

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

THE DESTRUCTION OF OZONE DEPLETING SUBSTANCES AND HIGH-GWP FOAM

VERSION 1.0

July 2017

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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

A/C	Air conditioning
AHRI	Air-Conditioning, Heating and Refrigeration Institute
ANSI	American National Standards Institute
CAA	Clean Air Act
CEMS	Continuous Emission Monitoring System
CFC	Chlorofluorocarbon
CH ₄	Methane
CO ₂	Carbon dioxide
CPT	Comprehensive Performance Test
DOT	U.S. Department of Transportation
DRE	Destruction and removal efficiency
EPA	United States Environmental Protection Agency
FTIR	Fourier transform infrared spectroscopy
GWP	Global warming potential
HBFC	Hydrobromofluorocarbon
HBR	High Boiling Residue
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HWC	Hazardous waste combustor
MT	Metric ton

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NESHAP	National Emissions Standards for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology
ODS	Ozone depleting substances
PU	Polyurethane
RCRA	Resource Conservation and Recovery Act
SSR	GHG Sources, GHG Sinks, and GHG Reservoirs
TEAP	Technology and Economic Assessment Panel to the Montreal Protocol Parties

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1 INTRODUCTION

1.1 PURPOSE

The purpose of the Methodology is to quantify greenhouse gas (GHG) emission reductions associated with the destruction of: 1) high global warming potential (GWP) ozone depleting substances (ODS) obtained from and destroyed within the U.S. that would have otherwise been released to the atmosphere; 2) high-GWP foam blowing agents that are extracted from insulation foam; and 3) insulation foam that contains blowing agent(s) with high GWP. This Methodology updates the CARB ODS Protocol to include additional sources of ODS used as refrigerant in air conditioning and refrigeration equipment, ODS in medical aerosol and fire suppression applications, and ODS and other high-GWP blowing agents in foam. Additionally, modifications have been made to emission factors and methods used to generate emission reductions for foam projects and to methods used for monitoring destruction events conducted at destruction facilities that are a part of an enclosed equipment de-manufacturing system.

2 ELIGIBLE ACTIVITIES: QUANTIFICATION METHODOLOGY

This Methodology defines a set of activities designed to reduce GHG emissions by the destruction of eligible ODS, high-GWP foam blowing agents, or high-GWP insulation foam at a single qualifying destruction facility.

2.1 ELIGIBLE DESTRUCTION FACILITIES

- I. The end fate of the ODS, high-GWP foam blowing agent, or high-GWP insulation foam must be destruction at either:
 - A. An approved HWC subject to the RCRA and with a RCRA permit for the ODS destruction facility stating an ODS destruction efficiency of at least 99.99%; or
 - B. A transformation or destruction facility that meets or exceeds the Montreal Protocol's TEAP standards provided in the *Report of the Task Force on Destruction Technologies*.
 - i. A facility must demonstrate DRE of 99.99% and emission levels consistent with the guidelines set forth in the TEAP report.
 - ii. A facility must have been certified by a third party no more than three years prior to the offset project start date and must show that it maintains its operational status as stated in the certification.
- II. A destruction facility must meet all applicable monitoring and operational requirements under CAA and NESHAP standards, as well as all applicable federal, state, and local laws that apply directly to ODS, high-GWP foam blowing agent, and high-GWP insulation foam destruction activities during the time the ODS, high-GWP foam blowing agent or high-GWP foam destruction occurs.
- III. At the time of ODS, high-GWP foam blowing agent, or high-GWP insulation foam destruction, the destruction facility must have a valid Title V air permit, if applicable, and any other air or water permits required by local, state or federal law to destroy ODS, high-GWP foam blowing agent, and/or high-GWP insulation foam and document compliance with all monitoring and operational requirements that apply to ODS, high-GWP foam blowing agent, and high-GWP insulation foam destruction project activities.
- IV. Any upsets or exceedances must be managed in accordance with an authorized SSMP.

2.2 ELIGIBLE ODS, HIGH-GWP FOAM BLOWING AGENTS AND HIGH-GWP INSULATION FOAM

- I. ODS, high-GWP foam blowing agents and high-GWP insulation foam destroyed under this Methodology must be from one or more of the eligible sources listed in subchapters 2.2.1, 2.2.2, 2.2.3, or 2.2.4 of this Methodology.
- II. Eligible ODS, high-GWP foam blowing agents, or high-GWP insulation foam may not be combined within the same container.
- III. ODS produced exclusively for use as solvents or other applications not listed in Sections 2.2.1, 2.2.2, 2.2.3, or 2.2.4 are not eligible.
- IV. A single offset project may incorporate ODS, high-GWP foam blowing agents, or high-GWP insulation foam obtained from one or more of the source categories listed in subchapters 2.2.1, 2.2.2, 2.2.3, or 2.2.4 of this Methodology.
- V. Destruction activity must take place under one or more Certificates of Destruction.
- VI. All the following conditions must be met for multiple Certificates of Destruction to be eligible as a single project:
 - A. The project proponent is the same for all ODS, high-GWP foam blowing agents, or high-GWP insulation foam destroyed;
 - B. All ODS, high-GWP foam blowing agents, or high-GWP insulation foam must be destroyed at the same eligible destruction facility; and
 - C. The destruction activities must occur during one reporting period.
- VII. A Certificate of Destruction may be used for only one offset project.
- VIII. Each Certificate of Destruction must be issued by the qualifying destruction facility and must include the following information:
 - A. Project Proponent;
 - B. Destruction facility;
 - C. Certificate of destruction ID number;
 - D. If applicable, serial, tracking, or ID number of all containers for which ODS destruction occurred;
 - E. If applicable, serial, tracking or ID number of all containers for which high-GWP insulation foam destruction occurred;
 - F. If applicable, serial, tracking or ID number of all appliances from which high-GWP foam blowing agents are extracted and destroyed in an enclosed equipment de-manufacturing system;

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- G. For ODS, extracted high-GWP foam blowing agent, and high-GWP insulation foam in containers, mass and type of material destroyed from each container;
- H. For high-GWP foam blowing agent extracted and destroyed in an enclosed equipment de-manufacturing system, mass of each high-GWP foam blowing agent destroyed.
- I. Start and end destruction dates.
- IX. The ODS destroyed may originate from a single source or from numerous sources.
- X. The high-GWP foam blowing agents may originate from a single source or from numerous sources.
- XI. The high-GWP insulation foam may originate from a single source or from numerous sources.
- XII. The handling, recovery, and disposal of ODS refrigerants must be performed by technicians certified by the U.S. EPA under CAA, sections 608 and 609, as applicable. Technicians may only service refrigeration or air conditioning equipment they are certified to service. Technician name and certification type(s) must be retained as part of the documentation retention requirements of this Methodology.

2.2.1 ODS Refrigerant Sources

- I. Eligible refrigerants must originate from equipment, systems, or other supplies in the United States. Imported refrigerant is not eligible under this Methodology.
- II. Refrigerants from government inventories or stockpiles are only eligible if they are allowed to be sold into commercial markets for subsequent use and are not required to be destroyed or converted.
- III. Only destruction of the following ODS refrigerants is eligible to generate ACR Emission Reduction Tonnes (ERTs) under this Methodology:
 - A. CFC-11;
 - B. CFC-12;
 - C. CFC-13;
 - D. CFC-113;
 - E. CFC-114;
 - F. CFC-115;
 - G. HCFC-22
- IV. HCFC-22 must be recovered from operating equipment that is subsequently de-commissioned or otherwise permanently retired from service.
- V. HCFC-22 obtained from stockpiles is not eligible under this Methodology.
- VI. ODS extracted from a foam source for use in refrigeration equipment is not considered part of this source category, and must instead be considered as a high-GWP insulation foam source.

2.2.2 High-GWP Insulation Foam Sources¹

- I. Eligible high-GWP insulation foam must originate from appliance foam, building foam, or other foam. Imported foams are not eligible under this Methodology.
- II. Only destruction of the following high-GWP insulation foam blowing agents is eligible to generate ACR ERTs under this Methodology:
 - A. CFC-11;
 - B. CFC-12;
 - C. HCFC-22;
 - D. HCFC-141b;
 - E. HFC-134a;
 - F. HFC-245fa.
- III. To be eligible, the high-GWP blowing agent must be destroyed in one of three ways:
 - A. If high-GWP blowing agent is extracted from insulation foam and subsequently destroyed at a separate destruction facility, the blowing agent must be extracted from the insulation foam under negative pressure and collected, stored, and transported in hermetically sealed containers;
 - B. If high-GWP blowing agent is extracted from foam and destroyed within an enclosed equipment de-manufacturing system, the blowing agent must be extracted from the foam and destroyed under negative pressure; or
 - C. If high-GWP insulation foam is destroyed, the intact foam (i.e., foam that is not shredded or compacted prior to destruction) must be separated from the application from which it originated (i.e. those applications cited in subchapter 2.2.2 I) and must be stored, transported, and destroyed in sealed containers (see section 6.6 I).

2.2.3 Medical Aerosol Sources

- I. Eligible medical aerosols must:
 - A. Originate from domestic U.S. stockpiles of ODS originally produced in the U.S. prior to January 1, 2012 under an essential use exemption; and
 - B. Be eligible for sale for use in medical products that are listed as essential uses by the U.S. Food and Drug Administration.
- II. Any medical aerosols destroyed prior to January 1, 2012 are not eligible for credits under this Methodology.
- III. Only destruction of the following ODS medical aerosols is eligible to generate ACR ERTs under this Methodology:

¹ Inclusive of high-GWP blowing agents extracted from insulation foam.

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- A. CFC-11;
- B. CFC-12;
- C. CFC-114.

2.2.4 Fire Suppressant Sources

- I. Eligible fire suppressants must originate from equipment or systems in the United States. Imported ODS fire suppressants are not eligible under this Methodology.
- II. Only destruction of the following fire suppressants is eligible under this Methodology:
 - A. Halon 1211;
 - B. Halon 1301.
- III. Halon 1301 originating in stockpiles is not eligible under this Methodology.

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3 ELIGIBILITY

ODS and high-GWP insulation foam (intact foam or extracted blowing agents) offset projects must adhere to the eligibility requirements below as well as general ACR program requirements included in the ACR Standard.

ACR may require revisions to this Methodology to ensure that monitoring, reporting, and verification systems adequately reflect changes to project 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.

3.1 GENERAL ELIGIBILITY REQUIREMENTS

- I. Offset projects that use this Methodology must:
 - A. Collect and destroy ODS, high-GWP foam blowing agents, or high-GWP insulation foam that would otherwise be emitted to the atmosphere;
 - B. Destroy the recovered ODS, high-GWP foam blowing agents, or high-GWP insulation foam through an eligible end-use management option pursuant to subchapter 2.1 of this Methodology;
 - C. Conform with the point of origin documentation requirements, as specified in chapter 6 of this Methodology; and
 - D. Conform to the chain of custody documentation requirements, as specified in chapter 6 of this Methodology.
- II. A project proponent that uses this Methodology must:
 - A. Monitor SSRs within the GHG Assessment Boundary as delineated in chapter 4 pursuant to the requirements of chapter 6 in this Methodology;
 - B. Quantify GHG emission reductions pursuant to chapter 5 of this Methodology;
 - C. Prepare and submit a GHG Project Plan in accordance with ACR Standard requirements; and
 - D. Obtain validation and verification services from an ANSI-accredited offset verification body approved by ACR.

3.2 LOCATION

- I. Only projects located in the United States or its territories are eligible under this Methodology.

- II. All ODS and high-GWP insulation foam must be obtained from equipment, systems, and other eligible supplies in the United States or its territories.
- III. All ODS, high-GWP foam blowing agents, and high-GWP insulation foam must be destroyed within the United States or its territories.

3.3 ADDITIONALITY

Offset projects must meet the additionality requirements included below. Eligible offsets must be generated by projects that yield additional GHG reductions that exceed any GHG reductions otherwise required by law or regulation or any GHG reduction that would otherwise occur in a conservative business-as-usual scenario. These requirements are assessed through the Legal Requirement Test in subchapter 3.3.1 and the Performance Standard Evaluation in subchapter 3.3.2 of this Methodology.

3.3.1 Legal Requirement Test

- I. Emission reductions achieved by a project using this Methodology must exceed those required by any law, regulation, or legally binding mandate.
- II. The following legal requirement test applies to all ODS and high-GWP insulation foam projects:
 - A. If no law, regulation, or legally binding mandate requires the destruction of ODS stocks, high-GWP foam blowing agent, or high-GWP insulation foam, all emission reductions resulting from the recovery and destruction of ODS and high-GWP insulation foam are considered to not be legally required, and therefore eligible for crediting under this Methodology.
 - B. If any law, regulation, or legally binding mandate requires the destruction of ODS stocks, high-GWP foam blowing agent, or high-GWP insulation foam, only emission reductions resulting from the recovery and destruction of ODS, high-GWP foam blowing agent, and high-GWP insulation foam that are in excess of what is required to comply with those laws, regulations, and legally binding mandates are eligible for crediting under this Methodology.

3.3.2 Performance Standard Evaluation

- I. Emission reductions achieved by a project using this Methodology must exceed those likely to occur in a conservative business-as-usual scenario.
- II. The destruction of HCFC-22 refrigerant obtained from stockpiles or other sources other than recovered from refrigeration or air conditioning equipment is ineligible for crediting under this Methodology.

- III. The destruction of halon 1301 obtained from stockpiles or sources other than those recovered from fire suppression equipment is ineligible for crediting under this Methodology.
- IV. The performance standard evaluation is satisfied if the ODS or high-GWP insulation foam project activities meet the project definition and all other eligibility requirements in the Methodology.

3.4 START DATE

- I. An offset project must meet the start date requirements set forth in the ACR Standard.
- II. For this Methodology, the project start date is defined as the date on which the earliest destruction activity of a project commences, as documented on a Certificate of Destruction.
- III. Offset project activities (i.e. collection of ODS or high-GWP insulation foam, transportation of ODS or high-GWP insulation foam, etc.) will occur prior to offset project commencement.

3.5 REPORTING PERIODS

- I. An ODS or high-GWP insulation foam project can only have a single reporting period.
- II. Multiple destruction events may be combined within a single reporting period subject to the requirements in subchapter 2.2 V of this Methodology.
- III. The reporting period must not exceed 12 consecutive months. The project proponent may choose a reporting period shorter than 12 consecutive months.
- IV. The project reporting period begins on the project start date.

