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 1.2

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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.

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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 to meet or exceed the latest Air Conditioning, Heating, and Refrigeration Institute 700 Standard for Specifications for Fluorocarbon Refrigerants[1] (i.e., AHRI Standard 700-2016 as of the date of this document) by an EPA-certified reclaimer (or equivalent in case of Canada and Mexico), and tested by an AHRI-certified refrigerant testing laboratory to meet the AHRI Standard, a laboratory accredited to ISO/IEC 17025, or a laboratory licensed and regulated by the federal government, and using the AHRI Standard 700 — Specifications for Refrigerants (AHRI 700).

[1] Air Conditioning, Heating, and Refrigeration Institute (AHRI) 700-2016 Standard for *Specifications for Fluorocarbon Refrigerants.* www.ahrinet.org

TERM	ACRONYM (if applicable)	DEFINITION
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. • 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, or • The reclamation and use of certified reclaimed HFC refrigerants in newly

TERM	ACRONYM (if applicable)	DEFINITION
		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.
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.

[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."

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1 BACKGROUND AND APPLICABILITY

1.1 SUMMARY DESCRIPTION OF THE METHODOLOGY

Modern society depends upon refrigeration to process, store, and transport food, as well as on air conditioning in the built environment and motor vehicles. Reliable, environmentally safe, 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). That said, not all refrigerants are created equal.

Up until the mid-1990s, chlorofluorocarbons (CFCs) and hydrofluorocarbons (HCFCs) were in widespread use as refrigerants. CFCs significantly deplete the Earth's protective ozone layer and are also powerful greenhouse gases (GHGs), and HCFCs also contribute to stratospheric ozone depletion and climate change, although to a lesser extent than CFCs. Under the Montreal Protocol and United States Clean Air Act (CAA), all CFC and nearly all HCFC production ended in the United States in 1996[3] and 2021, respectively. Similarly, Canada and Mexico have also ended CFC production and consumption and are set to phase out HCFCs completely by 2030 and 2040 respectively. Having ratified Kigali amendments to Montreal protocol, Canada and Mexico are also on the path to reduce production and consumption of HFC below 85% and 80% of baseline consumptions by years 2036 and 2045 respectively.

As a result of the scheduled production and consumption phase-out of CFCs and HCFCs, hydrofluorocarbons (HFCs), because they do not damage the ozone layer, were intentionally developed as replacement refrigerants for ozone-depleting substances (ODS), including CFCs and HCFCs. Although they have an ozone depletion potentials (ODPs) of zero (0), HFCs have global warming potentials (GWPs) that can be hundreds to thousands of times greater than carbon dioxide (CO2). Due to the worldwide phaseout of ODS and ever-increasing global demand for refrigeration and air-conditioning, HFCs have today become the most commonly used refrigerants globally.

[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.

1.1.1 Use of Certified Reclaimed HFC Refrigerants

Across the various refrigeration and air conditioning applications, there are a number of approaches that can be used to reduce releases of HFCs (and, thereby, reduce GHG emissions) from both new and installed equipment, including but not limited to the following:

- Monitoring and timely leak repair for systems that are inherently prone to leaks;
- 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 systems, air conditioning systems, and various types of equipment when they are manufactured and installed, and when the systems leak during normal operations. Re-using previously used HFCs that have 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 CFCs or HCFCs, which are being phased out of production and/or consumption.

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 Reclaimed HFC Refrigerants	Domestic Refrigeration	Residential refrigerators and freezers
	Commercial Refrigeration, also known as	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,

[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] See reclaimed refrigerant definition in page 5

PROJECT ACTIVITY	REFRIGERANT SECTOR	ELIGIBLE SEGMENTS IN SECTOR
	Retail Food Refrigeration	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 the United States, Canada, or Mexico.
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

