaimed HFC refrigerant		Used (recovered) HFC that has been reclaimed by an EPA-certified reclaimer to meet the AHRI 700-2015 Standard for Specifications for Fluorocarbon Refrigerants[1] by an EPA certified reclaimer, and tested by an AHRI certified refrigerant testing laboratory to meet the AHRI Standard.
Chlorofluorocarbon	CFC	A class of compounds of carbon, hydrogen, chlorine, and fluorine that are commonly used as refrigerants.
GHG Source, Sink, or Reservoir	SSR	• GHG Source – Physical unit or process that releases a GHG into the atmosphere • GHG Sink – Physical unit or process that removes a GHG from the atmosphere

[1] Air Conditioning, Heating, and Refrigeration Institute (AHRI) 700-2015 Standard for *Specifications for Fluorocarbon Refrigerants.* www.ahrinet.org

TERM	ACRONYM (if applicable)	DEFINITION
		• GHG Reservoir - Physical unit or component of the biosphere, geosphere or hydrosphere with the capability to store or accumulate a GHG removed from the atmosphere by a GHG sink or captured from a GHG source.
Hydrochlorofluorocarbon	HCFC	A class of compounds of carbon, hydrogen, chlorine, and fluorine that are commonly used as refrigerants.
Hydrofluorocarbon	HFC	A class of compounds that contain carbon, fluorine, and hydrogen that are commonly used as refrigerants, as well as solvents, aerosol propellants, and foam blowing agents.
HFC Refrigerant		Refrigerant comprised of either a mix of hydrofluorocarbons (HFCs) referred to as an "HFC blend", or a single HFC.
Project activity		• The reclamation and use of certified reclaimed HFC refrigerants to service existing refrigeration and air conditioning equipment, • The reclamation and use of certified reclaimed HFC refrigerants in newly manufactured refrigeration or air conditioning equipment
Refrigeration or air conditioning equipment		An Appliance[2], or component parts of a system, that uses refrigerant to provide cooling under controlled conditions.

[2] Per 40 CFR §82.3, an "Appliance" is defined as "any device which contains and uses a refrigerant and which is used for household or commercial purposes, including, without limitation, any air conditioner, refrigerator, chiller, or freezer."

TERM	ACRONYM (if applicable)	DEFINITION
Use of certified reclaimed HFC refrigerant		Production by the reclaimer, plus transfer/return/sale of certified reclaimed HFC refrigerant to refrigerant distributors, wholesalers, original equipment manufacturers, service technicians, or refrigerant end-users who are in the business of selling or using HFC refrigerant for use in refrigeration or air conditioning equipment.

CONTENTS

FIGURES

TABLES

EQUATIONS

1 BACKGROUND AND APPLICABILITY

1.1 SUMMARY DESCRIPTION OF THE METHODOLOGY

Modern society is dependent on refrigeration to process, store and transport food, as well as on air conditioning in the built environment and motor vehicles. Reliable and cost-effective cooling is also critical for other commercial and industrial processes, such as in pharmaceutical and chemical production, oil refining, aerospace and defense technologies, data servers, and ice rinks. These diverse applications typically rely on refrigerants, the chemical coolants that can reach low temperatures and transfer heat by undergoing a phase change between liquid and gas (through condensation).

Up until the mid-1990s, chlorofluorocarbons (CFCs) were in widespread use as refrigerants. CFCs destroy the Earth's protective ozone layer and are also powerful greenhouse gases (GHGs). Under the Montreal Protocol and United States Clean Air Act, nearly all CFC production ended in the United States in 1996.[3] As a result, many applications transitioned to using hydrochlorofluorocarbon (HCFC) refrigerants, which also contribute to ozone depletion and climate change, although to a lesser extent than CFCs. With the phase out of HCFCs currently underway, the most commonly used refrigerants today are hydrofluorocarbons (HFCs). HFCs, while safe for the ozone layer, are also powerful GHGs when released to the atmosphere.

Across the various refrigeration and air conditioning applications, there are a number of approaches that can be used to reduce GHG emissions from both new and installed equipment.

1.1.1 Use of Certified Reclaimed HFC refrigerants

For the large installed base of HFC equipment and infrastructure that will continue to operate, there are a number of ways that emissions can be reduced, including:

- Monitoring and timely leak repair for systems that are inherently prone to leaks,

[3] After 1996, the Montreal Protocol authorized limited production of CFCs for "essential uses" as propellants in medical devices (metered dose inhalers relied upon by asthmatics) and for laboratory and analytical uses. Production for essential medical uses ended in the U.S. on January 1, 2012. The exemption for de minimis CFC production essential laboratory and analytical uses remains in effect.

- Proper training and practices by professional engineers and contractors that install and service equipment, and
- Refrigerant management practices throughout the lifecycle of the refrigerant, from production, distribution, recovery, reclamation, and end-of-life disposal.

Another opportunity to mitigate emissions is by filling refrigeration equipment with reclaimed HFC refrigerants. Typically, virgin (newly produced, never previously used) refrigerant is used to "charge" refrigeration and A/C systems and various types of equipment when they are manufactured and installed, and when the systems leak during normal operations. Re-using previously used HFC that has been recovered[4], and reclaimed[5] to virgin-grade refrigerant purity, either to "recharge" existing systems that require servicing, or in newly manufactured equipment, displaces new production of virgin refrigerant that would otherwise be manufactured to meet that demand.

This Methodology focuses only on HFCs, and does not address HCFC-22, which is being phased out of production[6].

Table 1: Eligible Refrigerant Sectors and Segments

Sectors that are eligible under this Methodology.

PROJECT ACTIVITY	REFRIGERANT SECTOR	ELIGIBLE SEGMENTS IN SECTOR
Use of Certified	Domestic Refrigeration	Residential refrigerators and freezers

[4] Refrigerant that is recovered from refrigeration or air conditioning equipment is removed/extracted by a certified technician using certified recovery equipment from appliances during servicing or at end-of-life. HFCs can also be recovered from other sources including discarded aerosol cans, and reclaimed for re-use as refrigerant.

[5] Reclaimed refrigerant is used (recovered) refrigerant that has been processed to remove impurities and tested by an EPA certified reclaimer and certified to meet the AHRI 700-2015 Standard for Specifications for Fluorocarbon Refrigerants.