3.6 CREDITING PERIODS

- I. The project crediting period is the period of time over which emission reductions are quantified for the purpose of determining creditable GHG reductions.
- II. The project crediting period for this Methodology is ten years.
- III. The project crediting period begins on the project start date.

3.7 REGULATORY COMPLIANCE

- I. An offset project must meet the regulatory compliance requirements set forth in the ACR Standard.

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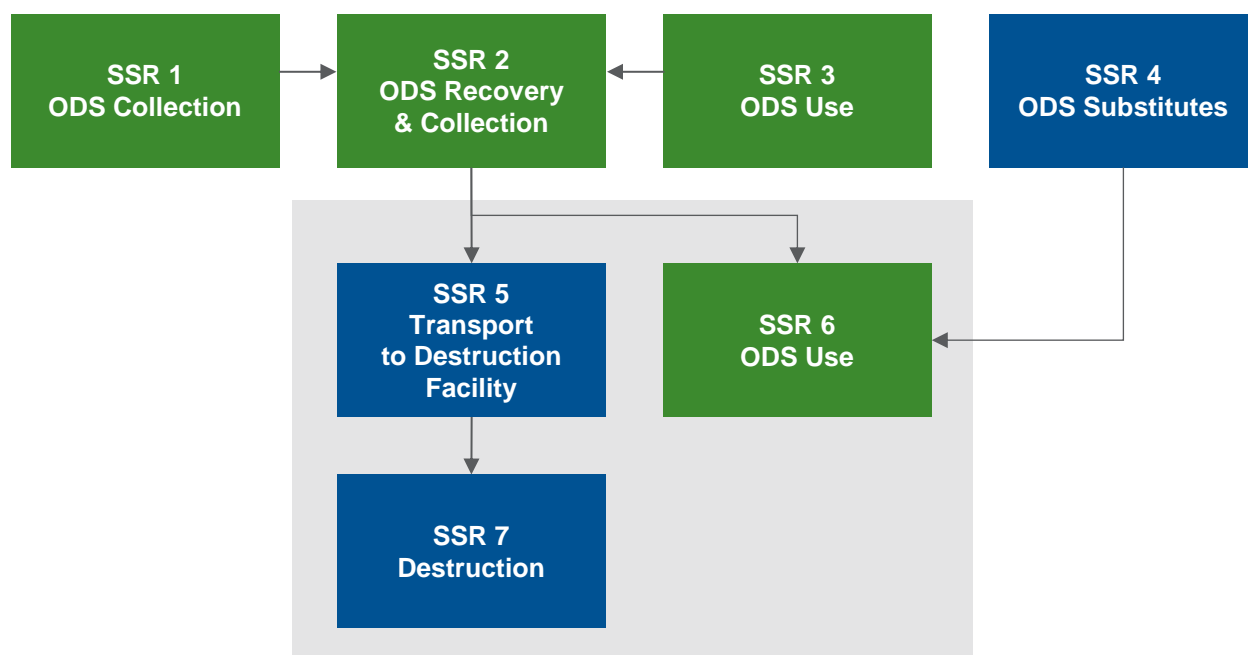
- II. The regulatory compliance requirements for a project apply to the collection, recovery, storage, transportation, mixing, and destruction of ODS, high-GWP foam blowing agents, or high-GWP insulation foam, including disposal of the post-destruction waste products that are directly applicable to the destruction activities. The regulatory compliance requirements in this section apply to the incinerator and any other unit or operation at the destruction facility, directly related to the destruction activities, during the time destruction occurs.

Any instances of non-compliance resulting from administrative or other issues not related to the project (those specific activities stated in Section 3.7 II) shall not be considered in a determination of project-related regulatory compliance.

4 OFFSET PROJECT BOUNDARY: QUANTIFICATION METHODOLOGY

- I. The GHG assessment boundary, or offset project boundary, delineates the SSRs that must be included or excluded when quantifying the net changes in emissions associated with the recovery and destruction ODS and high-GWP insulation foam.
- II. Figure 1 illustrates the GHG assessment boundary for refrigerant ODS, medical aerosol ODS, and fire suppressant ODS projects.
 - A. All SSRs inside the grey box are included and must be accounted for under this Methodology.
 - B. SSRs in green boxes are relevant to the baseline and project emissions.
 - C. SSRs in blue boxes are relevant only to project emissions.

Figure 1: Illustration of the Offset Project Boundary for Refrigerant, Medical Aerosol, and Fire Suppressant ODS Projects



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- III. Table 1 lists the SSRs for refrigerant, medical aerosol, and fire suppressant ODS projects indicating which gases are included or excluded from the offset project boundary.

Table 1: List of Identified SSRs for Refrigerant, Medical Aerosol, and Fire Suppressant ODS Projects

SSR	SOURCE DESCRIPTION	GAS	INCLUDED (I) OR EXCLUDED (E)
1 ODS Collection	Fossil fuel emissions from the collection and transport of ODS sources	CO ₂	E
		CH ₄	E
		N ₂ O	E
2 ODS Recovery and Collection	Emissions of ODS from the recovery and collection of ODS at end-of-life or servicing	ODS	E
	Fossil fuel emissions from the recovery and collection of refrigerant at end-of-life or servicing	CO ₂	E
		CH ₄	E
		N ₂ O	E
3 ODS Use	Emissions of ODS from equipment use, leaks, and servicing	ODS	E
	Fossil fuel emissions from the operation of refrigeration and A/C equipment and fire suppressant systems	CO ₂	E
		CH ₄	E
		N ₂ O	E
4 Substitute Refrigerant, Medical Aerosol, or Fire Suppressant Production	Emissions of substitute refrigerant, medical aerosols, or fire suppressants occurring during production	CO ₂ e	E
	Fossil fuel emissions from the production of substitute refrigerant, medical aerosols, or fire suppressants	CO ₂	E
		CH ₄	E
		N ₂ O	E

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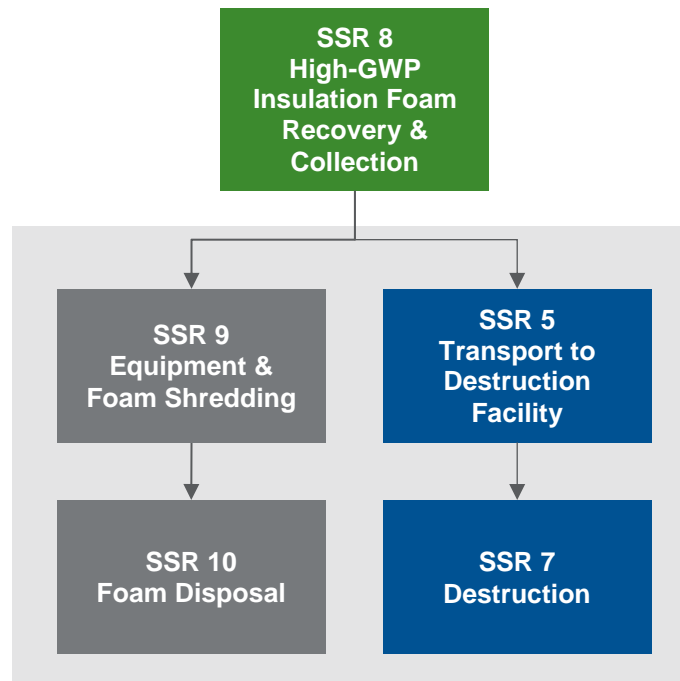
SSR	SOURCE DESCRIPTION	GAS	INCLUDED (I) OR EXCLUDED (E)
5 Transport to Destruction Facility	Fossil fuel emissions from the vehicular transport of ODS from aggregation point to final destruction facility	CO ₂	I
		CH ₄	E
		N ₂ O	E
6 ODS Use	Emissions of ODS from use, leaks and servic- ing through continued operation of equipment	ODS	I
	Emissions of substitute from use, leaks and servicing through continued operation of equipment	CO ₂ e	I
	Indirect emissions from grid-delivered electricity	CO ₂	E
		CH ₄	E
		N ₂ O	E
7 Destruction	Emissions of ODS from incomplete destruc- tion at destruction facility	ODS	I
	Emissions from the oxidation of carbon contained in destroyed ODS	CO ₂	I
	Fossil fuel emissions from the destruction of ODS at destruction facility	CO ₂	I
		CH ₄	E
		N ₂ O	E
	Indirect emissions from the use of grid- delivered electricity	CO ₂	I
		CH ₄	E
		N ₂ O	E

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- IV. Figure 2 illustrates the GHG assessment boundary for high-GWP insulation foam projects.
- A. All SSRs inside the grey box are included and must be accounted for under this Methodology.
 - B. SSRs in dark grey boxes are relevant only to baseline emissions.
 - C. SSRs in blue boxes are relevant only to project emissions.
 - D. SSRs in green boxes are relevant to the baseline and project emissions.

Figure 2: Illustration of the Offset Project Boundary for High-GWP Insulation Foam Projects



- V. Table 2 lists the SSRs for high-GWP insulation foam projects indicating which gases are included or excluded from the offset project boundary.

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Table 2: List of Identified SSRs for High-GWP Insulation Foam Projects

SSR	SOURCE DESCRIPTION	GAS	INCLUDED (I) OR EXCLUDED (E)
5 ODS Collection	Fossil fuel emissions from the vehicular transport of high-GWP insulation foam or extracted blowing agent from aggregation point to final destruction facility	CO ₂	I
		CH ₄	E
		N ₂ O	E
7 Destruction	Emissions from incomplete destruction at destruction facility	ODS/HFC	I
	Emissions from the oxidation of carbon contained in destroyed foam or blowing agent	CO ₂	I
		CH ₄	E
		N ₂ O	E
	Fossil fuel emissions from the destruction of foam or blowing agent at destruction facility	CO ₂	I
		CH ₄	E
		N ₂ O	E
	Indirect emissions from the use of grid-delivered electricity	CO ₂	I
		CH ₄	E
		N ₂ O	E
8 High-GWP Insulation Foam Recovery and Collection	Emissions of ODS/HFC from demolition, deconstruction, or other damage to foam sources	ODS/HFC	E
	Fossil fuel emissions from demolition or deconstruction of foam sources	CO ₂	E
		CH ₄	
		N ₂ O	
	Fossil fuel emissions from the collection and transport of high-GWP foam sources	CO ₂	E
		CH ₄	

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SSR	SOURCE DESCRIPTION	GAS	INCLUDED (I) OR EXCLUDED (E)
		N ₂ O	
9 Equipment and Foam Shredding ²	Emissions of ODS/HFC from the removal of foam from equipment for materials recovery, releasing ODS/HFC from foam	ODS/HFC	I
10 Foam Disposal	Emissions of ODS/HFC released from foam disposed of in landfills	ODS/HFC	I
	Fossil fuel emissions from the transport and placement of shredded foam waste in landfill	CO ₂	E
		CH ₄	E
		N ₂ O	E

² SSR 9 is only relevant to projects that manually remove foam in a non-enclosed equipment de-manufacturing system. For projects that destroy extracted high-GWP blowing agent from foam in an enclosed equipment de-manufacturing system, quantification of project emissions from foam removal is not required.

5 QUANTIFYING GHG EMISSION REDUCTIONS: QUANTIFICATION METHODOLOGY

- I. GHG emission reductions from an ODS or high-GWP insulation foam³ project are quantified by comparing actual project emissions to calculated project baseline emissions.
- II. A project proponent must use the calculation methods provided in this methodology to determine baseline and project GHG emissions.
- III. GHG emissions must be quantified using the GWP values in Tables 4-7.
- IV. GHG emission reductions (ER) must be quantified by subtracting the project emissions (PE) from the baseline emissions (BE) using Equation 1.

Equation 1: Total Emission Reductions

$$ER_t = BE_t - PE_t$$

WHERE		UNITS
ER_t	Total quantity of GHG emission reductions during the reporting period	MT CO ₂ e
BE_t	Total quantity of project baseline emissions during the reporting period	MT CO ₂ e
PE_t	Total quantity of project emissions during the reporting period	MT CO ₂ e

5.1 QUANTIFYING BASELINE EMISSIONS

- I. Baseline emissions (BE) must be estimated by using Equation 2 and by summing the baseline emissions for all SSRs identified as included in the baseline in Tables 1 and 2.

³ Whether intact high-GWP insulation foam or blowing agent extracted from high-GWP insulation foam

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Equation 2: Total Baseline Emissions

$$BE_t = BE_{refr} + BE_{foam} + BE_{aer} + BE_{fs}$$

WHERE		UNITS
BE_t	Total quantity of project baseline emissions during the reporting period	MT CO ₂ e
BE_{refr}	Total quantity of project baseline emissions from refrigerant ODS	MT CO ₂ e
BE_{foam}	Total quantity of project baseline emissions from high-GWP blowing agent	MT CO ₂ e
BE_{aer}	Total quantity of project baseline emissions from medical aerosol ODS	MT CO ₂ e
BE_{fs}	Total quantity of project baseline emissions from fire suppressant ODS	MT CO ₂ e

- II. Baseline emissions from refrigerant ODS (BE_{refr}) must be quantified using Equation 3.
- III. BE_{refr} must include the estimated CO₂e emissions that would have occurred over the ten-year crediting period had the destroyed ODS been used in existing refrigeration or air conditioning equipment.
- IV. The total mass of refrigerant ODS sent for destruction ($Q_{refr,i}$) includes eligible ODS and excludes the mass of HBR, moisture, ineligible ODS, and other ineligible material. Mass and composition of refrigerant ODS are determined per the procedures provided in Appendix C.
- V. The GWP values for refrigerant ODS (GWP_i) must be taken from Table 4.
- VI. The 10-year cumulative emission rate for refrigerant ODS ($ER_{refr,i}$) must be taken from Table 4.
- VII. If the project did not destroy any refrigerant ODS, then $BE_{refr} = 0$.