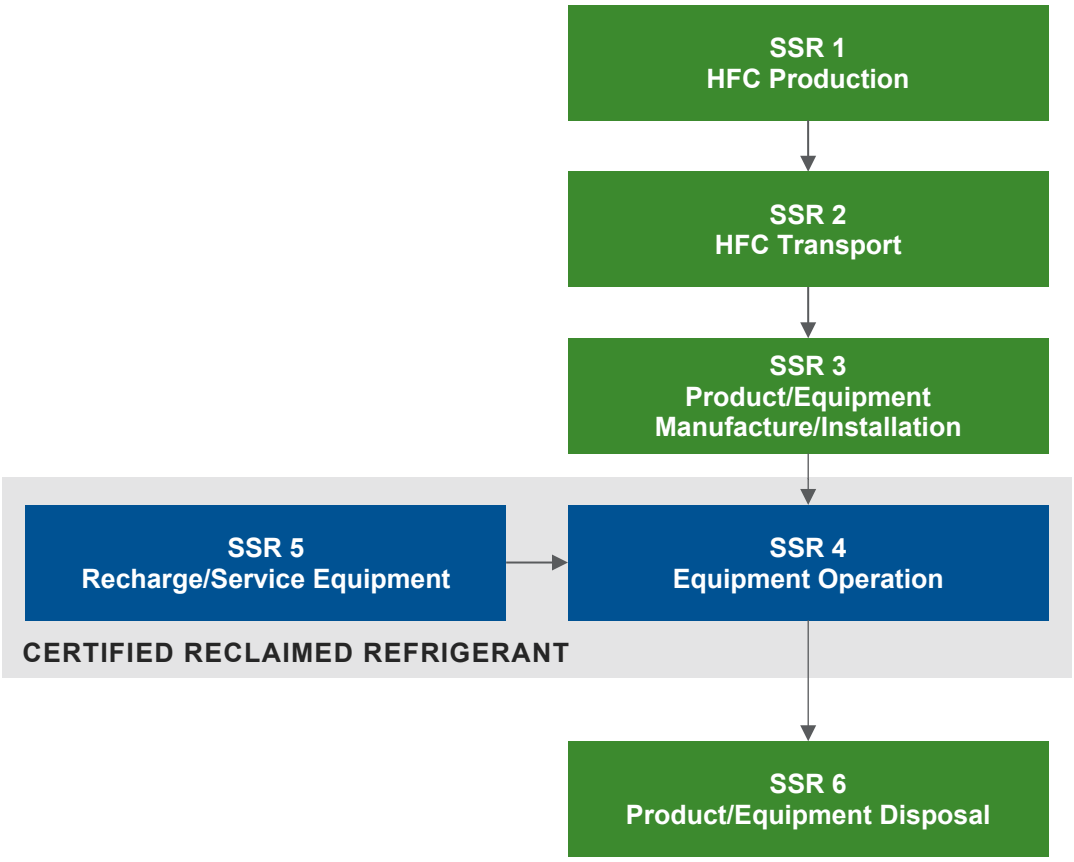
be periodically updated to reflect regulatory changes, emission factor revisions, or expanded applicability criteria. Before beginning a project, the project proponent should ensure that they are using the latest version of the Methodology.

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). Inventory of US greenhouse gas emissions and sinks: 1990-2019 states that HFC emission rates from servicing and leaks range from 0.5% to 36.4% annually depending on the type of end-use[6]. 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" existing appliances and 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

[6] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019 – Annex 3 Part A (epa.gov)

[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.

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 have been or are being phased out, there is currently little incentive for recovery, reclamation, and re-sale of HFC refrigerants. This is expected to change in future as HFCs also start being phased down in significant volumes.

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 or “first-fill”, equipment servicing, and leaks are included in this Methodology. Emissions at the disposal or end-of-life (EOL) are not included.

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

HFC RECOVERED FROM REFRIGERATION OR A/C EQUIPMENT	10-YEAR EMISSION RATE (%)
HFC-134a	55%
HFC-23	55%
HFC-32	56%
R-404A	82%
R-407A	87%

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

HFC RECOVERED FROM REFRIGERATION OR A/C EQUIPMENT	10-YEAR EMISSION RATE (%)
R-407C	59%
R-410A	57%
R-417C	66%
R-422B	59%
R-422C	87%
R-422D	87%
R-507A	87%
R-507B	10%

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 at 2% based on EPA data[10, 11] and IPCC AR5 GWP values. As new data become available on 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[12] and market adoption, ACR will update this table.

[10] https://www.epa.gov/ghgreporting/fluorinated-greenhouse-gas-emissions-and-supplies-reported-ghgrp#aim

[11] https://www.epa.gov/sites/default/files/2020-07/documents/2020_reclamation_table.pdf

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

Table 4: GWPs of Predominant HFC Refrigerants

HFC REFRIGERANT	GLOBAL WARMING POTENTIAL (GWP)	
	UP TO 2020 VINTAGES[13]	FROM 2021 VINTAGES[14]
HFC-152a	124	137
HFC-32	675	676
HFC-134a	1,430	1,301
R-407C	1,774	1,624
R-417C	1,820	1,643
R-410A	2,088	1,923
R-407A	2,107	1,923
R-422B	2,525	2,289
R-422D	2,730	2,473
R-422C	3,085	2,794
R-404A	3,922	3,945
R-507A	3,985	3,987
HFC-23	14,800	12,400

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.

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

[14] IPCC, Fifth Assessment Report (100 year)

- Regulatory Surplus Test, and
- 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.