[6] Production and import of R-22 is regulated in the United States by annual allocations issued by the EPA, in accordance with the phasedown schedule established in the Montreal Protocol and United States Clean Air Act. Until the complete phase-out in 2020, R-22 can only be produced/imported, and used, to service equipment manufactured prior to 2010. This methodology makes a conservative assumption that 100% of the remaining EPA allocations will be filled, i.e., the same quantity of R-22 will be produced/imported and ultimately used regardless of whether individual facilities or manufacturers choose to use reclaimed R-22 instead of virgin R-22. While not accounted for in this methodology, greater use of reclaimed R-22 absolutely has positive environmental benefit that was accounted for by the United States EPA in determining the annual R-22 allocations. In contrast, there are no controls in the United States on production/import of HFC refrigerants so increased use of reclaimed HFC refrigerant to meet demand has a direct impact on the volumes of HFC refrigerants that would otherwise be produced/imported.

PROJECT ACTIVITY	REFRIGERANT SECTOR	ELIGIBLE SEGMENTS IN SECTOR
Reclaimed HFC Refrigerants	Commercial Refrigeration, also known as Retail Food Refrigeration	Equipment used to store and display chilled and frozen goods for commercial sale such as in supermarkets, convenience stores, bakeries, and restaurants. This equipment includes centralized supermarket systems, remote condensing units, and stand-alone equipment (e.g., beverage vending machines, stand-alone display cases).
	Cold Storage Warehouses	Storage for meat, produce, dairy products, and other perishable goods.
	Industrial Process Refrigeration	Chemical, pharmaceutical, petrochemical and manufacturing industries, industrial ice machines and ice rinks.
	Transport Refrigeration	Refrigerated truck trailers, railway freight cars, ship holds, and other shipping containers.
	Mobile Air Conditioning	Automobiles, trucks, buses, and other motor vehicles.
	Stationary Air Conditioning	Comfort cooling for homes and commercial buildings, including multi-family buildings, office buildings, hospitals, universities, shopping malls, airports, sports arenas.

This Methodology provides the quantification framework for the creation of carbon offset credits from the reductions in GHG emissions resulting from the use of certified reclaimed HFCs. The Methodology is intended to be used as an incentive within the relevant industries to increase these activities.

1.2 APPLICABILITY CONDITIONS

Projects that avoid the emissions of refrigerant gases in the following activities are considered a "project activity":

- The reclamation and use of certified reclaimed HFC refrigerants to service existing refrigeration and air conditioning equipment, and

- The reclamation and use of certified reclaimed HFC refrigerants in newly manufactured refrigeration or air conditioning equipment.

For purposes of this Methodology, "reclamation and use" of certified reclaimed HFC refrigerant refers specifically to the production of such refrigerant (by a certified refrigerant reclaimer) and the subsequent sale, title transfer or return to a refrigerant distributor, refrigerant wholesaler, or an end-user (either through direct sale, title transfer or return to an end user or through installation conducted via service technician) for use in refrigeration or air conditioning equipment.

In addition to satisfying the latest ACR program eligibility requirements as found in the ACR Standard, project activities must satisfy the following conditions to be applicable:

I. The project is located in North America.
II. The project is within a sector and segment which has a low adoption rate for the relevant project activity ("Eligible Project Activity" & "Eligible Refrigerant Sector/Segment" (see Table 1)).
III. The refrigerant must meet the definition of certified reclaimed HFC refrigerant found in this Methodology.

1.3 REPORTING PERIODS

- Projects shall have one reporting period which must not exceed 12 months in length.
- Emission reductions shall be quantified for a period not to exceed 12 months based on the total amount of certified reclaimed HFC produced and the subsequent sale, title transfer or return to a refrigerant distributor, refrigerant wholesaler, or an end-user (either through direct sale, title transfer or return to an end user or through installation conducted via service technician) for use in refrigeration or air conditioning equipment.
- A reporting period begins on the date that the initial volume of certified reclaimed HFC is sold, title transferred, or returned to a refrigerant distributor, refrigerant wholesaler, or and end-user (either through direct sale, title transfer or return to an end user or through installation conducted via service technician) for use in refrigeration or air conditioning equipment.

1.4 CREDITING PERIODS

A Crediting Period is the finite length of time for which a GHG Project Plan is valid, and during which a project can generate offsets against its baseline scenario. The crediting period for all project activities shall be ten years.

1.5 PERIODIC REVIEWS AND REVISIONS

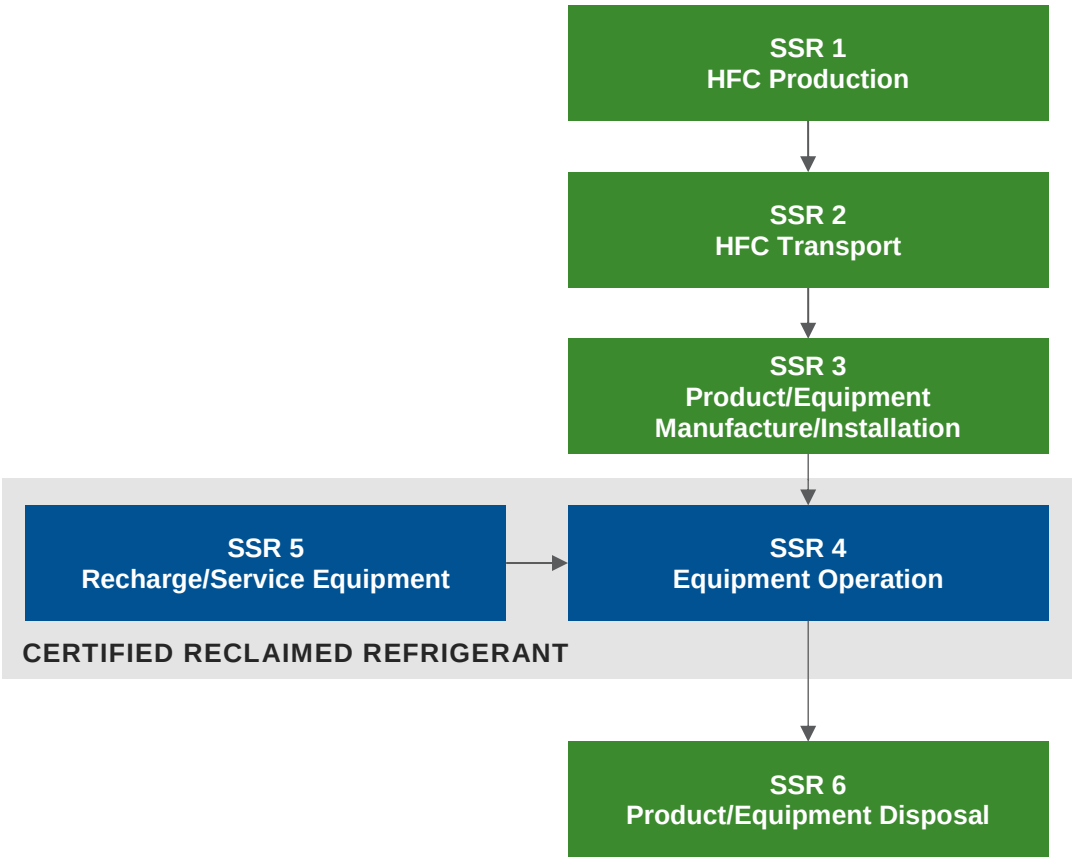
ACR may require revisions to this Methodology to ensure that monitoring, reporting, and verification systems adequately reflect changes in the project's activities. This Methodology may also be periodically updated to reflect regulatory changes, emission factor revisions, or expanded applicability criteria. Before beginning a project, the project proponent should ensure that they are using the latest version of the Methodology.