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Equation 3: Baseline Emissions from Refrigerant ODS

$$BE_{\text{refr}} = \sum_i (Q_{\text{refr},i} \times ER_{\text{refr},i} \times GWP_i)$$

WHERE		UNITS
BE_{refr}	Total quantity of refrigerant project baseline emissions during the reporting period	MT CO ₂ e
$Q_{\text{refr},i}$	Total quantity of refrigerant ODS <i>i</i> sent for destruction by the offset_project	MT ODS
$ER_{\text{refr},i}$	10-year cumulative emission rate of refrigerant ODS <i>i</i> (see Table 4)	%
GWP_i	Global warming potential of ODS <i>i</i> (see Table 4)	MT CO ₂ e/ MT ODS

- VIII. Baseline emissions from high-GWP foam blowing agents (BE_{foam}) (blowing agent extracted from foam or intact foam) must be quantified using Equation 4.
- IX. BE_{foam} must include the estimated CO₂e emissions that would have occurred over ten years as the result of foam disposal.
- X. The 10-year cumulative emission rate for high-GWP blowing agents must be taken from Table 5.
- XI. The mass and composition of extracted blowing agent from high-GWP foam (EBA_i) must be calculated per the procedures in Appendix C.
- XII. The mass of intact high-GWP foam ($Q_{\text{intf},i}$) must be calculated using the scales of the eligible destruction facility as specified in Appendix B.
- XIII. The mass fraction of intact high-GWP blowing agent ($BA\%_{\text{intf},i}$) must be calculated per Appendix B II.
- XIV. If the project did not destroy any high-GWP blowing agent, then $BE_{\text{foam}} = 0$

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Equation 4: Baseline Emissions from High-GWP Insulation Foam

$$BE_{\text{foam}} = \sum_{i,j} [(EBA_i + BA_{\text{intf},i}) \times ER_{i,j} \times GWP_i]$$

WHERE		UNITS
BE_{foam}	Total quantity of high-GWP blowing agent project baseline emissions	MT CO ₂ e
EBA_i	Total quantity of high-GWP blowing agent i extracted from foam and destroyed (as determined through the procedures provided in Appendix C)	MT BA
$BA_{\text{intf},i}$	Total quantity of high-GWP blowing agent i in intact foam sent for destruction (as determined through Equation 5)	MT BA
$ER_{i,j}$	10-year emission rate of high-GWP blowing agent i from application j (see Table 5)	%
GWP_i	Global warming potential of high GWP blowing agent i (see Table 5)	MT CO ₂ e/ MT BA

Equation 5: Quantity of high-GWP blowing agent from intact foam

$$BA_{\text{intf},i} = Q_{\text{intf},i} \times BA\%_{\text{intf},i}$$

WHERE		UNITS
$BA_{\text{intf},i}$	Total quantity of high-GWP blowing agent i from intact foam sent for destruction	MT BA
$Q_{\text{intf},i}$	Total mass of intact foam, i , with entrained high-GWP blowing agent sent for destruction (as determined through procedures in Appendix B I)	MT
$BA\%_{\text{intf},i}$	Mass ratio of high-GWP blowing agent, i , entrained in intact foam (as determined per the procedures in Appendix B II)	% (0-1)

XV. Baseline emissions from medical aerosol ODS (BE_{aer}) must be quantified using Equation 6.

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- XVI. BE_{aer} must include the estimated CO_2e emissions that would have occurred over the ten-year crediting period had the destroyed ODS been used in medical aerosols.
- XVII. The total mass of medical aerosol ODS sent for destruction ($Q_{aer,i}$) includes eligible ODS and excludes the mass of HBR, moisture, ineligible ODS, and other ineligible material. Mass and composition of medical aerosol ODS are determined per the procedures found in Appendix C.
- XVIII. The GWP values for medical aerosol ODS (GWP_i) must be taken from Table 6.
- XIX. The 10-year cumulative emission rate for medical aerosol ODS ($ER_{aer,i}$) must be taken from Table 6.
- XX. If the project did not destroy any medical aerosol ODS, then $BE_{aer} = 0$.

Equation 6: Baseline Emissions from Medical Aerosol ODS

$$BE_{aer} = \sum_i (Q_{aer,i} \times ER_{aer,i} \times GWP_i)$$

WHERE		UNITS
BE_{aer}	Total quantity of medical aerosol project baseline emissions during the reporting period	MT CO_2e
$Q_{aer,i}$	Total quantity of medical aerosol ODS i sent for destruction by the project	MT ODS
$ER_{aer,i}$	10-year cumulative emission rate of medical aerosol ODS i (see Table 6)	%
GWP_i	Global warming potential of ODS i (see Table 6)	MT CO_2e / MT ODS

- XXI. Baseline emissions from fire suppressant ODS (BE_{fs}) must be quantified using Equation 7.
- XXII. BE_{fs} must include the estimated CO_2e emissions that would have occurred over the ten-year crediting period had the destroyed ODS been used in existing fire suppression equipment or systems.
- XXIII. The total mass of fire suppressant ODS sent for destruction ($Q_{fs,i}$) includes eligible ODS and excludes the mass of HBR, moisture, ineligible ODS, and other ineligible material.

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Mass and composition of fire suppressant ODS are determined per the procedures provided in Appendix C.

XXIV. The GWP values for fire suppressant ODS (GWP_i) must be taken from Table 7.

XXV. The 10-year cumulative emission rate for fire suppressant ODS ($ER_{fs,i}$) must be taken from Table 7.

XXVI. If the project did not destroy any fire suppressant ODS, then $BE_{fs} = 0$.

Equation 7: Baseline Emissions from Fire Suppressant ODS

$$BE_{fs} = \sum_i Q_{fs} \times ER_{fs,i} \times GWP_i$$

WHERE		UNITS
BE_{fs}	Total quantity of fire suppressant project baseline emissions during the reporting period	MT CO ₂ e
Q_{fs}	Total quantity of fire suppressant ODS i sent for destruction by the project	MT ODS
$ER_{fs,i}$	10-year cumulative emission rate of fire suppressant ODS i (see Table 7)	%
GWP_i	Global warming potential of ODS i (see Table 7)	MT CO ₂ e/ MT ODS

5.2 QUANTIFYING PROJECT EMISSIONS

- I. Project emissions (PE) must be quantified by summing the emissions for all SSRs identified as included in the project in Tables 1 and 2 using Equation 8.

Equation 8: Total Project Emissions

$$PE_t = Sub_{refr} + Sub_{fs} + Sub_{aer} + Rem_f + Tr\&Dest$$

WHERE		UNITS
PE_t	Total quantity of project emissions during the reporting period	MT CO ₂ e

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Sub_{refr}	Total GHG emissions from substitute refrigerant	MT CO ₂ e
Sub_{fs}	Total GHG emissions from substitute fire suppressant	MT CO ₂ e
Sub_{aer}	Total GHG emissions from substitute medical aerosol	MT CO ₂ e
Rem_f	Total GHG emissions from removal of high GWP foam in a non-enclosed equipment de-manufacturing system	MT CO ₂ e
Tr&Dest	Total GHG emissions from transportation and destruction of ODS and high-GWP insulation foam/blowing agents	MT CO ₂ e

- II. Project emissions from substitute refrigerants (Sub_{refr}) must be quantified using Equation 9.
- III. Sub_{refr} must include the estimated CO₂e emissions over a ten-year period from non-ODS substitute refrigerants that are used. The emission factors for substitute refrigerants in Table 4 must be used.
- IV. The total mass of refrigerant ODS sent for destruction (Q_{ref,i}) excludes the mass of HBR, moisture, and ineligible ODS. Mass and composition of refrigerant ODS are determined per the procedures provided in Appendix C.
- V. If the project did not destroy any refrigerant, then Sub_{refr} = 0.

Equation 9: Project Emissions from the Use of Non-ODS Refrigerants

$$\text{Sub}_{\text{refr}} = \sum_i Q_{\text{ref},i} \times \text{SE}_i$$

WHERE		UNITS
Sub_{refr}	Total quantity of refrigerant substitute emissions	MT CO ₂ e
Q_{ref,i}	Total quantity of refrigerant i sent for destruction	MT ODS
SE_i	Emission factor for substitute(s) for refrigerant i , per Table 4	MT CO ₂ e/ MT ODS destroyed

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- VI. If high-GWP foam is manually removed in a non-enclosed equipment de-manufacturing system, project emissions from removal of the foam (Rem_f) must be quantified using Equation 10.
 - A. The default percentage of blowing agent that is lost when foam is removed from appliances in a non-enclosed manufacturing facility is 10% (Lfr).
- VII. If the project did not destroy any high-GWP blowing agent, then $Rem_f = 0$.

Equation 10: Project Emissions from Removal of Foam in a Non-Enclosed Equipment De-Manufacturing System

$$Rem_f = (BE_{foam} \times Lfr)$$

WHERE		UNITS
Rem_f	Total GHG emissions from removal of high GWP foam in a non-enclosed equipment de-manufacturing system	MT CO ₂ e
BE_{foam}	Total quantity of high-GWP blowing agent project baseline emissions (as determined through Equation 4) ⁴	MT CO ₂ e
Lfr	Default percentage of blowing agent that is lost in removal of foam from appliances in a non-enclosed equipment de-manufacturing system	10%

- VIII. Project emissions from substitute medical aerosols (Sub_{aer}) must be quantified using Equation 11.
- IX. Sub_{aer} must include the estimated CO₂e emissions over a ten-year period from non-ODS substitute medical aerosols that are used. The emission factors for substitute medical aerosols in Table 6 must be used.
- X. The total mass of medical aerosol ODS sent for destruction ($Q_{aer,i}$) excludes the mass of HBR, moisture, and ineligible ODS. Mass and composition of medical aerosol ODS are determined per the procedures found in Appendix C.
- XI. If the project did not destroy any medical aerosols, then $Sub_{aer} = 0$.

⁴ Note that, for purposes of quantifying project foam removal emissions, project baseline emissions used in this equation shall only include the proportion of emissions associated with foam that is manually removed in a non-enclosed manufacturing facility.

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Equation 11: Project Emissions from the Use of Non-ODS Medical Aerosols

$$\text{Sub}_{\text{aer}} = \sum_i (\text{Q}_{\text{aer},i} \times \text{SE}_i)$$

WHERE		UNITS
Sub_{aer}	Total quantity of medical aerosol substitute emissions	MT CO ₂ e
$\text{Q}_{\text{aer},i}$	Total quantity of medical aerosol <i>i</i> sent for destruction	MT ODS
SE_i	Emission factor for substitute(s) medical aerosols <i>i</i> , per Table 6	MT CO ₂ e/ MT ODS destroyed

- XII. Project emissions from substitute fire suppressants (Sub_{fs}) must be quantified using Equation 12.
- XIII. Sub_{fs} must include the estimated CO₂e emissions over a ten-year period from non-ODS substitute fire suppressants that are used. The emission factors for substitute fire suppressants in Table 7 must be used.
- XIV. The total mass of fire suppressant ODS sent for destruction ($\text{Q}_{\text{fs},i}$) excludes the mass of HBR, moisture, and ineligible ODS. Mass and composition of fire suppressant ODS are determined per the procedures provided in Appendix C.
- XV. If the project did not destroy any fire suppressant, then $\text{Sub}_{\text{fs}} = 0$.

Equation 12: Project Emissions from the Use of Non-ODS Fire Suppressants

$$\text{Sub}_{\text{fs}} = \sum_i (\text{Q}_{\text{fs},i} \times \text{SE}_i)$$

WHERE		UNITS
Sub_{fs}	Total quantity of fire suppressant substitute emissions	MT CO ₂ e
$\text{Q}_{\text{fs},i}$	Total quantity of fire suppressant <i>i</i> sent for destruction	MT ODS
SE_i	Emission factor for substitute(s) for fire suppressant <i>i</i> , per Table 7	MT CO ₂ e/ MT ODS destroyed

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XVI. Project emission from the transportation and destruction of ODS and high-GWP insulation foam/blowing agent shall be quantified using default emission factors in Equation 13.

- A.** The default emission factor for ODS transportation and destruction is 7.5 MT CO₂e per MT ODS for refrigerant, medical aerosol, fire suppressant or blowing agent extracted from high-GWP foam.
- B.** The default emission factor for transportation and destruction is 75 MT CO₂e per MT of high-GWP foam for intact foam projects.
- C.** Q_{ODS} and Q_{BA} include the mass of all eligible and ineligible ODS and high-GWP blowing agent, moisture, HBR, and other accompanying material.

Equation 13: Project Emissions from Transportation and Destruction Using the Default Emission Factors

$$\text{Tr\&Dest} = (Q_{\text{ODS}} \times \text{EF}) + (Q_{\text{BA}} \times \text{EF}) + (Q_{\text{intf}} \times \text{EF})$$

WHERE		UNITS
Tr&Dest	Total GHG emissions from ODS and high-GWP insulation foam/blowing agent transportation and destruction, as calculated using default emission factors	MT CO ₂ e
Q _{ODS}	Total quantity of refrigerant, medical aerosol, and/or fire suppressant ODS sent for destruction in the project	MT ODS
Q _{BA}	Total quantity of high-GWP blowing agent extracted from insulation foam and sent for destruction in the project	MT BA
Q _{intf}	Total mass of intact foam with entrained high-GWP blowing agent sent for destruction	MT
EF	Default emission factor for transportation and destruction of ODS or High-GWP Blowing Agent foam (7.5 for refrigerant, medical aerosol, fire suppressant or extracted blowing agent projects, 75 for intact high-GWP foam projects)	MT CO ₂ e/ MT ODS/ MT BA or MT

5.3 ACCOUNTING FOR DISQUALIFIED ODS MATERIAL AND HIGH-GWP FOAM AFTER DESTRUCTION

ERTs may only be generated for the destruction of eligible ODS, high-GWP foam blowing agents, and high-GWP insulation foam that meet the point of origin and chain of custody requirements specified in chapter 6 of this Methodology. Any disqualified ODS, high-GWP foam blowing agents, or high-GWP insulation foam must be removed from baseline emission calculations using the following method to determine the mass and species of the disqualified ODS, high-GWP foam blowing agents, or high-GWP insulation foam:

- I. The total mass of each container of disqualified ODS (from refrigerant, medical aerosol, or fire suppressant ODS or high-GWP blowing agent) or high-GWP insulation foam shall be considered as the original container when the ODS or high-GWP foam was acquired. Documentation of the acquired ODS, high-GWP blowing agent, or high-GWP insulation foam must identify the capacity of the disqualified ODS, high-GWP blowing agent or high-GWP insulation foam container or the entire destruction event is not eligible for crediting. If a container's capacity is labelled in volume rather than in mass, the densities in Table 8 must be used to convert the volume to mass.
 - A. For refrigerant, medical aerosol, or fire suppressant ODS or high-GWP foam blowing agent: If converting between mass and volume, the ODS or blowing agent must be in a liquid state.
- II. The species of each disqualified ODS or high-GWP blowing agent shall be the species with the highest GWP of the destruction event.
- III. The determined mass of disqualified ODS or high-GWP blowing agent shall be subtracted from the total mass of that ODS or high-GWP blowing agent species destroyed in the project.
 - A. The total mass of refrigerant ODS sent for destruction ($Q_{refr,i}$) shall be adjusted in Equation 3.
 - B. The total quantity of blowing agent extracted from high-GWP foam and sent for destruction (EBA_i) shall be adjusted in Equation 4.
 - C. The total mass of high-GWP blowing agent from intact high-GWP foam sent for destruction ($BA_{intf,i}$) shall be adjusted in Equation 5.
 - D. The total mass of medical aerosol ODS sent for destruction ($Q_{aer,i}$) shall be adjusted in Equation 6.
 - E. The total mass of fire suppressant ODS sent for destruction ($Q_{fs,i}$) shall be adjusted in Equation 7.