The AIM Act, enacted by Congress in December of 2020, directs the U.S. EPA to address the environmental impact of hydrofluorocarbons (HFCs) by: phasing down production and consumption, maximizing reclamation and minimizing releases from equipment, and facilitating the transition to next-generation technologies through sector-based restrictions; although the United States has not ratified the October 15, 2016 Kigali Amendment to the Montreal Protocol, the AIM Act's phase-down schedule is consistent with the applicable Kigali schedule. Similarly, the Ozone-depleting Substances and Halocarbon Alternatives Regulations (ODSHAR), made under the authority of the Canadian Environmental Protection Act, 1999, and enforceable on December 29, 2016, include provisions to phase down the consumption and production of HFCs in alignment with Canada's adoption of the Kigali Amendment to the Montreal Accord. Although Mexico accepted the Kigali Amendments on September 25, 2018, Mexico, as a Group 1 Article 5 party, is following a slower HFC phase-down trajectory (e.g., a 10% reduction in consumption below baseline by 2029 rather than by 2019 for Canada, a Main Group Non-Article 5 party) and has not yet passed legislation analogous to the United States' AIM Act or promulgated regulations analogous to Canada's ODSHAR.

Due 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 HFCs for years 2017 to 2019, the percentage of available HFCs that are reclaimed in the U.S. is extremely low at around 2% (annually) of the net virgin HFCs available for consumption in the U.S. when compared on a metric ton of carbon dioxide equivalent (MT CO2e) basis[10, 11]. For purposes of this Methodology, the rate by which HFC refrigerants are reclaimed under the baseline scenario is taken as 2%.

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 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)[15]

4.2 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.

4.3 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.

4.4 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)

[15] Percentage of HFC refrigerant that would be reclaimed in the business-as-usual case, currently estimated to be 2% 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 (or equivalent for Canada and Mexico) reclaimer;
  - Date(s) received by the EPA-certified (or equivalent for Canada and Mexico) reclaimer;

- Attestation from EPA-certified (or equivalent for Canada and Mexico) 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 (or equivalent for Canada and Mexico) 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 (or equivalent for Canada and Mexico) 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 (or equivalent for Canada and Mexico) 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 (or equivalent for Canada and Mexico) 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 (or equivalent for Canada and Mexico) reclaimer; and
  - Date(s) received by the EPA-certified (or equivalent for Canada and Mexico) 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 (or equivalent for Canada and Mexico) reclaimer;
  - The weight of the recovered HFC after processing by the EPA-certified (or equivalent for Canada and Mexico) reclaimer; and
  - Date(s) received by the EPA-certified (or equivalent for Canada and Mexico) 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.[16]
- 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 (or equivalent for Canada and Mexico) reclaimer and reclaimed the refrigerant using equipment listed with the EPA (equivalent equipment should be used by reclaimers in Canada and Mexico), including:
  - The most recent equipment list provided to the EPA (list of equivalent equipment should be provided by reclaimers in Canada and Mexico) by the EPA Certified (or equivalent for Canada and Mexico) reclaimer; and
  - The physical address where the reclamation was conducted.
- Documentation showing that used (recovered) HFC refrigerant processed by the EPA-Certified (or equivalent for Canada and Mexico) reclaimer is tested by an AHRI-certified refrigerant testing laboratory to meet the AHRI Standard, a laboratory accredited to ISO/IEC 17025, or a laboratory licensed and regulated by the federal government, and using the AHRI Standard 700 – Specifications for Refrigerants (AHRI 700)[17].

[16] 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.

[17] Air Conditioning, Heating, and Refrigeration Institute (AHRI) 700-2016 Standard for *Specifications for Fluorocarbon Refrigerants.* www.ahrinet.org

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
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. Starting year 2017, reclaimers in the U.S. are also required to report quantities of HFCs reclaimed to the EPA.

HFC production and consumption phase down is in early stages in Canada and haven't yet begun in U.S. and Mexico. As such there are no significant restrictions on production of HFCs, and because of the additional costs to recover, transport, and separate/process back to virgin purity levels[18] — unlike the strong incentive to reclaim CFCs and R-22 — there is currently little incentive for recovery, reclamation, and re-sale of HFCs. To estimate the amount of HFC refrigerant that is reclaimed in the baseline scenario, HFC reclamation data for years 2017-2019 from the United States EPA is used as described below.

Table 5: Total Reclaimed HFCs Reported to EPA

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

YEAR	AMOUNT RECLAIMED IN POUNDS[19]	AMOUNT RECLAIMED IN MILLION $MTCO_2E$
2017	5,001,821	4.4
2018	5,158,987	4.6
2019	6,056,195	5.1

To calculate the HFC reclaim rate (%) for a given year, the quantity of HFC reclaimed (in pounds) is converted to metric tons (MT) by dividing it with 2204.62. The reclaimed HFCs (in MT) is then converted to metric tons of carbon dioxide equivalent ($MTCO_2e$) by multiplying the

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

[19] https://www.epa.gov/sites/default/files/2020-07/documents/2020_reclamation_table.pdf

HFCs with their respective GWP values (using IPCC AR5 values). For unidentified HFCs that are in the other HFCs category, a conservative GWP value of 3,000 is used.