2 PROJECT BOUNDARIES

2.1 GEOGRAPHIC BOUNDARY

For projects using certified reclaimed HFC refrigerant, the project boundary, depicted by the light grey box in Figure 1, is the physical and geographical site where the reclaimed HFC refrigerant is produced in the project by a certified refrigerant reclaimer, for use in equipment operations and servicing/recharging to replace refrigerant that leaks or to charge newly manufactured refrigeration or air conditioning equipment.

Figure 1: Project Boundary Diagram for Certified Reclaimed Refrigerant



Within the boundaries, the sources of GHG emissions are from the operations of the refrigeration and air conditioning equipment, including recharging equipment that has leaked. Table 2 lists the GHG sources included and excluded depending on whether the sources are within or outside project boundaries.

Table 2: Greenhouse Gases and Sources

SSR	SOURCE DESCRIPTION	GAS	INCLUDED (I) OR EXCLUDED (E)	QUANTIFI-CATION METHOD
1 HFC Production	Fossil fuel emissions from the production of HFCs	CO_2	E	N/A
		CH_4	E	N/A
	HFC leaks during HFC production	HFCs	E	N/A
2 Refrigerant Transport	Fossil fuel emissions from transport of HFCs	CO_2	E	N/A
		CH_4	E	N/A
		N_2O	E	N/A
	HFC leaks during transport	HFCs	E	N/A
3 Equipment Manufacture and Installa-tion	Emissions of HFCs during manufacture or installation of refrigeration or A/C equip-ment or system or product	HFCs	E	N/A
4 Equipment Operations	Fossil fuel emissions from the operation of the refriger-ation or A/C equipment or system	CO_2	E	N/A
		CH_4	E	N/A
		N_2O	E	N/A
	HFC leaks from the opera-tion of the refrigeration or A/C equipment or system or product	HFCs	I	Equation 1
5 Service Equipment	Fossil fuel emissions from servicing refrigeration or A/C equipment or system to re-place leaked refrigerant	CO_2	E	N/A
		CH_4	E	N/A
		N_2O	E	N/A

SSR	SOURCE DESCRIPTION	GAS	INCLUDED (I) OR EXCLUDED (E)	QUANTIFI-CATION METHOD
	HFC emissions from servic-ing refrigeration or A/C equipment or system to re-place leaked refrigerant	HFCs	I	Equation 1
6 Equipment Disposal	Emissions from the disposal of the equipment at end-of-life including destruction of refrigerant	HFCs	E	N/A

3 BASELINE DETERMINATION AND ADDITIONALITY

3.1 BASELINE DETERMINATION

The baseline for a project activity is determined utilizing industry standards and represents the most commonly used practices and technologies.

Refrigeration and air conditioning (A/C) appliances and other components that comprise a system are "charged" with refrigerant, either at the manufacturing plant, or at the facility where a system is installed, e.g., a supermarket.

Under normal operating conditions, depending on the type of equipment and the location, between 1 and 50% of the refrigerant in stationary and mobile air conditioning and refrigeration systems leaks each year (IPCC/TEAP, 2006; IPCC, 2006; RTOC 2010; EPA, 2014; ACR ODS Methodology). Even with active leak detection and aggressive maintenance efforts, it is difficult to eliminate leaks completely.[7] Consequently, to maintain proper performance, leaky equipment and systems require periodic servicing to replace the lost refrigerant.

In the majority of situations, virgin (newly produced, never previously used) refrigerant is used both to charge newly manufactured equipment and systems, and to "recharge" systems that leak during normal operations.

As an alternative, reclaimed refrigerant can be used. This is refrigerant that has been previously used, recovered from other air conditioning or refrigeration equipment or disposed aerosol products (e.g., cleaning and personal care products, office dusters, safety horns, asthma inhalers), and processed to remove impurities and restored to virgin-grade quality.[8] Using reclaimed refrigerant effectively displaces the use – and therefore avoids production and eventual emissions – of virgin refrigerant. Within the existing reclamation industry, there is capacity to significantly increase reclaimed refrigerant use (EPA, 2014). Thus, using reclaimed refrigerant would result in a net GHG reduction.

Reclaimed HFCs comprise a small proportion of the HFC refrigerants that are in use today in the United States. Unlike the strong incentive to reclaim CFC refrigerants and HCFC-22 that

[7] Refrigerants can also be released during equipment servicing or when the system is decommissioned.

[8] HFCs recovered from air conditioning or refrigeration equipment, or discarded aerosol products can be restored to virgin grade quality for re-use as refrigerant, whereupon the material becomes defined as "reclaimed HFC refrigerant". In other words, this Methodology allows credits for use of reclaimed HFC refrigerants sourced from both refrigeration and air conditioning equipment, and from discarded aerosol products.

have been or are being phased out, there is currently little incentive for recovery, reclamation, and re-sale of HFC refrigerants.

Appendix A.1 provides the basis for the rate by which HFCs are reclaimed in the United States under the baseline scenario in this Methodology.