5.4 CONVERSION FACTORS AND ROUNDING PRACTICES

- I. For the purpose of this Methodology, 1 pound (lb) equals 0.45359 kilogram (Kg).
- II. The following rounding practices shall be applied for the purpose of this Methodology:
 - A. At least five significant digits shall be maintained.
 - B. There shall be no rounding to the left side of the decimal.

6 MONITORING

6.1 GENERAL MONITORING REQUIREMENTS

- I. The project proponent is responsible for monitoring all project activities to ensure compliance with this Methodology.
- II. The point of origin of all ODS and high-GWP foam must be documented. The project proponent must collect and maintain documentation showing regulatory compliance back to all points of origin.
- III. Documentation of the point of origin must be generated at the time of collection from the point of origin and must include all the following:
 - A. Facility name and physical address;
 - B. Point of origin zip code;
 - C. Identification of any refrigeration or air conditioning equipment by serial number, if available, or description, location, and function, if serial number is unavailable (for refrigerant ODS quantities greater than 500 pounds that originate in equipment that is not processed at an enclosed equipment de-manufacturing facility); and
 - D. Serial or ID number of containers used for storage and transport.
- IV. For refrigerant ODS, medical aerosol ODS, and fire suppressant ODS, the project proponent must collect and maintain documentation on the chain of custody and ownership of the ODS beginning at the point of origin until destruction, including all the following:
 - A. Names, addresses, and contact information of all entities buying and selling ODS for destruction; and
 - B. The mass of ODS including ineligible ODS and contaminants, at each transaction.
- V. For projects destroying refrigerant ODS sourced from government stockpiles or inventories, the project proponent must maintain documentation that the ODS could be sold into commercial markets, and that the ODS is not required to be destroyed or converted.
- VI. For projects destroying medical aerosol ODS, the project proponent must maintain documentation that the ODS is eligible to be sold for use in a medical product that is listed as an essential use by the U.S. Food and Drug Administration.
- VII. For projects recovering and destroying HCFC-22 refrigerant or Halon 1301 fire suppressant and that meet the point of origin determination requirements in Section 6.2 II B ii, the project proponent must obtain a signed attestation from a representative at the point of origin facility regarding the source of the HCFC-22 or Halon 1301. Specifically, this attestation must state whether the source equipment has been decommissioned or otherwise

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permanently retired from service and the date of decommissioning or retirement. The attestation shall be supplied to the ACR and to the validation and verification body for assessment.

- VIII. For intact high-GWP foam sources (i.e. those where blowing agent is not extracted prior to destruction), the project proponent must collect and maintain all the following information:
- A. For intact high-GWP building and intact other foams:
 - i. Total quantity of foam from each foam type (i.e. differentiated by building and specific allowable other foams) that is the source of the high-GWP blowing agent in the project;
 - ii. Type and amount of blowing agent in the foam determined through procedures in Appendix BII; and
 - B. For intact appliance high-GWP foams:
 - i. Numbers of units containing high-GWP foam that are processed;
 - ii. Type and amount of blowing agent(s) in the foam, determined through the procedures in Appendix B II, as applicable.
- IX. For refrigerant ODS, medical aerosol ODS, and fire suppressant ODS and extracted high-GWP foam blowing agent that is not destroyed in an enclosed equipment de-manufacturing process, the project proponent must collect and maintain all the following information from the composition and mass analysis:
- A. Time and date of sample;
 - B. Name of project proponent;
 - C. Name of technician taking sample;
 - D. Employer of technician taking sample;
 - E. Volume of container from which sample was extracted;
 - F. Ambient air temperature at time of sampling; and
 - G. Chain of custody for each sample from the point of sampling to the AHRI-certified lab.
- X. For refrigerant ODS, medical aerosol ODS, and fire suppressant ODS and extracted high-GWP foam blowing agent, the destruction facility must track continuously during the destruction process the following parameters and provide the data about these parameters to the project proponent. The project proponent must collect and maintain all the following information from the destruction facility:
- A. The feed rate;
 - B. Operating temperature and pressure of the destruction unit during destruction;
 - C. Effluent discharges measured in terms of water and pH levels;
 - D. CEMS data on the emissions of carbon monoxide during destruction; and
 - E. If applicable, for an enclosed equipment de-manufacturing system:

- i. Mass and composition of ODS and high-GWP blowing agent(s) entering the destruction unit,
 - ii. Time and date(s) of chemical analyses,
 - iii. Number of appliances that are de-manufactured in the system, and
 - iv. Date(s) appliances enter equipment de-manufacturing system.
- XI. For intact high-GWP insulation foam, the destruction facility must track during the destruction process the following parameters and provide the data about these parameters to the project proponent. The project proponent must collect and maintain all the following information from the destruction facility:
 - A. Mass of high-GWP foam fed into the destruction unit;
 - B. Operating temperature and pressure of the destruction unit during foam destruction;
 - C. Effluent discharges measured in terms of water and pH levels; and
 - D. CEMS data on the emissions of carbon monoxide during foam destruction.

6.2 POINT OF ORIGIN DETERMINATION

- I. The project proponent must collect and maintain data on the point of origin of each refrigerant ODS, medical aerosol ODS, or fire suppressant ODS, high-GWP foam blowing agent, and high-GWP insulation foam as part of tracking chain of custody. Data must be generated at the time of collection from the point of origin.
- II. Point of origin is defined as follows:
 - A. For refrigerant ODS, medical aerosol ODS, or fire suppressant ODS which is stored as a stockpile for more than 24 months prior to acquisition by the project proponent:
 - i. The point of origin for stockpiled refrigerant ODS, medical aerosol ODS, or fire suppressant ODS is the location of the stockpile⁵.
 - B. For refrigerant ODS, medical aerosol ODS, or fire suppressant ODS which is not part of a stockpile for at least 24 months prior to acquisition by the project proponent:
 - i. The point of origin for refrigerant ODS, medical aerosol ODS, or fire suppressant ODS with mass less than 500 pounds is the site at which greater than or equal to 500 pounds of ODS is aggregated.
 - ii. The point of origin for refrigerant ODS, medical aerosol ODS, or fire suppressant ODS with mass greater than or equal to 500 pounds is the site where the ODS is removed from service.
 - iii. The point of origin for refrigerant ODS recovered from appliances at an equipment de-manufacturing facility is the equipment de-manufacturing facility.

⁵ Per Section 3.3.2, stockpiled HCFC-22 and Halon 1301 is ineligible for crediting.

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- C. For blowing agent extracted from high-GWP foam, the point of origin is the facility where the blowing agent is extracted.
 - D. For blowing agent in intact appliance or intact other high-GWP foam, the point of origin is the location at which the foam is removed.
 - E. For blowing agent in intact building high-GWP foam, the point of origin is the location at which the building high-GWP foam was taken.
- III. For refrigerant ODS, medical aerosol ODS, or fire suppressant ODS, the following provisions also apply to point of origin determination:
- A. Any location at which 500 pounds is reached in a single transaction or shipment is a point of origin; the 500 pounds does not need to be in a single container.
 - B. For each container included within the project, the mass of HBR, moisture, ineligible ODS, and other ineligible material shall be included to determine if the 500-pound threshold is reached.
 - C. If refrigeration or air conditioning equipment or fire suppression equipment containing at least 500 pounds of ODS is transported prior to the ODS being removed from the equipment, then the point of origin is the site at which the ODS was removed from the equipment.
 - D. When ODS is added to a single container which is part of a stockpile and a portion of the ODS is subsequently removed from the container, the ODS removed must be considered the ODS stored the longest (i.e., first-in, first-out method).

6.3 INSTRUMENT QA/QC

- I. For a destruction facility that is not part of an enclosed equipment de-manufacturing system, the scales used to determine the mass of ODS, high-GWP foam blowing agent, or high-GWP insulation foam used in calculating emission reductions must be:
 - A. Inspected at least quarterly; and
 - B. Properly calibrated per the destruction facility's RCRA permit, or for non-RCRA facilities, calibrated at least quarterly to 5% or better accuracy. RCRA facilities that do not have calibration requirements defined in their RCRA permits must calibrate scales quarterly to 5% or better accuracy.
- II. For a destruction facility that is part of an enclosed equipment de-manufacturing system, the following requirements apply:
 - A. FTIR must be used to determine the mass and composition of ODS or high-GWP blowing agent and:
 - i. No more than one day prior to the commencement of the destruction event, conduct a check for calibration accuracy using a gas of known quality:

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- a. This check must demonstrate that the FTIR equipment is accurate to within +/- 1% relative to the reference gas;
 - ii. Conduct and record a daily zero validation of the FTIR equipment output;
 - iii. No more than one day prior to the end of the destruction event, conduct a check for calibration accuracy using a gas of known quality:
 - a. This check must demonstrate that the FTIR equipment is accurate to within +/- 1% relative to the reference gas
 - iv. The FTIR equipment must be calibrated by the manufacturer or a certified calibration service per manufacturer's specifications or every 5 years, whichever is more frequent. Instruments are exempted from calibration requirements if the manufacturer's specifications state that no calibration is required.
 - v. If a check on the FTIR equipment reveals accuracy less than +/- 1% threshold (reading relative to the reference gas), corrective action such as calibration by the manufacturer or a certified service provider is required for the FTIR equipment.
 - vi. If the check on the FTIR equipment reveals accuracy less than +/- 1% threshold during the check stipulated in Section 6.3 II A i, the destruction event may not commence until corrective action is performed and a subsequent check reveals accuracy within a +/-1% threshold
 - vii. If the check on the FTIR equipment reveals accuracy less than +/- 1% of threshold during the check stipulated in Section 6.3 II A iii, the mass and composition data from the FTIR equipment must be scaled per the following procedure. These adjustments must be made for the entire period from the check required in Section 6.3 II A i through to the end of the reporting period.
 - a. The project proponent shall calculate total emission reductions using:
 - 1. The monitored values without correction; and
 - 2. The monitored values adjusted based on the calibration drift recorded at the time of the check as required in Section 6.3 II A iii.
 - b. The lower of the two emission reduction estimates shall be reported as the emission reductions claimed for the reporting period.
- B. If a catalyst is used in the destruction process, maintenance procedures related to catalyst replacement, carbon filter cleaning or other system controls needed to ensure the required 99.99% destruction efficiency is maintained must be implemented in accordance with manufacturer's guidance and specifications.

6.4 DOCUMENT RETENTION

- I. The project proponent is required to keep all documentation and information outlined in this methodology.
- II. Information that must be retained by the project proponent includes:
 - A. All data inputs for the calculation of the offset project emission reductions, including all required sampled data;
 - B. Copies of all permits, Notices of Violations (NOVs), and any relevant administrative or legal consent orders dating back at least 3 years prior to the project commencement date;
 - C. Destruction facility monitoring and maintenance information (CEMS data, DRE documentation, scale readings, calibration procedures, calibration checks and daily zero validations (if applicable), manufacturer guidance pertaining to facility or technology maintenance, and permits);
 - D. Chain of custody and point of origin documentation; and
 - E. ODS and high-GWP blowing agent composition and mass determinations (i.e., from laboratory reports or other procedures included in this Methodology).

6.5 MONITORING PARAMETERS: QUANTIFICATION METHODOLOGY

The project proponent must monitor the parameters described in Table 3.