RR_{BL} = HFC Reclaimed (in Million $MTCO_2e$) ÷ Net Virgin HFCs available for use in the U.S. (in Million $MTCO_2e$)

EPA's Greenhouse Gas Reporting Program (GHGRP) reports that, for the most recent years (2017-19), 285, 303, and 294 Million $MTCO_2e$ of net virgin HFCs were available for consumption in the U.S. for years 2017, 2018 and 2019 respectively.

The average annual HFC reclaim rate for 2017-2019 is calculated as (all values are in Million $MTCO_2e$):

$$[(4.4 \div 285) + (4.6 \div 303) + (5.1 \div 294)] \div 3 \times 100\% = 2\%$$

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 the US EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2019 (published 2021).

Table 7 presents the 10-year weighted-average leak rates incorporating the data in Table 6.[20]

Table 6: Emission Factors for Refrigeration and Air Conditioning Systems

REFRIGERANT SECTOR	SEGMENT	AVERAGE ANNUAL EMISSION RATE[21]
Domestic Refrigeration	Residential refrigerators and freezers	1%
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 (e.g., beverage vending machines, stand-alone display cases).	18% (Average of Large Retail Food (25%) and Condensing Units/ Medium Retail Food (12%)) 1% (Stand-alone Equipment)
Cold Storage Warehouses		15%
Industrial Process Refrigeration	Chemical, pharmaceutical, petrochemical and manufacturing industries, industrial ice machines and ice rinks.	8%
Transport Refrigeration	Refrigerated truck trailers, railway freight cars, ship holds, and other shipping containers.	28%

[20] 10-year emission rates are calculated from the annual emission rates using the following formula: 10 yr ER = 1-(1-Annual ER)[10]

[21] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019 – Annex 3 Part A (epa.gov) (Table A-131) – All emission rates are averaged and rounded to nearest whole numbers.

REFRIGERANT SECTOR	SEGMENT	AVERAGE ANNUAL EMISSION RATE[21]
Stationary Air Conditioning (Residential and Commercial)	Comfort cooling for homes and commercial buildings, including multi-family buildings, office buildings, hospitals, universities, shopping malls, airports, sports arenas.	8%
Mobile Air Conditioning	Automobiles and Trucks	10%
Chillers		6%

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%	10%	55%
	Commercial Refrigeration	5%	18%	
	Stand-Alone Commercial Refrigeration	15%	1%	
	Chillers	5%	6%	
	Domestic Refrigeration	15%	1%	
HFC-23	Industrial Process Refrigeration	85%	8%	55%
	Chillers	15%	6%	
HFC-32	Residential and Commercial A/C	85%	8%	56%
	Chillers	15%	6%	
R-404A	Commercial Refrigeration	80%	18%	82%
	Stand-alone Commercial Refrigeration	5%	1%	

REFRIGERANT	END-USE	DEPLOYMENT OF REFRIGERANT BY END-USE (%)	END-USE WEIGHTED EMISSION RATE (%/YEAR) *	10-YEAR EMISSION RATE (%)
	Industrial Process Refrigeration	15%	8%	
R-407A	Commercial Refrigeration	100%	18%	87%
R-407C	Residential and Commercial A/C	95%	8%	59%
	Commercial Refrigeration	5%	18%	
R-410A	Residential and Commercial A/C	100%	8%	57%
R-417C	Mobile A/C	100%	10%	66%
R-422B	Residential and Commercial A/C	95%	8%	59%
	Commercial Refrigeration	5%	18%	
R-422C	Commercial Refrigeration	100%	18%	87%
R-422D	Commercial Refrigeration	100%	18%	87%

REFRIGERANT	END-USE	DEPLOYMENT OF REFRIGERANT BY END-USE (%)	END-USE WEIGHTED EMISSION RATE (%/YEAR) *	10-YEAR EMISSION RATE (%)
R-507A	Commercial Refrigeration	100%	18%	87%
R-508B	Stand-Alone Commercial Refrigeration	100%	1%	10%

* Annual emission rates for specific refrigerant end-uses taken from Table 6. Where those emission rates are presented as ranges in Table 6, 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[22], and HFC-227ea, which is not used as a refrigerant.[23]

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, 2021). The 10-year cumulative emission factor used in this Methodology for HFCs originating from aerosol products is 100%.

[22] 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.

[23] 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 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)[24]
$GWP_{HFC,j}$	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

[24] Percentage of refrigerant that would be reclaimed in the business-as-usual case, currently estimated to be 2.0% 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.[25]

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

APPENDIX C: REFERENCES

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

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