To calculate baseline emissions of HFC refrigerants in the United States, emission factors for individual HFC refrigerants were calculated, as detailed in Appendix A.2. Table 3 lists the 10-year emission rates used in this Methodology for HFCs that are recovered from refrigeration, A/C equipment, or aerosol products (see Appendix A.3 for a discussion of the baseline emission factor for aerosol products).

All HFC refrigerants that are placed into commerce – either through sale or through any other method to transfer title – are used. For purposes of this Methodology, it is assumed that from the time that any reclaimed HFC refrigerant is sold or otherwise transferred from the reclaimer to a distributor, wholesaler, service technician, or an end-user (e.g., equipment manufacturer, supermarket) that refrigerant will be used.

Emissions of refrigerant that occur during equipment manufacturing or installation are less than 3% of the initial charge (IPCC, 2006) and are therefore considered negligible and not included in this Methodology.

Table 3: 10-Year Emission Rates for Predominant HFCs[9]

HFC RECOVERED FROM REFRIGERATION OR A/C EQUIPMENT	10-YEAR EMISSION RATE (%)
HFC-134a	76%
HFC-23	73%
HFC-32	64%
R-404A	89%
R-407A	89%
R-407C	68%
R-410A	66%
R-417C	86%

[9] See Appendices A.2 and A.3

HFC RECOVERED FROM REFRIGERATION OR A/C EQUIPMENT	10-YEAR EMISSION RATE (%)
R-422B	68%
R-422C	89%
R-422D	89%
R-507A	89%

HFC RECOVERED FROM DISCARDED AEROSOL PRODUCTS	10-YEAR EMISSION RATE (%)
HFC-134a	100%
HFC-152a	100%

As discussed in Appendix A.1, for purposes of this Methodology, the baseline reclamation rate for HFCs in the United States is set conservatively at 8.9% which is the R-22 reclaim rate from 2013 which is the most recent year in which there are EPA published data. As new data become available on R-22 reclamation, and eventually HFC reclamation, ACR will update this factor.

Table 4 lists the GWPs of the HFC refrigerants for both the baseline and project scenario calculations. As additional refrigerants become available through United States EPA SNAP listings[10] and market adoption, ACR will update this table.

[10] http://www.epa.gov/spdpublc/snap/refrigerants/lists/index.html

Table 4: GWPs of Predominant HFC Refrigerants

HFC REFRIGERANT	GLOBAL WARMING POTENTIAL[11]
HFC-152a	124
HFC-32	675
HFC-134a	1,430
R-407C	1,774
R-417C	1,820
R-410A	2,088
R-407A	2,107
R-422B	2,525
R-422D	2,730
R-422C	3,085
R-404A	3,922
R-507A	3,985
HFC-23	14,800

3.2 ADDITIONALITY ASSESSMENT

Emission reductions from the project must be additional, or deemed not to occur in the "business-as-usual" scenario. Assessment of the additionality of a project will be made based on passing the two tests cited below. These two tests require the project proponent to demonstrate that the project activity is surplus to regulations and reduces emissions below the level established in the Methodology.

- Regulatory Surplus Test, and

[11] IPCC, Fourth Assessment Report (100 year)

- Practice-Based Performance Standard

3.2.1 Regulatory Surplus Test

In order to pass the regulatory surplus test a project must not be mandated by existing laws, regulations, statutes, legal rulings, or other regulatory frameworks in effect as of the project start date that directly or indirectly affect the credited GHG emissions associated with a project. The project proponent must demonstrate that there is no existing regulation that mandates the project or effectively requires the GHG emission reductions associated with using certified reclaimed HFC refrigerant..

Currently, there are no restrictions in the United States or elsewhere in North America on the quantities of HFCs that can be produced, imported, or used. There are no requirements on the quantities of reclaimed HFC refrigerants that must be used for any application. Users are free to use virgin HFC, stockpiled HFC, or recycled or reclaimed HFC refrigerant in any amount of their choosing. There are regulatory requirements pertaining to certification of the equipment used to recover ODS refrigerants and the service technicians that handle ODS refrigerants, as well as certification requirements for refrigerant reclaimers. All regulatory requirements that apply to ODS refrigerants must be complied with as part of projects involving HFC refrigerants under this Methodology.

As discussed in Section A.1, because of the lack of production controls for HFCs, combined with the additional costs to recover, transport, and separate/process refrigerants back to virgin purity levels, there is currently little incentive for recovery, reclamation, and re-sale of HFC refrigerants. Based on U.S. EPA data on reclamation of HCFC-22 (for which there is a strong incentive to recover and reclaim), and industry information, the percentage of available HFCs that are reclaimed in the U.S. is extremely low. For purposes of this Methodology, a conservative assumption is made that the rate by which HFC refrigerants are reclaimed under the baseline scenario is the same (8.9%) as the R-22 reclaim rate based on the most recent data.

3.2.2 Practice-Based Performance Standard

In order for a project to qualify for offset credits under this Methodology it must be demonstrated that the sector has a low market adoption rate for certified reclaimed HFC refrigerant. A market adoption analysis, and hence the additionality demonstration under Applicability Condition 1.2 (II) was conducted for the relevant sectors and segments (see Table 1). A review of US EPA's reclamation data (see Appendix A.1) indicate that these sectors and segments have a low market adoption rate for using certified reclaimed HFCs. Therefore, project activities within these sectors and segments qualify for offset credit creation under this Methodology.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS

Quantification of project emission reductions requires calculation of baseline emissions and project emissions.

4.1.1 Baseline Emissions

This is the amount of baseline emissions that would take place without the use of certified reclaimed HFCs. It is equal to the total amount of reclaimed HFC refrigerant produced and the subsequent sale, title transfer or return to a refrigerant distributor, refrigerant wholesaler, or an end-user (either through direct sale, title transfer or return to an end user or through installation conducted via service technician) for use in refrigeration or air conditioning equipment during the reporting period. In the absence of the project, most of the refrigerant used to recharge the system would have come from virgin HFC production, and some would come from HFCs that would normally be reclaimed.