Table 3: Project Monitoring Parameters – Quantification Methodology

EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
		Legal Requirement Test	N/A	For each off-set project		Must be monitored and determined for each project
		Mass of ODS (or ODS mixture) or HFC in each container	Mass of mixture	Per container	M	Must be determined for each container

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EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
		Concentration of ODS (or ODS mixture) or HFC in each container	Mass ODS or HFC/ Mass of mixture	Per container	M	Must be determined for each container
		Mass of ODS or HFC destroyed in an enclosed equipment de-manufacturing system	Mass of mixture	Continuous	M	Readings taken and recorded every two minutes
		Concentration of ODS or HFC destroyed in an enclosed equipment de-manufacturing system	Concentration of ODS or HFC	Continuous	M	Readings taken and recorded every two minutes
		Mass of building foam used as source of ODS and high GWP blowing agent	Mass of building foam	For each off-set project	M	Must be monitored for each project
1	ER _t	Total quantity of GHG emission reductions during the reporting period	MT CO ₂ e	For each off-set project	C	
1 2	BE _t	Total quantity of baseline emissions during the reporting period	MT CO ₂ e	For each off-set project	C	

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EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
18	PE_t	Total quantity of project emissions during the reporting period	MT CO ₂ e	For each off-set project	C	
23	BE_{refr}	Total quantity of baseline emissions from refrigerant ODS	MT CO ₂ e	For each off-set project	C	
2410	BE_{foam}	Total quantity of baseline emissions from high-GWP blowing agent	MT CO ₂ e	For each off-set project	C	
26	BE_{aer}	Total quantity of medical aerosol ODS baseline emissions	MT CO ₂ e	For each off-set project	C	
27	BE_{fs}	Total quantity of fire suppressant ODS baseline emissions	MT CO ₂ e	For each off-set project	C	
39	$Q_{refr,i}$	Total quantity of refrigerant ODS <i>i</i> sent for destruction	MT ODS	For each off-set project	M	
3	$ER_{refr,i}$	10-year cumulative emission rate of refrigerant ODS <i>i</i>	0 - 1.0	N/A	R	See Table 4
346	GWP_i	Global warming potential of ODS or HFC <i>i</i>	MT CO ₂ e/ MT	N/A	R	See Tables 4-7

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EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
7			ODS or MT BA			
4	$EBA_{i,j}$	Total quantity of high-GWP blowing agent i extracted from foam and destroyed	MT BA	For each off-set project	C	
4 5	$BA_{intf,i}$	Total quantity of high-GWP blowing agent i in intact foam sent for destruction	MT BA	For each off-set project	C	
4	$ER_{i,j}$	10-year emission rate of high-GWP blowing agent i from application j	% (0-1)	N/A	R	See Table 5
5	$Q_{intf,i}$	Total mass of intact foam, i , with entrained high-GWP blowing agent sent for destruction	MT	For each off-set project	M	
5	$BA\%_{intf,i}$	Mass ratio of high-GWP blowing agent, i , entrained in intact foam	% (0-1)	For each off-set project	M	
6 11	$Q_{aer,i}$	Total quantity of medical aerosol ODS, i , sent for destruction	MT ODS	For each off-set project	M	

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EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
6	ER _{aer,i}	10-year cumulative emission rate of medical aerosol ODS <i>i</i>	0 - 1.0	N/A	R	See Table 6
7 12	Q _{fs,i}	Total quantity of fire suppressant ODS, <i>i</i> , sent for destruction	MT ODS	For each off-set project	M	
7	ER _{fs,i}	10-year cumulative emission rate of fire suppressant ODS <i>i</i>	0 - 1.0	N/A	R	See Table 7
8 9	Sub _{refr}	Total GHG emissions from substitute refrigerant	MT CO ₂ e	For each off-set project	C	
8 10	Rem _f	Total quantity of high-GWP blowing agent project baseline emissions from destruction of intact foam manually removed in a non-enclosed equipment de-manufacturing system	MT CO ₂ e	For each off-set project	C	
10	L _f	Default percentage of blowing agent that is lost in manual removal of intact foam in a non-	% (0-1)	For each off-set project	R	Equal to 10% for foam removed in a non-enclosed equipment de-manufacturing system

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EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
		enclosed equipment de-manufacturing system				
8 11	Sub _{aer}	Total GHG emissions from substitute medical aerosols	MT CO ₂ e	For each off-set project	C	
8 11	Sub _{fs}	Total GHG emissions from substitute fire suppressant	MT CO ₂ e	For each off-set project	C	
8 13	Tr&Des _t	Total GHG emissions from ODS and high-GWP insulation foam/blowing agent transportation and destruction	MT CO ₂ e	For each off-set project	C	
9 11 12	SE _i	Emission factor for substitute emissions of refrigerant, medical aerosol, or fire suppressant, <i>i</i>	MT CO ₂ e/ MT ODS destroyed	Per container	R	See Tables 4, 6, 7
13	Q _{ods}	Total quantity of refrigerant, medical aerosol and/or fire suppressant ODS sent for destruction	MT ODS	For each off-set project	M/C	

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EQUATION #	PARAMETER	DESCRIPTION	DATA UNIT	MEASUREMENT FREQUENCY	CALCULATED (C) MEASURED (M) REFERENCE (R) OPERATING RECORDS (O)	COMMENT
13	Q_{BA}	Total quantity of high-GWP blowing agent extracted from insulation foam and sent for destruction in the project	MT BA	For each off-set project	M/C	
13	Q_{intf}	Total mass of intact foam, i , with entrained high-GWP blowing agent sent for destruction	MT	For each off-set project	M/C	
13	EF	Default emission factor for transportation and destruction of ODS or High-GWP Blowing Agent foam	MT CO ₂ e/ MT ODS/ MT BA or MT	N/A	R	Equal to 7.5 MT CO ₂ e per MT for refrigerant, medical aerosol, or fire suppressant projects and blowing agent extracted from high-GWP foam Equal to 75 MT CO ₂ e per MT for intact foam projects

6.6 OTHER MONITORING REQUIREMENTS: QUANTIFICATION METHODOLOGY

This subchapter provides monitoring requirements in addition to the general requirements in subchapter 6.1.

- I. When transporting intact high-GWP insulation foam, all recovered foam pieces must be placed in air-tight and water-tight storage until arrival at the destruction facility.
- II. Projects using this Methodology to quantify emission reductions from extracted high-GWP foam blowing agent must meet all the following requirements:
 - A. The blowing agent must be extracted from the foam to a concentrated form prior to destruction.
 - B. The extraction must occur under negative pressure.
 - C. If the recovered blowing agent is not destroyed in an enclosed equipment de-manufacturing system, the recovered blowing agent must be collected, stored, and transported in containers meeting DOT standards for refrigerants and analyzed prior to destruction as specified in Appendix C.
 - D. The processes, training, QA/QC, and management systems relevant to the collection, storage, and transport of the blowing agent must be documented.
 - E. If the recovered blowing agent is destroyed in a destruction unit that is within an enclosed equipment de-manufacturing system, the blowing agent must be analyzed prior to destruction as specified in Appendix C.
- III. Projects destroying high-GWP blowing agent from intact foam must follow the procedures in Appendix B. The project proponent must collect and maintain documentation showing conformance with the procedures in Appendix B.
- IV. Projects destroying refrigerant ODS, medical aerosol ODS, fire suppressant ODS, or extracted high-GWP foam blowing agent must follow the procedures in Appendix C. The project proponent must collect and maintain information showing conformance with the procedures in Appendix C.

7 VERIFICATION REQUIREMENTS

- I. See the ACR Standard for guidance on project validation and verification requirements.
- II. An ODS or high-GWP insulation foam offset project requires only one site visit regardless of the number of destruction events within that reporting period.
- III. For the purpose of this Methodology, the site visit must include a visit to the destruction facility. The site visit may also include a visit to the project proponent's office(s) where all project-related documents and data were produced, managed, and retained. The site visit may also include a visit to any facility in the chain of custody, such as an aggregation facility or other point of origin.

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DEFINITIONS

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

Aggregation	The grouping together of multiple containers of ODS, high-GWP foam blowing agents, or high-GWP insulation foam into a single shipment or single container. Aggregation does not require the collected ODS to be combined into a single container. Multiple containers shipped together are considered an aggregate.
Appliance Foam	Insulation foam in domestic appliances such as refrigerators and freezers, water heaters, and in commercial appliances such as refrigerator display cases and vending machines.
Building Foam	Insulation foam used in roofing, flooring, or walls.
Certificate of Destruction	An official document provided by the destruction facility certifying the date, mass, and species of ODS or high-GWP foam blowing agents destroyed.
Container	An air-tight and water-tight unit for storing or transporting ODS, high-GWP foam blowing agents, or high-GWP insulation foam material without leakage or escape. Containers used in transporting project material must comply with all applicable U.S. Department of Transportation (DOT) requirements.
Destruction	The destruction of ODS, high-GWP foam blowing agents, or high-GWP insulation foam by qualified destruction, transformation or conversion plants achieving greater than 99.99% destruction and removal efficiency (DRE), so that the destroyed ODS, high-GWP foam blowing agents, or high-GWP insulation foam are not emitted to the atmosphere. Destruction may be performed using any technology, including transformation, that results in the complete breakdown of ODS, high-GWP foam blowing agents, or high-GWP insulation foam into a waste product, a usable by-product, or end product.
Destruction facility	A facility that destroys, transforms, or converts ODS, high-GWP foam blowing agents, or high-GWP insulation foam and conforms with the description in either subchapter 2.1 I A or 2.1 I B in this Methodology.

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Disqualified ODS, high-GWP foam blowing agents, or high-GWP insulation foam	ODS, high-GWP foam blowing agents, or high-GWP insulation foam that does not conform, or cannot be determined to conform, to the point of origin or chain of custody documentation requirements specified in chapter 6 of this Methodology and must be removed from baseline emission calculations pursuant to subchapter 5.3 in this Methodology.
Eligible ODS, high-GWP foam blowing agents, or high-GWP insulation foam	Those ODS, high-GWP foam blowing agents, or high-GWP insulation foam included in subchapter 2.2.1., 2.2.2, 2.2.3 and 2.2.4 in this Methodology.
Emission rate	The rate at which refrigerant, fire suppressant, medical aerosol, or foam blowing agent is released to the atmosphere.
Enclosed equipment de-manufacturing system	A system involving the disassembly and recycling of refrigerators and other appliances in which the cabinet, including insulation foam, is shredded and materials are recovered, measured, and destroyed in one or more enclosed, self-contained unit or units operating under negative pressure.
Essential Use Exemption	An exception, granted by the Parties to the Montreal Protocol, for continued production of medical aerosol ODS after the production prohibition for ODS used in other applications.
Fire suppression equipment/system	The equipment or system employed to control and extinguish fires used in any sector (including commercial, industrial, or residential).
Halons	A class of ODS that are powerful greenhouse gases and that contribute significantly to stratospheric ozone depletion. These substances are used in various fire suppression equipment and systems.
High-GWP Foam Blowing Agent	ODS or HFC entrained in insulation foam that was used in manufacture of the foam to provide insulation, structural and other performance properties. When reclaimed, ODS or HFC blowing agents have identical chemical properties as ODS or HFC refrigerants and may be sold and used as refrigerants. Unless they are reclaimed to virgin specifications, they cannot be sold on the market.

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Ineligible ODS	Those ODS, high-GWP foam blowing agents, or high-GWP insulation foam not included in subchapter 2.2.1., 2.2.2, 2.2.3 and 2.2.4 in this Methodology.
Intact foam	Insulation foam that is not shredded or compacted prior to destruction.
Medical aerosol	The propellant used to dispense medication from a self-pressurized container. Certain ODS species have been used as medical aerosols.
Metered dose inhaler (MDI)	A device that delivers a specific amount of medication to the lungs, used to treat asthma and other respiratory diseases.
Mixed ODS or high-GWP foam blowing agent	Less than or equal to 90% composition of a single ODS or high-GWP foam blowing agent species.
Non-enclosed equipment de-manufacturing system	A system in which insulation foam in refrigerators and other appliances is removed manually in an open space that is not under negative pressure.
Non-mixed ODS or high-GWP foam blowing agent	Greater than 90% composition of a single ODS or high-GWP foam blowing agent species.
Other Foam	Insulation foam used in refrigerated transportation, marine applications (such as boats and buoys), walk-in cooling units, and pipe-in-pipe/preformed pipe applications.
Ozone Depleting Substances (ODS)	Substances known to deplete the stratospheric ozone layer. The ODS controlled under the Montreal Protocol and its Amendments are chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons, methyl bromide (CH ₃ Br), carbon tetrachloride (CCl ₄), methyl chloroform (CH ₃ CCl ₃), hydrobromofluorocarbons (HBFC) and bromochloromethane (CHBrCl).
ODS or high-GWP foam blowing agent species	Any individual type of ODS or high-GWP foam blowing agent (e.g., CFC-11, CFC-113, HCFC-22, HFC-134a, etc.).

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Refrigeration or air conditioning equipment	A refrigeration or air conditioning appliance or system used in any sector (including commercial, industrial, or residential).
Startup, shutdown, and malfunction plan (SSMP)	A plan, as specified under 40 CFR 63.1206, that includes a description of potential causes of malfunctions, including releases from emergency safety vents, that may result in significant releases of hazardous air pollutants, and actions the source is taking to minimize the frequency and severity of those malfunctions.
Stockpile	ODS stored for future use or disposal in bulk quantities at a single facility. The ODS may be stored in multiple containers or a single container.
Substitute refrigerant, medical aerosol, or fire suppressant	Those refrigerants, medical aerosols, or fire suppressants that will be used to fulfill the function that would have been filled by the destroyed ODS refrigerants, medical aerosols, or fire suppressants. These refrigerants, medical aerosols, or fire suppressants may be drop-in replacements or may be used in new equipment or devices that fulfill the same market function.
Substitute emissions	GHG emitted from the use of substitute refrigerants, medical aerosols, or fire suppressants in technologies that are used to replace the ODS destroyed in a project.
Transformation or Conversion	The breakdown of a substance into a waste product, a usable by-product, or end-product.

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APPENDIX A: EMISSION FACTOR TABLES – QUANTIFICATION METHODOLOGY

Table 4: Parameters for ODS Refrigerants

ODS	100-YR GLOBAL WARMING POTENTIAL (MT CO ₂ E/MT ODS) (GWP _i)	10-YEAR CUMULATIVE EMISSION RATE (%/10 YEARS) (ER _{REFR,i})	SUBSTITUTE EMISSIONS (MT CO ₂ E/MT ODS) (SE _i)
CFC-11	4,750	89%	223
CFC-12	10,900	95%	686
CFC-13	14,400	61%	7,144
CFC-113	6,130	89%	220
CFC-114	10,000	78%	659
CFC-115	7,370	61%	1,139
HCFC-22	1,810	72%	389

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Table 5: Parameters for High-GWP Foam Blowing Agents

HIGH-GWP BLOWING AGENT	100-YR GLOBAL WARMING POTENTIAL (MT CO ₂ E/MT ODS OR BA) (GWP ₁₀₀)	APPLIANCE HIGH-GWP BLOWING AGENT 10-YEAR EMISSION RATE (ER ₁₀)	BUILDING HIGH-GWP BLOWING AGENT 10-YEAR EMISSION RATE (ER ₁₀)	"OTHER FOAM" HIGH-GWP BLOWING AGENT 10-YEAR EMISSION RATE (ER ₁₀)
CFC-11	4,750	70%	88%	88%
CFC-12	10,900	n/a	88%	88%
HCFC-22	1,810	87%	87%	88%
HCFC-141b	725	70%	87%	88%
HFC-134a	1,430	70%	88%	87%
HFC-245fa	1,030	71%	88%	89%

Table 6: Parameters for ODS Medical Aerosols

ODS	100-YR GLOBAL WARMING POTENTIAL (MT CO ₂ E/MT ODS) (GWP ₁₀₀)	10-YEAR CUMULATIVE EMISSION RATE (%/10 YEARS) (ER _{AER,10})	SUBSTITUTE EMISSIONS (MT CO ₂ E/MT ODS) (SE ₁)
CFC-11	4,750	100%	152
CFC-12	10,900	100%	
CFC-114	10,000	100%	

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Table 7: Parameters for ODS Fire Suppressants