For projects using certified reclaimed HFC refrigerant, the baseline emissions are calculated by the following:

Equation 1

$$\mathbf{BE_{HFC_{rp}}} = \sum_{\mathbf{n}}^{\mathbf{y}} [(\mathbf{VR_{HFC,j,_{rp}}} \times \mathbf{ER10_{HFC,j}} \times \mathbf{GWP_{HFC,j}})] \times (\mathbf{1} - \mathbf{RR_{BL}}) \div \mathbf{1000}$$

WHERE

$BE_{HFC_{rp}}$	Baseline emissions during the reporting period (MT CO_2e)
$VR_{HFC,j,_{rp}}$	Total quantity of virgin HFC refrigerant **j** used to recharge equipment during the reporting period (kgs), derived from the quantity of monitored certified reclaimed HFC refrigerant that is documented according to the procedures in Section 3.1 and Section 5
$ER10_{HFC,j}$	The 10-year loss rate of HFC refrigerant **j** from equipment (%; see Table 3)
$GWP_{HFC,j}$	The global warming potential of HFC refrigerant **j** (see Table 4)

RR_{BL}	Baseline Refrigerant Reclamation Rate (% per year)[12]

4.1.2 Project Emissions

As discussed above in Section 3, by using previously used, reclaimed HFC refrigerants, project participants are displacing new production of virgin HFC. In this Methodology, any project related emissions from using reclaimed refrigerant, for example, from transport of certified reclaimed HFCs, are considered negligible and outside the project boundary. Thus, project activity emissions can be disregarded.

4.1.3 Leakage

In GHG project literature, leakage is a term that refers to secondary effects associated with where the GHG emission reductions of a project may be negated by shifts in market activity or shifts in materials, infrastructure, or other physical assets associated with the project. Projects involving certified reclaimed HFC refrigerant would not increase demand for refrigerant beyond current baseline demand, i.e., use of more reclaimed refrigerant would not cause an increase in virgin HFC production (to the contrary), or increase refrigerant emission rates. Therefore, for this Methodology, "leakage" can be disregarded.

4.1.4 Project Emission Reductions

Equation 2

$$\mathbf{ER_{rp} = BE_{HFC_{rp}}}$$

WHERE

ER_{rp}	Project emission reductions during reporting period (MT CO_2e)
$BE_{HFC_{rp}}$	Baseline emissions of HFC refrigerant during reporting period (MT CO_2e)

[12] Percentage of HFC refrigerant that would be reclaimed in the business-as-usual case, currently estimated to be 8.9% per year (see Appendix A.1)

5 MONITORING AND DATA COLLECTION

Each project shall include a monitoring, reporting and verification plan sufficient to meet the requirements of the ACR Standard. The plan shall collect all data required to be monitored and in a manner which meets the requirements for accuracy and precision of this Methodology.

5.1 DESCRIPTION OF THE MONITORING PLAN

These are expanded upon in the sections below. The project proponent must prepare a monitoring plan describing (for each separately) the following: a) project implementation; b) technical description of the monitoring task; c) data to be monitored and collected; d) overview of data collection procedures; e) frequency of the monitoring; f) quality control and quality assurance procedures; g) data archiving; and h) organization and responsibilities of the parties involved in all the above.

The rationale of monitoring project implementation is to document all project activities implemented by the project that could cause an increase in GHG emissions compared to the baseline scenario.

5.2 DATA COLLECTION AND PARAMETERS TO BE MONITORED

For a specific quantity of HFC refrigerants that are reclaimed, monitoring the emission reduction parameters includes:

- Where the HFC was recovered by service technicians in individual containers of 500 pounds gross refrigerant weight or more, documentation of the point of origin of the reclaimed HFC including:
  - Facility name and address where HFC was recovered;
  - Equipment/product (including, if available, manufacturer, model number, and serial number; if unavailable, a description of the equipment/product) from which HFC was extracted;
  - Date(s) of recovery;
  - The cylinder number, gross refrigerant weight, and net refrigerant weight of each container received by the EPA-certified reclaimer;
  - Date(s) received by the EPA-certified reclaimer;

- Attestation from EPA-certified reclaimer regarding the source of the HFC refrigerant that is reclaimed. Specifically, this attestation must document whether the reclaimer has previously obtained recovered HFC refrigerant from the source and, if so, the dates on which that HFC refrigerant was acquired; and
- Chain of custody and ownership of the recovered HFC must be demonstrated from the point of origin through the delivery of recovered HFC to the EPA-certified reclaimer. The following information must be provided to track chain of custody:
  - Names and addresses for all persons/entities buying and selling the recovered HFC;
  - The quantity of HFC purchased/sold at each transaction.

- Where HFCs were recovered by service technicians in individual containers of less than 500 pounds and aggregated with other recovered HFCs to greater than 500 pounds gross refrigerant weight in an individual container prior to delivery to an EPA-certified reclaimer, documentation of the point of origin of the reclaimed HFC including:
  - Name and address of the service company, wholesaler or distributor where recovered HFC was aggregated to individual containers of greater than 500 pounds;
  - If applicable, chain of custody and ownership of the recovered HFC must be demonstrated from the point of origin (location where recovered HFC was aggregated into individual containers to greater than 500 pounds) through to the delivery of recovered HFC to an EPA-certified reclaimer. The following information must be provided to track chain of custody:
    - Names and addresses for all entities buying and selling the recovered HFC;
    - The quantity of HFC purchased/sold at each transaction.
  - The cylinder number, gross refrigerant weight, and net refrigerant weight of each container received by the reclaimer; and
  - Date(s) received by the reclaimer.

- Where the HFC was recovered by service technicians in an individual container of less than 500 pounds gross refrigerant weight and delivered to a wholesaler or distributor, or delivered directly to an EPA-Certified reclaimer, documentation of the point of origin of the reclaimed HFC including:
  - Name and address of the service company, wholesaler or distributor that delivered the individual container of less than 500 pounds to the reclaimer;
  - The cylinder number, gross refrigerant weight, and net refrigerant weight of each container received by the EPA-certified reclaimer; and
  - Date(s) received by the EPA-certified reclaimer.

- For disposed aerosol products, documentation on the point of origin of the HFC including:

- Name and address of the entity that delivered the disposed aerosol products to the EPA-Certified reclaimer;
- The weight of the recovered HFC after processing by the EPA-certified reclaimer; and
- Date(s) received by the EPA-certified reclaimer.