ODS	100-YR GLOBAL WARMING POTENTIAL (MT CO ₂ E/MT ODS) (GWP ₁₀₀)	10-YEAR CUMULATIVE EMISSION RATE (%/10 YEARS) (ER _{FS,10})	SUBSTITUTE EMISSIONS (MT CO ₂ E/MT ODS) (SE ₁)
Halon 1211	1,890	46%	3
Halon 1301	7,140	57%	254

Table 8: ODS Carbon Ratio and Density

ODS	CARBON RATIO (CR _i)	DENSITY (G/CM ³)
CFC-11	12/137	1.494
CFC-12	12/121	1.486
CFC-13	12/104	1.526
CFC-113	24/187	1.560
CFC-114	24/171	1.455
CFC-115	24/154	1.568
HCFC-22	12/87	3.66
HCFC-141b	24/117	1.25
Halon 1211	12/165	1.8
Halon 1301	12/149	1.54
HFC-134a	12/90	4.25
HFC-245fa	12/134	5.84

APPENDIX B: MASS AND COMPOSITION FROM INTACT HIGH-GWP FOAM PROJECTS – QUANTIFICATION METHODOLOGY

- I. Prior to destruction, the precise mass and composition of intact high-GWP foam must be determined following the procedures described in this appendix.
 - A. The foam's mass shall be determined on scales at the destruction facility. The scales must be calibrated at least quarterly with a demonstrated +/- 5% or better accuracy.
 - B. Prior to determining building foam mass, any construction debris (e.g., wood, metal, glass) or any other non-foam material shall be separated from the foam.
- II. To determine the composition and mass ratio of the high-GWP foam blowing agent(s) present in the intact foam, the following sampling requirements apply:
 - A. For foams removed from buildings, at least two samples per building surface (e.g., wall, roof) must be taken;
 - B. For foams removed from walk-in coolers or refrigerated transportation, one sample from each unit must be taken;
 - C. For foams removed from pipes or marine applications, one sample must be taken from one unit from which foam will be taken for purposes of destruction (i.e. for projects that will aggregate multiple pipe sections or multiple units from marine sources such as buoys, one sample is required for each source type).
 - D. The samples must conform to all the following requirements:
 - i. Each sample must be at least 2 inches in length, 2 inches in width, and 2 inches thick;
 - ii. For storage and transport, each sample must be placed and sealed in a separate air-tight and water-tight container that is at least 2 millimeters thick;
 - iii. The analysis of high-GWP foam blowing agent content and mass ratio shall be performed at an independent laboratory unaffiliated with the project proponent. The analysis shall be done using one of the two following methods: (1) ASTM Method D 7132-14 Standard Test Method for Determination of Retained Blowing Agent in Extruded Polystyrene Foam or (2) the heating method to extract ODS blowing agent from the foam samples described in Scheutz *et al.* (2007). The Scheutz method must include all the following steps:

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- a. Each sample shall be prepared to a thickness no greater than 1 cm, placed in a 1123 mL glass bottle, weighed using a calibrated scale⁶, and sealed with Teflon-coated septa and aluminum caps;
 - b. To release the high-GWP blowing agent from the foam, the samples must be incubated in an oven for 48 hours at 140 degrees C;
 - c. When cooled to room temperature, gas samples must be redrawn from the headspace and analyzed by gas chromatography⁷;
 - d. The lids must be removed after analysis, and the headspace must be flushed with atmospheric air for approximately 5 minutes using a compressor. Afterwards, septa and caps must be replaced and the bottles subjected to a second 48-hr heating step to drive out the remaining high-GWP blowing agent from the sampled foam; and
 - e. When cooled down to room temperature after the second heating step, gas samples must be redrawn from the headspace and analyzed by gas chromatography⁸.
- E. The mass of high-GWP blowing agent(s) recovered shall then be divided by the total mass of the initial foam samples prior to analysis to determine the mass ratio of each high-GWP foam blowing agent present; and
- F. For foams removed from buildings, the results from all samples from a single building shall be averaged to determine the mass fraction of blowing agent in foam ($BA\%_{\text{intf},i}$) used in Equation 5.

⁶ The scale must be calibrated at least quarterly with a demonstrated +/- 1% or better accuracy

⁷ Room temperature is defined as a range between 20 and 25 degrees Celsius. Room temperature shall be recorded and documented at time of sampling.

APPENDIX C: MASS AND COMPOSITION FROM REFRIGERANT, MEDICAL AEROSOL, FIRE SUPPRESSANT AND EXTRACTED HIGH-GWP FOAM BLOWING AGENT PROJECTS – QUANTIFICATION METHODOLOGY

Prior to destruction, the precise mass and composition of ODS refrigerant, ODS medical aerosol, ODS fire suppression agent, and extracted high-GWP blowing agent must be determined.

- I. For ODS and high-GWP blowing agent extracted into containers prior to destruction, the following analysis must be conducted:
 - A. Mass must be determined by individually measuring the mass of each container first when it is full prior to destruction and then after destruction is complete. The mass of ODS or high-GWP blowing agent and any contaminants is equal to the difference between the full and empty mass, as measured. To be eligible to receive ERTs, all the following requirements must be met when weighing the containers:
 - i. A single scale conforming with the requirements in (subchapter 6.3) of this Methodology must be used for generating both the full and empty mass tickets at the destruction facility;
 - ii. The full mass must be measured no more than 48 hours prior to commencement of destruction per the CEMS data, if available, or the Certificate of Destruction;
 - iii. The empty mass must be measured no more than 48 hours after the conclusion of destruction per the CEMS data, if available, or, the Certificate of Destruction; and
 - iv. Each single compartment, cylinder, drum, or any other eligible ODS or high-GWP blowing agent container that has been identified and destined for destruction must

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- be weighed separately, sampled separately, and treated as a separate destruction event.
- v. Recovery, collection, and aggregation activities may occur until the container has been identified and destined for destruction. After the ODS or high-GWP blowing agent container has been identified and destined for destruction, ODS or high-GWP blowing agent must not be added or removed, except for the purpose of sampling and analysis.
- B. The following procedures must be applied for the full and empty masses required within 48 hours of both the commencement and conclusion of destruction, pursuant to subsections I A ii and I A iii in Appendix C of this Methodology:
- i. For containers permanently affixed to a detachable trailer:
 - a. The trailer must be detached from its transportation vehicle, and the trailer must be weighed separately from its transportation vehicle;
 - b. Any accessories, such as spare tires or tire chains, or any part of the trailer's load other than the ODS or high-GWP blowing agent which are included in the trailer's full mass prior to ODS or high-GWP blowing agent destruction must be included in the trailer's empty mass after destruction; and
 - c. A container with a capacity over 1,000 pounds must be placed on the scale motionless for at least 3 minutes to allow the mass to stabilize before the mass measurement is recorded.
 - ii. For containers not permanently affixed to a truck or detachable trailer:
 - a. Each container may be weighed by placing it individually on the scale prescribed in subsection I A i in Appendix C of this Methodology; and
 - b. A container with a capacity over 1,000 pounds must be placed on the scale motionless for at least 3 minutes to allow the mass to stabilize before the mass measurement is recorded.
 - iii. For containers weighed with the transportation vehicle included:
 - a. The driver and any other passengers must exit the vehicle such that their mass is not included;
 - b. Any accessories, such as spare tires or tire chains, or any part of the truck's load other than the ODS or high-GWP blowing agent which are included in the truck's full mass prior to ODS or high-GWP blowing agent destruction must be included in the truck's empty mass after destruction;
 - c. If more than 1,000 pounds of ODS or high-GWP blowing agent is being transported for destruction, then the truck must be situated motionless on the scale for at least 3 minutes to allow the mass to stabilize before the mass measurement is recorded.

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- d. The transportation vehicle's weight classification and load rating must be recorded;
 - e. The transportation vehicle's fuel capacity must be recorded. Its fuel level at the time of each scale recording must also be recorded. Fuel level must be recorded in an increment of one eighth of the fuel tank capacity. If the fuel level is in between two increments, the fuel level prior to ODS or high-GWP blowing agent destruction must be rounded down and the fuel level after ODS or high-GWP blowing agent destruction must be rounded up;
 - f. If the transportation vehicle's fuel level is lower after destruction than the fuel level before destruction, the difference in fuel mass must be subtracted, as applicable from $Q_{\text{refr},i}$ in Equations 3 and 9, $EBA_{,i}$ and $BA_{\text{intf},i}$ in Equation 5, Q_{aer} in Equations 6 and 11, $Q_{\text{fs},i}$ in Equation 7 and Equation 12, and Q_{ODS} , Q_{BA} , and Q_{intf} in Equation 13. The following fuel densities shall be used to adjust for mass:
7.0851 lb/gal for diesel; or
6.0023 lb/gal for gasoline; and
 - g. If different transportation vehicles are used to transport containers to a destruction facility and to pick up the empty containers after destruction, each transport vehicle shall be weighed both upon its arrival and departure from the destruction facility. If the vehicle transporting the full ODS containers to the destruction facility weighs more than the vehicle carrying the empty ODS containers from the facility, the mass discrepancy must be subtracted, as applicable from $Q_{\text{refr},i}$ in Equations 3 and 9, $EBA_{,i}$ and $BA_{\text{intf},i}$ in Equation 5, Q_{aer} in Equations 6 and 11, $Q_{\text{fs},i}$ in Equations 7 and Equation 12, and Q_{ODS} , Q_{BA} , and Q_{intf} in Equation 13.
- C. Composition and concentration of ODS or high-GWP blowing agent must be established for each individual container by taking a sample from each container of ODS or high-GWP blowing agent and having it analyzed for composition and concentration at an AHRI-certified laboratory using the AHRI Standard 700 – Specifications for Refrigerants (AHRI 700). The laboratory performing the composition analysis must not be affiliated with the project proponent. All the following requirements must be met for each sample:
- i. The sample must be taken while ODS or high-GWP blowing agent is in the possession of the company that will destroy the ODS or high-GWP blowing agent;
 - ii. Samples must be taken by a technician unaffiliated with the project proponent; if the destruction facility is the project proponent, an outside technician must perform this task;
 - iii. Samples must be taken with a clean, fully evacuated sample bottle that meets applicable DOT requirements with a minimum capacity of one pound;
 - iv. Each sample must be taken in liquid state;

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- v. A minimum sample size of one pound must be drawn for each sample;
- vi. Each sample must be individually labeled and tracked according to the container from which it was taken, and all the following information recorded:
 - a. Time and date of sample;
 - b. Name of project proponent;
 - c. Name of technician taking sample;
 - d. Employer of technician taking sample;
 - e. Volume of container from which sample was extracted; and
 - f. Ambient air temperature at time of sampling; and
 - g. Chain of custody for each sample from the point of sampling to the AHRI-certified lab must be documented by paper bills of lading or electronic, third-party tracking that includes proof of delivery.
- D. All project samples shall be analyzed using AHRI 700 to confirm the mass percentage and identification of each component of the sample. The analysis shall provide:
 - i. Identification of the ODS or high-GWP blowing agent;
 - ii. Purity (%) of the ODS or high-GWP blowing agent mixture by mass using gas chromatography;
 - iii. Moisture level in parts per million. The moisture content of each sample must be less than 75% of the saturation point for the ODS or high-GWP blowing agent based on the temperature recorded at the time the sample was taken;
 - a. For non-mixed ODS or high-GWP blowing agent, the saturation point is the saturation point of the major ODS or high-GWP blowing agent species;
 - b. For mixed ODS or high-GWP blowing agent, the saturation point is the lowest saturation value of any species that makes up at least 10% of the composition;
 - iv. Analysis of HBR, which must be less than 10% by mass; and
 - v. Analysis of other ODS or high-GWP blowing agent in the case of mixtures of ODS or high-GWP blowing agent, and their percentage by mass.
- E. If any of the requirements in sections I A through I C of this appendix are not met, no GHG reductions may be verified for ODS or high-GWP blowing agent destruction associated with that container.
- F. If a container holds non-mixed ODS or high-GWP blowing agent, no further information or sampling is required to determine the mass and composition of the ODS or high-GWP blowing agent. For non-mixed ODS or high-GWP blowing agent, the analysis conducted for the sample taken at the destruction facility must be used for quantifying GHG emissions.

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- G. If the container holds mixed ODS or high-GWP blowing agent, the project proponent must meet all the following additional requirements:
- i. The required sampling may be conducted at the final destruction facility or prior to delivery to the destruction facility;
 - ii. Circulation and sampling activities must be conducted by a contracted third-party and by individuals who have been properly trained for the functions they perform;
 - iii. The offset project documentation must specify the procedures by which mixed ODS or high-GWP blowing agent are analyzed;
 - iv. Prior to sampling, the ODS or high-GWP blowing agent mixture must be circulated in a single container or two connected containers that meet all the following criteria:
 - a. The containers have no solid interior obstructions;
 - b. The containers were fully evacuated prior to filling;
 - c. The containers must have sampling ports to sample liquid and gas phase ODS or high-GWP blowing agent;
 - d. The sampling ports must be located in the middle third of all of the containers (i.e., not at one end or the other); and
 - e. The containers and associated equipment can circulate the mixture via a closed loop system from the bottom to top for a single container, or from the bottom of one tank to the top of another tank if two connected containers are used.
 - v. If the original mixed ODS or high-GWP blowing agent container or two connected containers do not meet these requirements, the mixed ODS or high-GWP blowing agent must be transferred into a temporary holding tank or container or two connected containers that meet all the above criteria. The mass of the contents placed into the temporary container or two connected containers shall be calculated and recorded. During transfer of ODS or high-GWP blowing agent into and out of the temporary container or two connected containers, ODS or high-GWP blowing agent shall be recovered to the vacuum levels required by the U.S. EPA for that ODS or high-GWP blowing agent (see 40 CFR 82.156);
 - vi. Once the mixed ODS or high-GWP blowing agent is in a container, two connected containers, or temporary storage unit that meets the criteria above, circulation of mixed ODS or high-GWP blowing agent must be conducted as follows:
 - a. Liquid mixture shall be circulated from the liquid port to the vapor port for a single container, or from the liquid port of one tank into the vapor port for another tank if two connected containers are used;
 - b. A volume of the mixture equal to two times the volume in the container shall be circulated;

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- c. Calculations converting between mass and volume shall use the densities provided in Table 8; if converting between mass and volume, the mixed ODS or high-GWP blowing agent must be in a liquid state;
 - d. Circulation must occur at a rate of at least 30 gallons/minute; and
 - e. Start and end times shall be recorded;
 - vii. Within 30 minutes of the completion of circulation, a minimum of two samples shall be taken from the bottom liquid port for a single container, or minimum of two samples must be taken from the liquid port of each tank if two connected tanks are used and both samples must be analyzed at an AHRI-certified laboratory; and
 - viii. The project proponent must calculate the project GHG emission reductions using both sample results, and choose the sample resulting in the lower project emission reductions.
- II. Refrigerant and extracted high-GWP blowing agents destroyed in enclosed equipment de-manufacturing systems shall be analyzed using FTIR. FTIR shall be used to determine the mass and composition of each ODS refrigerant and extracted high-GWP blowing agent destroyed.