- Tracking of the containers that are used for collection and transport to the reclaimer of the recovered HFC refrigerant (e.g. unique identification with serial number or barcode).
- Documentation on the type of HFC that is recovered from equipment or product and that is subsequently reclaimed.
- Documentation on the quantity of HFC refrigerant produced in the reclamation process, accounting for contaminants that are removed in the reclamation process.[13]
- Documentation that the same quantity of reclaimed HFC refrigerant (i.e. equal to the volume of HFC that was reclaimed during the reporting period) is transferred, sold, or returned to a refrigerant wholesaler, distributor, or end-user (either through direct sale, title transfer or return to an end user or through installation conducted via service technician).
- Documentation demonstrating that the reclaimer is an EPA-Certified reclaimer and reclaimed the refrigerant using equipment listed with the EPA, including:
  - The most recent equipment list provided to the EPA by the EPA Certified reclaimer; and
  - The physical address where the reclamation was conducted.
- Documentation showing that used HFC refrigerant processed by the EPA-Certified reclaimer is tested by an AHRI certified refrigerant testing laboratory to meet the AHRI 700-2015 Standard for Specification for Fluorocarbon Refrigerants.

5.2.1 Parameters Monitored

PARAMETER	$VR_{HFC,j,rp}$
UNITS	kg
DESCRIPTION	Total quantity of virgin HFC refrigerant j that would have been used to recharge equipment during the reporting period (kgs), derived from the quantity of monitored certified reclaimed HFC refrigerant that is documented according to the procedures in Section 3.1 and Section 5

[13] In any measurement of the quantity of refrigerant that involves weighing of a cylinder(s) (e.g., refrigerant recovered from equipment), the weight of the "empty" cylinder(s) (prior to filling with refrigerant) must be measured so that that any residual refrigerant (the cylinder "heel") is considered.

RELEVANT SECTION	4.1.1
RELEVANT EQUATION(S)	1
SOURCE OF DATA	Operating Records
MEASUREMENT FREQUENCY	Determined once for each project (which consists of only one reporting period).

APPENDIX A: BASELINE DATA INPUTS

A.1 RATE OF HFC RECLAMATION

Reclaimers in the United States are required to report to EPA the quantities of CFCs and HCFCs that they reclaim. Currently there are no reporting requirements for HFC reclamation. Because CFC production ended in 1996, reclaimed CFCs are essentially the only source of CFCs for CFC-based equipment still in use. Similarly, because HCFC-22 production is being phased out and will end in 2020, there is a strong incentive for system owners and service technicians to recover and re-use as much R-22 as possible to service equipment.

In contrast, there are no restrictions on production of HFCs, and because of the additional costs to recover, transport, and separate/process back to virgin purity levels[14] — unlike the strong incentive to reclaim CFCs and R-22 — there is currently little incentive for recovery, reclamation, and re-sale of HFCs. Thus, a conservative approach to estimate the amount of HFC refrigerant that is reclaimed in the baseline scenario is to use data from the United States EPA on R-22 reclamation, described below.

Table 5: Total reclaimed R-22 reported to EPA

Most recent data on the quantity of reclaimed R-22 in the U.S., as reported to the EPA.

YEAR	AMOUNT RECLAIMED IN POUNDS[15]
2010	7,985,289
2011	8,325,390
2012	9,401,446
2013	8,898,470

[14] http://ozone.unep.org/new_site/en/ozone_data_tools_reclaimation_facilities.php

[15] EPA (2014)

To calculate the R-22 reclaim rate (%) for a given year, the quantity of R-22 reclaimed is divided into the estimated quantity of R-22 being recovered from end-of-life equipment:

RR_{BL} = R-22 Reclaimed ÷ R-22 coming off-line

Based on data presented in an EPA report, for the most recent year (2013), it is estimated that 100 Million pounds of R-22 came "off-line":

- Estimated installed base of R-22 based refrigeration and air conditioning equipment contained 1.5 billion pounds of R-22 (ICF 2009; Tables A-1 and B-1)
- Assumed turnover rate of 7% per year on average (1/15 lifetime of equipment) (ICF, 2009; Table A-1)

The R-22 reclaim rate for 2013 is calculated as: **8.9 M ÷ 100 M = 8.9%**

Based on industry communications, the reclaim rate for HFC refrigerants is significantly lower than 8.9%. This is expected because R-22 production and import is being phased out and is tightly controlled under EPA's annual allocations. However, for purposes of this Methodology, a conservative assumption is made that the rate by which HFC refrigerants are reclaimed under the baseline scenario is the same (8.9%) as the R-22 reclaim rate based on the most recent data. As new data become available on R-22 reclamation, and eventually HFC reclamation, ACR will update this factor.

This Methodology also allows credits for use of HFCs that are recovered from discarded aerosol products and subsequently reclaimed for re-use as refrigerant. Since R-22 is not used as an aerosol propellant, the EPA data on R-22 reclamation would not reflect the baseline rate of reclamation of HFC aerosols. Industry information indicates that there may be very small quantities of HFCs in discarded medical aerosol products that are being recovered in the U.S. (e.g., less than a few thousand pounds per year) and that none of the non-medical aerosol products that are discarded in the U.S. are being managed at end-of-life such that none of the HFCs in those products are being recovered. Therefore, using the current reclamation rate of R-22 as a proxy for the baseline reclamation rate for HFCs that are recovered from aerosol products is an extremely conservative approach.

A.2 HFC REFRIGERANT EMISSION FACTORS

Under this Methodology, baseline emissions for reclaimed HFC refrigerant projects are estimated in reference to the emission loss rates of equipment into which virgin HFC refrigerants would have been installed. The calculation is based on the actual quantities of certified reclaimed HFC refrigerant that enter commerce through sale, transfer, or return to a refrigerant end-user or distributor. It would be difficult to track the exact equipment where the reclaimed

HFC refrigerant is ultimately used. Therefore, the baseline is defined for a specific HFC refrigerant by the weighted-average emission rate for the equipment where that refrigerant is typically used.

Some HFC refrigerants are used in predominantly single applications, e.g., R-404A in commercial multiplex refrigeration systems. In this example, the average emission rate used in this Methodology for R-404A would be the average emission leak rate for commercial refrigeration.

In contrast, other HFC refrigerants are used in a variety of applications, e.g., HFC-134a is used for automotive A/C, residential refrigerator-freezers, stand-alone commercial refrigerators, and large chillers. In this case, a weighted-average emission rate is calculated for the refrigerant based on its "market share" across the various end-uses (e.g., 30% of HFC-134a refrigerant is used for automotive A/C, 25% of HFC-134a refrigerant is used for residential refrigerator-freezers, etc.), multiplied by the average leak rates for those end-uses.