APPENDIX D: DISCUSSION AND RATIONALE FOR UPDATES TO CARB ODS PROTOCOL

The California Air Resources Board (CARB) ODS Destruction Protocol was first adopted in 2011 and subsequently revised in 2014. The CARB ODS Protocol is essentially a re-formatting of the 2011 CARB ODS Protocol with no major substantive changes. In turn, the 2011 CARB ODS Protocol, with some minor exceptions, is based on a voluntary ODS protocol which was first developed in 2008-2009 and approved in 2010.

Consequently, all the underlying information relevant to additionality, quantification, and monitoring in the CARB ODS Protocol trace back to data and other information from 2008-2009 or earlier. In the nearly 7 years since, there have been several significant changes in underlying regulatory conditions, market dynamics, and baseline scenarios, and new technical data. These changes are summarized here for each of the major updates in this Methodology.

D.1 HIGH-GWP INSULATION FOAM

D.1.1 Eligibility of High-GWP Blowing Agents

The CARB ODS Protocol lists several ODS foam blowing agents that are eligible for destruction credits – CFC-11, CFC-12, HCFC-22, and HCFC-141b. These ODS were discontinued from use in foam applications beginning in 1996, and more recently in the case of HCFC-141b and HCFC-22, in 2003 and 2009, respectively. This Methodology adds two HFCs to the list of eligible blowing agents for foam destruction projects – HFC-134a and HFC-245fa.

These HFCs are in production in the U.S. for use in the manufacture of foam products, particularly appliance foam. Destruction of foam recovered from end-of-life appliances does not trigger additional production of the HFC blowing agents beyond what would be produced anyway.

At a macro-level, when an appliance reaches end-of-life, demand is created for the manufacture of a new replacement appliance. For example, the decision to purchase a new refrigerator-freezer, in general, is made when the old fridge is discarded. That decision at the consumer level translates to a decision at the manufacturing level to produce a new fridge. Today, the new fridge may be manufactured with insulation foam containing HFC-134a, HFC-245fa, or in some

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cases, a hydrocarbon-based blowing agent. Regardless of how the foam in the end-of-life appliance is discarded - shredded and landfilled (the baseline scenario), or incinerated in conformance with this Methodology - the same quantity of new blowing agent will be produced for use in a newly manufactured appliance. As is the case for ODS refrigerants and the other eligible ODS categories in this Methodology, destruction of CFC, HCFC, and HFC blowing agents therefore prevents greenhouse gas emissions that would otherwise occur under the baseline scenario (shredding and landfilling of the foam).

D.1.2 Eligibility of High-GWP Foam Sources

In addition to the inclusion of new high-GWP foam blowing agents, this Methodology has been expanded to include additional foam sources. The CARB ODS Protocol only allows foam removed from appliances or buildings. Based on industry communications and research conducted during the development of this Methodology, it was determined that there were no compelling reasons to exclude additional sources of high-GWP foam. Therefore, the following sources have been added:

- Walk-in coolers,
- Refrigerated transportation,
- Refrigeration cases,
- Pipe-in-pipe/preformed pipe, and
- Marine applications.

D.1.3 Foam Baseline Emission Rates

For quantification of baseline emissions of ODS from appliance foam, the CARB ODS Protocol used estimates of how ODS blowing agents are released during: (a) foam shredding, (b) foam compaction, and (c) landfill decomposition. Foam shredding and foam compaction release rates of ODS blowing agents were estimated to be 24% and 19%, respectively, derived from research at the Institute of Environment and Resources at the Technical University of Denmark (Kjeldsen et al., 2000, 2003).

The estimated release of ODS from shredded foam material in the landfill used in the CARB ODS Protocol was derived from a laboratory study (Scheutz et al., 2007) where pure ODS blowing agent was mixed in test tubes with simulated landfill material, and inoculated with anaerobic bacteria capable of digesting CFCs and HCFCs. As noted by the investigators, the study was not intended to reflect real world conditions, for example:

- The idealized anaerobic conditions maintained in the laboratory test tubes would be unlikely in an active landfill;

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- The “landfill” material in the study contained only shredder residue, rather than the diverse mix of solid waste in a typical municipal landfill; and,
- In contrast to the simulated conditions in the experiments, actual landfills would not be biologically pretreated, and there would be larger quantities of landfill gas generated.

Scheutz et al. (2007) modeled two diffusion rate coefficients to analyze the sensitivity of this factor in predicting the fraction of blowing agent that would be released in landfilled foam (see Table 9).

Table 9: Summary of results from Table 3 of Scheutz et al. (2007)

PERCENTAGE OF BLOWING AGENT RELEASED FROM LANDFILLED FOAM	CFC-11	HCFC-141B	CFC-12	HCFC-22
Lower Bound (%)	35	41	52	100
Upper Bound (%)	83	91	98	100
Mid-Point (%)	59	66	75	100

The voluntary protocol upon which the CARB ODS Protocol is based used only the lower bound result from the Scheutz et al. (2007) modeling (35% of the CFC-11 blowing agent remaining in the landfilled material would be released in the landfill), and conservatively assumed that 95% of that CFC-11 would undergo anaerobic degradation in landfills. This resulted in an estimate that 1% ($0.35 * (1-.95)$) of the CFC-11 blowing agent in landfilled appliance foam would be released to the atmosphere.

A German research institute (RUK Ingenieurguppe, 2012) subjected the assumptions made in Scheutz et al. (2007) to experimental and computational checks and concluded the following:

- Scheutz et al. (2007) assumed that the half-life of the anaerobic degradation of CFC-11 was **ten times** longer than that indicated by the laboratory experiments;
- A value of 5% for the percentage of CFC-11 that would not undergo anaerobic degradation is only justified for the kind of “mono-landfill” investigated by Scheutz et al. (2007) that generates very small quantities of landfill gas. Only in very rare cases will the type of mono-landfill assumed in the CARB ODS Protocol provide an adequate representation of baseline emissions; and
- The value assumed for the percent of ODS blowing agent degraded should reflect the particular type of landfill under consideration.

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RUK Ingenieurguppe calculated CFC-11 landfill degradation rates for a range of solid-waste disposal sites representing a range of climate zones. The re-calculated degradation rates are based on case studies using the landfill gas forecasting model used in CDM and JI projects, approved by the UNFCCC (see Table 10).

Table 10: Recalculated degradation rates for solid waste disposal in various climate zones

LOCATION	CLIMATE ZONE	PERCENT OF RELEASED CFC-11 BLOWING AGENT NOT DEGRADED IN ANAEROBIC LANDFILL CONDITIONS
Europe: Central, without biological pre-treatment ⁸	Wet temperate	83.6%
Europe: Northern	Wet temperate	64.2%
Asia: South-central	Moist and wet tropical	62.9%
Africa: Southern	Wet temperate	61.9%
America: Central	Dry tropical	55.2%
Asia: Western & Middle East	Dry temperate	48.3%
Minimum: mono-landfill for shredder waste	(no relevant influence)	5.0%

More recently, CARB and the California EPA commissioned a study by the Global Waste Research Institute at California Polytechnic State University, the University of California-Irvine, and the University of Illinois at Chicago to assess fluorochemical (CFCs, HCFCs, HFCs) emissions from discarded appliance and building foam insulation in landfills (Yesiller et al., 2016). The study consisted of: 1) a comprehensive literature review of emissions data for fluorocarbon blowing agents from landfills; 2) a materials flow analysis to quantify emissions between appli-

⁸ All locations in Europe, with the exception of Northern Europe, were calculated for landfills without biological treatment.

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ance and building material end of life and time of entry to landfills; and 3) an extensive field testing program at a landfill in Northern California to measure air quality and gas emissions under different cover types and over different seasons.

D.1.3.1 BASELINE BLOWING AGENT EMISSION RATES FOR FOAM WASTE PRIOR TO LANDFILLING

Table 11 provides the estimated rates by which different blowing agents are released during different stages of appliance foam waste disposal up to the time the foam waste is landfilled. The values are from the materials flow analysis conducted by Yesiller et al. (2016) which quantified blowing agent emissions between appliance end-of-life and the time of entry of the foam waste to the landfill. The values are the proportions of remaining blowing agents released at different stages of foam disposal relative to the initial amount of blowing agents present in new foam materials at the beginning of service life.

For this Methodology, the baseline scenario for appliance foam disposal is shredding of the appliance, with no manual foam recovery, followed by landfilling of the foam material.

The investigators did not include HCFC-22 blowing agent in their analysis; for this Methodology, the emission rates calculated in Yesiller et al. (2016) for HCFC-141b are assumed for HCFC-22.

Table 11: Calculated Blowing Agent Release Fractions from Domestic Appliance Foam Waste

DISPOSAL STAGE	FRACTION OF THE INITIAL BLOWING AGENT CONTENT RELEASED (%)			
	CFC-11	HCFC-141b	HFC-134a	HFC-245fa
Foam Recovery	4	4	4	4
Transportation	2	1.3	2.3	2.6
Shredding	24	24	24	24
Stockpiling at Landfill for Alternative Daily Cover	2.2	2.3	2.2	2.2
Total Excluding Foam Recovery	28.2	27.6	28.5	28.8

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Tables 12 through 15 present the pre-landfill blowing agent emission rates for the other foam waste categories that were quantified in the Yesiller et al. (2016) materials flow analysis.

Table 12: Calculated Blowing Agent Release Fractions from Building Foam Waste⁹

DISPOSAL STAGE	FRACTION OF THE INITIAL BLOWING AGENT CONTENT RELEASED (%)			
	CFC-11	HCFC-141b	HFC-134a	HFC-245fa
Decommissioning	3	3	3	3
Transportation	2.6	2	2.3	2.4
Shredding	24	24	24	24
Stockpiling at Landfill for Alternative Daily Cover	2.5	2.1	2.9	2.75
Total without Decommissioning¹⁰	29.1	28.1	29.2	29.2

⁹ Yesiller et al. (2016) analyzed blowing agent emissions from end-of-life building insulation in construction and demolition foam waste.

¹⁰ Blowing agent emissions from building decommissioning are not included in the baseline because the same emissions would occur in the project scenario.

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Table 13: Calculated Blowing Agent Release Fractions from Commercial Appliance/Water Heater Foam Waste¹¹

DISPOSAL STAGE	FRACTION OF THE INITIAL BLOWING AGENT CONTENT RELEASED (%)			
	CFC-11	HCFC-141b	HFC-134a	HFC-245fa
Transportation	1.63	1.2	1.9	2
Shredding	24	24	24	24
Stockpiling at Landfill for Alternative Daily Cover	4.4	4.4	4.5	5
Total	30	29.6	30.4	31

Table 14: Calculated Blowing Agent Release Fractions from Refrigerated Transport Foam Waste¹²

DISPOSAL STAGE	FRACTION OF THE INITIAL BLOWING AGENT CONTENT RELEASED (%)			
	CFC-11	HCFC-141b	HFC-134a	HFC-245fa
Transportation	1	1	1	1
Shredding	24	24	24	24
Stockpiling at Landfill for Alternative Daily Cover	4.4	4.4	4.5	5
Total	29.4	29.4	29.5	30

¹¹ Commercial appliances include grocery display cases, stand-alone refrigeration equipment, and vending machines.

¹² Refrigerated transport includes the transport refrigerated units used for transportation of perishable goods in trucks, vans, rail units, and ships.

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Table 15: Calculated Blowing Agent Release Fractions from Marine and Other Waste Foams¹³

DISPOSAL STAGE	FRACTION OF THE INITIAL BLOWING AGENT CONTENT RELEASED (%)			
	CFC-11	HCFC-141b	HFC-134a	HFC-245fa
Transportation	1.2	1.1	1	1.1
Shredding	24	24	24	24
Stockpiling at Landfill for Alternative Daily Cover	4.4	4.4	4.6	5
Total	29.6	29.5	29.6	30.1

D.1.3.2 BASELINE BLOWING AGENT EMISSION RATES FROM FOAM WASTE IN THE LANDFILL

Based upon analysis of published landfill modeling studies, including the Scheutz et al. studies relied upon in the original ODS destruction protocol adopted by CARB, as well as relevant additional studies (Scheutz and Kjeldsen, 2003; Fredenslund et al., 2005; ICF, 2011), Yesiller et al. (2016) estimated release rates of fluorochemical blowing agents in the landfill environment over three time periods, summarized in Table 16. The shredded insulation foam waste category includes both domestic and commercial insulation foam waste. The “Panel Insulation Foam” category includes building foam and other types of foam (e.g., refrigerated transport, marine, walk-in coolers).

The time periods for blowing agent releases in the landfill were defined by Yesiller et al. (2016) to include the following processes:

- Initial releases from compaction of shredded foam or discarded foam panels
- Short-term releases over hours to days occurring during the aerobic period as well as during the adjustment period from aerobic to complete anaerobic degradation
- Long-term releases over weeks to years from microbial degradation

¹³ Marine and other foam insulation includes foam used in boats and walk-in cold storage applications.

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Table 16: Baseline Emission Rates for Blowing Agents in the Landfill Environment¹⁴

WASTE TYPE	INITIAL RELEASE	SHORT-TERM RELEASE	LONG-TERM RELEASE WITH LANDFILL GAS RECOVERY
Shredded Insulation Foam Waste	10%	14%	18%
Panel Insulation Foam Waste	11%	19%	29%

D.1.3.3 AGGREGATED BASELINE BLOWING AGENT EMISSION RATES

Table 17 combines the pre-landfill emission rates of blowing agents from foam wastes encompassing foam waste transportation, foam shredding, and foam stockpiling (Tables 11 through 15) as well as blowing agent releases from foam waste in the landfill (Table 16). For purposes of this Methodology, the foam categories used by Yesiller et al. (2016) are divided into three categories: appliance foam, building foam, and “other foam”.