Table 8 presents average annual emission rates for the major refrigeration and air conditioning end-use categories, derived from two sources –the US EPA Vintaging Model and the 2006 IPCC Guidelines for National GHG Inventories. The EPA Vintaging Model outputs are publicly available (CAR, 2012; EPA, 2015). To be conservative, the values from the IPCC Guidelines are the low end of ranges presented in Table 7.9 of that report.

Table 9 presents the 10-year weighted-average leak rates incorporating the data in Table 8.[16]

Table 6: Emission Factors for Refrigeration and Air Conditioning Systems

REFRIGERANT SECTOR	SEGMENT	AVERAGE ANNUAL EMISSION RATE*
Domestic Refrigeration	Residential refrigerators and freezers	0.6%
Commercial or Retail Food Refrigeration	Equipment used to store and display chilled and frozen goods for commercial sale such as supermarkets, convenience stores, bakeries, and restaurants. This equipment includes centralized supermarket systems, remote condensing units, and stand-alone equipment	20% (all but stand-alone equipment) 8% (stand-alone equipment)

[16] 10-year emission rates are calculated from the annual emission rates using the following formula: 10 yr ER = 1-(1-Annual ER)^{10})

REFRIGERANT SECTOR	SEGMENT	AVERAGE ANNUAL EMISSION RATE*
	(e.g., beverage vending machines, stand-alone display cases).	
Cold Storage Warehouses		12.3-15%
Industrial Process Refrigeration	Chemical, pharmaceutical, petrochemical and manufacturing industries, industrial ice machines and ice rinks.	12.3-15%
Transport Refrigeration	Refrigerated truck trailers, railway freight cars, ship holds, and other shipping containers.	20.6-27.9%
Stationary Air Conditioning (including chillers)	Comfort cooling for homes and commercial buildings, including multi-family buildings, office buildings, hospitals, universities, shopping malls, airports, sports arenas.	2-11.8%
Mobile Air Conditioning	Automobiles and Trucks	18%**

* Unless otherwise noted, emission rates are from the US EPA Vintaging Model as reported in ICF (2009) and EPA (2015).

** Lowest value in range in Table 7.9 of the 2006 IPCC Guidelines.

Table 7: 10-Year Emission Rates for Individual HFC Refrigerants

REFRIGERANT	END-USE	DEPLOYMENT OF REFRIGERANT BY END-USE (%)	END-USE WEIGHTED EMISSION RATE (%/YEAR) *	10-YEAR EMISSION RATE (%)
HFC-134a	Mobile A/C	60%	18%	76%
	Commercial Refrigeration	5%	20%	
	Stand-Alone Commercial Refrigeration	15%	8%	
	Chillers	5%	6.5%	
	Domestic Refrigeration	15%	0.6%	
HFC-23	Industrial Process Refrigeration	85%	13.7%	74%
	Chillers	15%	6.5%	
HFC-32	Residential and Commercial A/C	85%	10.2%	64%
	Chillers	15%	6.5%	
R-404A	Commercial Refrigeration	80%	20%	84%
	Stand-alone Commercial Refrigeration	5%	8%	
	Industrial Process Refrigeration	15%	13.7%	
R-407A	Commercial Refrigeration	100%	20%	89%

REFRIGERANT	END-USE	DEPLOYMENT OF REFRIGERANT BY END-USE (%)	END-USE WEIGHTED EMISSION RATE (%/YEAR) *	10-YEAR EMISSION RATE (%)
R-407C	Residential and Commercial A/C	95%	10.2%	68%
	Commercial Refrigeration	5%	20%	
R-410A	Residential and Commercial A/C	100%	10.2%	66%
R-417C	Mobile A/C	100%	18%	86%
R-422B	Residential and Commercial A/C	95%	10.2%	68%
	Commercial Refrigeration	5%	20%	
R-422C	Commercial Refrigeration	100%	20%	89%
R-422D	Commercial Refrigeration	100%	20%	89%
R-507A	Commercial Refrigeration	100%	20%	89%
R-508B	Stand-Alone Commercial Refrigeration	100%	8%	57%

* Annual emission rates for specific refrigerant end-uses taken from Table 8. Where those emission rates are presented as ranges in Table 8, the midpoint of the range is used.

A.3 HFC AEROSOL EMISSION FACTOR

For projects conducted under this Methodology involving HFCs that are recovered from discarded aerosol products, and subsequently reclaimed for re-use as refrigerant, baseline emissions for reclaimed HFC refrigerant projects are estimated in reference to the emission loss rate of products in which virgin HFCs would have been used as aerosol propellants. The HFCs that are currently used in aerosol products are HFC-134a and HFC-152a, both of which could be re-used as refrigerants[17], and HFC-227ea, which is not used as a refrigerant.[18]

Unlike refrigeration and air conditioning equipment, which leak gradually under normal operations, aerosol products are designed to release their contents (including propellant) completely with each use. All HFCs used in aerosols are assumed to be emitted in the year of manufacture (EPA, 2015). The 10-year cumulative emission factor used in this Methodology for HFCs originating from aerosol products is 100%.

[17] In contrast to HFC-152a, HFC-134a is a commonly used refrigerant so the expectation is that a very large proportion of any HFC aerosols that will be recovered for re-use will be HFC-134a.

[18] In addition to its use as an aerosol propellant, HFC-227ea is also used in fire-fighting applications.

APPENDIX B: OTHER METHODOLOGY CONSIDERATIONS AND GUIDANCE

B.1 LIFECYCLE GHG REDUCTION OF CERTIFIED RECLAIMED REFRIGERANT

This Methodology provides the method to quantify GHG emission reductions over a 10-year "crediting period" associated with specific "project activities" within a specific project boundary, e.g., Company A uses X lbs of certified reclaimed HFC-404A in 2016 to re-charge a supermarket refrigeration system.

Another quantification approach is to measure the climate benefits of certified reclaimed HFC refrigerant over its full lifecycle. This approach is based on the fact that all refrigeration and A/C equipment leaks, and that in the absence of any incentive or requirement to destroy HFC refrigerants at equipment end-of-life, all HFC refrigerants are ultimately emitted. In other words, under current regulatory and economic conditions, the lifecycle of HFC refrigerants ends with release to the atmosphere, regardless of what equipment the refrigerants are used in, the annual leak rates of that equipment, how the equipment is serviced, and the lifetime of that equipment.

As described in this Methodology, using certified reclaimed HFC refrigerant displaces production of virgin refrigerant, and therefore, prevents the inevitable release of that virgin refrigerant to the atmosphere. To account for the fact that some amount of HFC refrigerant is being reclaimed under business as usual, the baseline rate of HFC reclamation cited in Section 3.1of this Methodology shall be applied.

Under this approach, the full lifecycle climate benefit of certified reclaimed HFC refrigerant is calculated by:

Equation 3

$$\mathbf{ER_y = \sum_i [Q_{HFC,Reclaimed,j} \times (1 - RR_{BL})] \times GWP_{HFC,j} \div 1000}$$

WHERE

ER_y	Emission reductions in year y (MT CO_2eq per year)
$Q_{HFC,Reclaimed,j}$	Total quantity of certified reclaimed HFC refrigerant j used to recharge equipment i in year y (kg per year).
RR_{BL}	Baseline Refrigerant Reclamation Rate (% per year)[19]
$GWP_{HFC,j}$	Global warming potential of refrigerant j used in the project (see Table 4)

B.2 BEST PRACTICES

Users of this Methodology should ensure that best practices for managing refrigerants are incorporated throughout their operations, and to the extent practicable, adopted by other companies in their supply chain or other network. This section focuses on two areas: (1) tracking refrigerants within the organization and (2) ensuring proper control of refrigerants off-site. For the second category, even though refrigerants may be under the control of an outside party, this section provides guidance to consider when selecting a contractor or other partner.

- If a system owner, facility operator, or other party that controls refrigeration or air conditioning operations (collectively referred to as the "organization") has refrigeration equipment or a cooling system that contains an operating charge of 50 lbs or more per circuit, the organization should have a refrigerant tracking system. A tracking system must enable the organization to quantify leaks, isolate leak sources, and manage and repair refrigerant leaks across multiple systems and facilities. The organization should use the tracking system to establish a benchmark against industry trends and set and meet leak reduction goals. The organization should set a goal in terms of maximum amount and rate of refrigerant leakage.
- Refrigerant tracking software should have the ability to view inventory in systems and storage, generate targeted compliance reports and track refrigerants or refrigerant assets (e.g., 1000 lbs of R-22 owned by Party A) across their lifespan, including use in equipment, recovery/processing/reclamation, and disposal/destruction. The tracking system should have the following minimum capabilities:
  - Record & track properties & location of refrigerants
  - Record & track properties & location of cylinders
  - Record & track properties & location of systems

[19] Percentage of refrigerant that would be reclaimed in the business-as-usual case, currently estimated to be 8.9% per year; see Appendix A.1.

- Record & track who owns each of the above assets wherever they are in the supply chain.
- Record & track when & who performed all maintenance/service events

- When refrigeration equipment reaches its end of life, or when equipment is serviced and evacuated, all refrigerant must be recovered and if either recycled or reclaimed, it must be done in conformance with EPA Section 608 requirements. Refrigerant should not simply be taken out and put back into another system (re-use) without removing impurities that can affect the performance of the equipment receiving the used refrigerant.
- Filling of the recovery cylinder should be done carefully by monitoring the mass of refrigerant added into the cylinder, thus the cylinder should be kept preferably on electronic balance throughout the entire procedure. Ensure that the cylinder does not overfill, that means the cylinder is not filled to more than 80% of its volume with liquid refrigerant. Similarly, the discharge pressure should also be monitored to ensure that the maximum allowable pressure of the recovery cylinder is never exceeded. After recovery has been completed, the recovery cylinder should be labelled with the type and mass of refrigerant it now contains; this information should be entered into the electronic tracking system.
- Refrigerant handlers must recover the existing refrigerant charge from the system into proper pressure-rated recovery cylinders as specified in AHRI Guideline K-2009 for Containers for Recovered Non-Flammable Fluorocarbon Refrigerants. Any refrigerant shipped must comply with all DOT regulations and be in DOT-approved cylinders. Cylinders must be weighed with scales that are calibrated annually at a minimum to ensure accuracy.
- For any refrigerants that are shipped offsite for reclamation, a monitoring system should be used that enables the project participants to track cylinders so its location can be viewed online.
- Refrigerants should be managed so that system owners can access information that shows the cylinder number, the location of the refrigerant, the quantity and overall status (reclaimed, needs to be reclaimed, etc.). Owners of refrigerant must be able to know the location of their cylinders at all times.

Used refrigerant must be reprocessed to at least the purity level specified in Appendix A to 40 CFR Part 82, Subpart F.4 Reclaimed refrigerant must be verified to meet AHRI-700 standards.[20]

[20] AHRI Standard 700, *Specifications for Fluorocarbon Refrigerants*. www.ahrinet.org

APPENDIX C: REFERENCES

EPA (2010) Transitioning to Low-GWP Alternatives in Commercial Refrigeration.

EPA (2010) Amendments to the Section 608 Leak Repair Requirements, Notice of Proposed Rulemaking, 75 FR 78558 – 78583, December 15, 2010.

EPA (2011) EPA Vintaging Model, Version VM IO file_v4.4_3.23.11, as cited in CAR (2012).

EPA (2012) Summary of refrigerant reclaimed 2012. http://www.epa.gov/ozone/title6/608/reclamation/recsum.pdf

EPA (2014) Adjustments to the Allowance System for Controlling HCFC Production, Import and Export, 2015-2019, 79 FR 64253 – 64290, October 28, 2014.

EPA (2015) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013, Annex 3 Methodological Descriptions for Additional Source or Sink Categories.

ICF (2009) The U.S. Phaseout of HCFCs: Projected Servicing Needs in the Air Conditioning and Refrigeration Sector. Prepared for the U.S. EPA by ICF International.

IPCC (2006) Guidelines for GHG Inventories, Volume 3: Industrial Processes and Product Use; Chapter 7 Emissions of Fluorinated Substitutes for Ozone Depleting Substances.

IPCC (2007) Climate Change 2007, Synthesis Report. International Panel on Climate Change, World Meteorological Organization, United Nations Environment Programme.

RTOC (2010) Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee, 2010 Assessment, United Nations Environment Programme.