The appliance foam category includes both domestic and commercial appliances and water heaters. Under the baseline scenario, it is assumed that foam recovered from these units are shredded prior to landfilling. The “pre-landfill” blowing agent emission rates for domestic appliance foam waste calculated by Yesiller et al. (2016) are lower than those for commercial appliances and water heaters; therefore, the blowing agent emission rates for domestic appliance foam waste are used to represent the appliance foam category.

The “other foam” category includes insulation used for commercial appliances, water heaters, refrigerated transport, boats, walk-in coolers, and other miscellaneous applications. Yesiller et al. (2016) calculated nearly identical emission rates for the various foam waste types in the “other” category; for purposes of this Methodology, the rates calculated for refrigerated transport foam are assigned to the “other foam” category because they are the lowest rates reported in the study.

Pre-landfill emission rates for CFC-12 and HCFC-22 blowing agent were not calculated in the materials flow analysis by Yesiller et al. (2016) although both were included in the literature review analysis of landfill emission rates and in the field measurements at the California landfill.

¹⁴ From Table 1.10 in Yesiller et al. (2016); values presented are the mean estimates for the various categories.

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For purposes of this Methodology, rates calculated for CFC-11 blowing agent are assigned to CFC-12 blowing agent, and emission rates for HCFC-141b are assigned to HCFC-22.

Table 17: Emission Rates for Blowing Agents in Appliance, Building, and Other Foam in Baseline Scenario

HIGH-GWP BLOWING AGENT	APPLIANCE HIGH-GWP BLOWING AGENT 10-YEAR EMISSION RATE (ER _{i,j})	BUILDING HIGH-GWP BLOWING AGENT 10-YEAR EMISSION RATE (ER _{i,j})	“OTHER FOAM” HIGH-GWP BLOWING AGENT 10-YEAR EMISSION RATE (ER _{i,j})
CFC-11	70.2%	88.1%	88.4%
CFC-12	n/a	88.1%	88.4%
HCFC-22	87.1%	87.1%	88.4%
HCFC-141b	69.6%	87.1%	88.4%
HFC-134a	70.5%	88.2%	87.5%
HFC-245fa	70.8%	88.2%	89%

D.1.4 High-GWP Foam Emissions Reduction Quantification

In addition to the changes regarding emission rates discussed above, this Methodology significantly simplifies the process of emission reduction quantification for high-GWP foam projects that extract blowing agents. The CARB ODS Protocol requires the calculation of a recovery efficiency which has been removed as it was unnecessary to accurately determine baseline emissions for blowing agents that are extracted and concentrated. The concept of recovery efficiency was also applied in the determination of foam project emissions.

D.1.5 High-GWP Foam Blowing Agent Concentration and Analysis

This Methodology preserves the ability of a project proponent to extract high-GWP blowing agents, containerize them, and have the constituents analyzed just as any refrigerant, medical aerosol, or fire suppressant ODS destruction project. However, it is highly unlikely, due to cost

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and complexity, that this method will be employed in practice. To that end, the Methodology includes provisions for the destruction of extracted blowing agents in enclosed equipment de-manufacturing systems. Recently, new equipment de-manufacturing technologies have been introduced that allow for a closed loop process where blowing agents are extracted and destroyed in enclosed systems. These systems are capable of real time analysis of constituent gases as well as the determination of total volumes destroyed over selected time frames. The Methodology includes requirements for the necessary continuous monitoring and maintenance of these systems.

D.1.6 Project Emissions During Removal of Foam from Appliances

For appliance foam ODS destruction projects that do not involve foam extraction within an enclosed appliance de-manufacturing system, project emissions include the ODS foam blowing agent that is released during manual removal of the foam from the interior walls of the appliance. The 2005 TEAP Task Force on Foam End-of-Life Issues (TEAP 2005) cited research (JTCCM, 2004) that showed that emissions of ODS blowing agent from manual removal of foam can range from 1.5 to 5%.

A more recent life-cycle analysis on appliances used an assumption based on industry input that emissions of blowing agent from manual foam removal can range from 10-15% but could be lower if best practices are used (ICF, 2011). The industry input was provided by two U.S. appliance recyclers. One of the recyclers had employed manual foam removal in unconfined space. That company is no longer operating and has since been replaced in the market by a business that relies exclusively on enclosed equipment de-manufacturing in which the insulation foam is separated in a closed system under negative pressure, resulting in no fugitive emissions.

The Yesiller et al. (2016) analyses calculated blowing agent emissions from appliance foam recovery rate in the range of 4% of the initial blowing agent content (see Table 11).

Given the full range of estimates (1.5% to 15%), and the more recent trends in the U.S. towards more advanced appliance recycling technology, this Methodology applies a default value of 10% for the ODS blowing agent project emissions from removal of foam from appliances in a non-enclosed equipment de-manufacturing system, as specified in Equation 10.

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D.2 HCFC-22 REFRIGERANT

HCFC-22 was excluded as an eligible refrigerant at the time of development of early ODS destruction protocols because HCFC-22 production in the U.S. was not controlled.¹⁵ Beginning in 2010, the phase out of HCFC-22 began in the U.S. under the U.S. Clean Air Act. As of January 1, 2010, production and import of HCFC-22 was banned except for servicing equipment manufactured before January 1, 2010.

Newer equipment manufactured after January 1, 2010 must be serviced with reclaimed HCFC-22 refrigerant. To service older equipment, the U.S. EPA has issued annual production and import consumption¹⁶ allowances, with a declining cap, to 21 companies, including chemical producers and equipment manufacturers. EPA has developed its annual allocations based on precise calculations of the servicing needs of the industry (EPA, 2014 – see Table 18). These allocations will continue through 2019. On January 1, 2020, all production and import of HCFC-22 will end in the U.S.

Table 18: EPA's Annual HCFC-22 Consumption Allowances Relative to Baseline

YEAR	% OF BASELINE
2009	100
2010	41.9
2011	32.0
2012	17.7
2013	18.0
2014	14.2
2015	7.0
2016	5.6
2017	4.2

¹⁵ Destruction credits for HCFC-22 foam blowing agent was allowed because its use in the U.S. as a blowing agent ended as of March 1, 2008.

¹⁶ Consumption = (Production + Imports) - Exports

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YEAR	% OF BASELINE
2018	2.8
2019	1.4
2020	0

D.2.1 Additionality of HCFC-22 Destruction

First, as is the case for CFCs, there is no requirement for destruction of HCFC-22 in the U.S.

Second, as also is the case for CFC refrigerants, under business as usual, all HCFC-22 currently in equipment will either leak, or be recovered for re-use in other leaky equipment. Thus, all HCFC-22 that has been produced will ultimately be released to the atmosphere.

The question is whether destruction of HCFC-22 would trigger *new* production and therefore has no net benefit.

This Methodology enables offset credits from destruction of HCFC-22 only under the condition that the HCFC-22 is recovered from refrigeration or air conditioning equipment and that equipment is subsequently de-commissioned as part of the project. Destruction of HCFC-22 stock-piles is not eligible for offset credits. Because of the hard caps established by EPA, destruction of HCFC-22 recovered from retired equipment cannot trigger any additional production or importation:

- Manufacture of new equipment containing HCFC-22 is prohibited; the retired equipment would be replaced with new equipment containing alternative refrigerants such as HFCs, HFOs, hydrocarbons, ammonia, or CO₂;
- Removal of HCFC-22 from the “national inventory” via destruction could not be replaced by new production or import, but it would increase incentives for recovery and recycling/reclamation of remaining sources of HCFC-22.

There is no expected adverse impact in terms of affecting the market availability of HCFC-22 needed for servicing older equipment. Any destruction would be done on a voluntary basis to accelerate the retirement of older equipment. Companies with annual consumption allowances can be expected to maximize the quantities of HCFC-22 that they produce and/or import to build up inventories for future needs, regardless of how much HCFC-22 is destroyed.

D.2.2 HCFC-22 Emission Rate

Table 19 summarizes the calculation of the 10-year emission rate for HCFC-22 from refrigeration and air conditioning equipment. Recent data and modeling assumptions from the EPA and the CARB (CARB, 2009) are incorporated.

Table 19: 2015 Weighted Average Annual Loss Rate Percent and Market Share for HCFC-22

REFRIGERATION AND A/C SECTOR	HCFC-22 MARKET SHARE ¹⁷	HCFC-22 ANNUAL LOSS RATE ¹⁸
Mobile	-	-
Large Refrigeration	17%	27%
Large A/C	83%	5%
Market-Weighted Annual Loss Rate	12.1%	
10-year Total Loss	72%	

D.2.3 HCFC-22 Substitute Emissions

The GHG emissions of substitute refrigerants associated with project scenario emissions are estimated using Equation 9. The approach is based on the fact that by removing ODS refrigerant through destruction projects – including HCFC-22 - from the re-sale market, substitute refrigerants will be required to fulfill demand in the U.S. for refrigeration and air conditioning. The impacts of these substitute refrigerants are calculated for different end-use categories based on leak rates, relative charge sizes, and the proportion of HCFC-22 used, as modeled by the EPA Vintaging Model (U.S. EPA 2015a). Market share allocations account for recently published EPA SNAP regulations that make several HFC refrigerants unacceptable for use for commercial refrigeration and air conditioning applications, with effective dates ranging from 2016 to 2020

¹⁷ Calculated from U.S. EPA data on average charge sizes for commercial A/C, chillers, retail food refrigeration, cold storage, and industrial process refrigeration systems and U.S. Department of Energy data on commercial buildings in the U.S.

¹⁸ From U.S. EPA Vintaging Model and CARB data on refrigeration and air conditioning leak rates in California facilities.

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(80 FR 42870, July 20, 2015; EPA, 2015b). Table 20 provides the calculations of emissions of substitute refrigerants associated with destruction of HCFC-22.

Table 20: Calculation of Substitute Emissions for HCFC-22

APPLI- CATION	HCF C-22 MAR	HCFC-22 SUBSTI- TUTE	MARKET SHARE RELATIVE TO SUB- SECTOR (BY MASS)	OVER- ALL HCFC- 22 MAR- KET SHARE	GWP	RELA- TIVE CHARGE SIZE (LB SUB/ LB ODS)	SUB USED TO REPLACE ONE LB HCFC-22 (LBS)	LOSS RATE OF SUB (%/YR)	10-YR LBS CO ₂ E/ ODS DE- STROYED
Large Refriger- ation	0.32	R-407C	50%	16%	1774	0.78	0.125	2%	40.59
		HFC- 134a	5%	1.6%	1430	1.4	0.02	18%	27.69
		CO ₂	22.5%	7.2%	1	1	0.07	2%	0.01
		Hydro- carbons	22.5%	7.2%	1	1	0.07	2%	0.01
Large A/C	0.68	HFC- 134a	85%	57.74%	1430	1.4	0.808	3%	303.50
		R-407C	10%	6.79%	1774	0.76	0.052	2%	16.75
		HFOs	5%	3.40%	1	0.76	0.026	1%	0.0025
		HCFC-22-Sub Emissions (lbCO ₂ e/lbHCFC-22 destroyed)							388.57

D.3 MEDICAL AEROSOL ODS

D.3.1 CFC Phaseout

Under the Montreal Protocol “essential use nominations” program, limited production of CFCs was authorized in the U.S. and other countries for use as the propellant in metered dose inhalers (MDIs), which are relied upon by asthmatics, and in other medical devices. Essential use production for MDIs in the U.S. was gradually phased out as the Food and Drug Administration approved CFC-free products for treatment of asthma, chronic obstructive pulmonary disease, and other respiratory diseases, including HFC-propelled MDIs, dry powder inhalers, and oral medications. As of January 1, 2012, all production and import of CFCs in the U.S. for MDIs ended, and on January 1, 2013, sale of CFC-based inhalers ended in the United States.

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Two medical products remain classified as essential uses of CFC propellant: anesthetic drugs requiring a cannula for application for use on accessible mucous membranes (21 CFR 2.125(e)(4)(iii)), and sterile aerosol talc administered intrapleurally by thorascopy (21 CFR 2.125(e)(4)(ix)).

D.3.2 Additionality of Destruction of U.S. Inventories

Some of the CFCs that had been produced under the essential use nominations in the U.S. before 2012 have never been used. The resulting stockpile is eligible for sale in the United States for use in remaining essential use applications. Given continued demand for CFC-11 and CFC-114 for at least one of the exempted products, under business as usual, the U.S. CFC stockpile would be sold for use as a propellant in the exempted product, and eventually released to the atmosphere. In contrast, under the alternative “project” scenario, the CFCs would be destroyed, preventing direct GHG emissions, and result in increased use of CFC-free alternative products.

Any additional production of CFCs in the U.S. for remaining essential uses would require approval by the Parties to the Montreal Protocol, as recommended by the Montreal Protocol Medical Technical Options Committee of the Technology and Economics Assessment Panel. Production of CFCs for asthma inhalers has ended. Because of the remaining stockpiles, there is no indication and virtually no likelihood that the U.S. would request any new production of CFCs for the remaining exempted products. In other words, if some of the existing CFC stockpiles are destroyed, there would be no new, compensatory CFC production.

D.3.3 Emission Rates

The CFC and HFC propellants in medical products provide the chemical energy to uniformly deliver medication onto target tissues. With each discharge of the product, the propellant is emitted and eventually reaches the atmosphere. The EPA Vintaging Model assumes that for aerosol propellants, all emissions occur when the product is used. For purposes of this Methodology, it is assumed that 100% of the CFC (baseline scenario) and HFC (project scenario) propellants used as medical aerosols are emitted to the atmosphere within the 10-year crediting period.

D.3.4 CFC Substitute Emissions

In response to the Montreal Protocol phase out of CFCs, the pharmaceutical industry, with oversight from the U.S. Food and Drug Administration, developed CFC-free formulations to serve asthmatics and other patients with chronic respiratory disease. Following extensive safety studies and engineering innovations, two HFC propellants were approved – HFC-134a and HFC-

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227ea – for use in MDIs in the United States. The ban on CFCs has also spurred new dry powder technology and other classes of specialty inhalers but these are not relevant alternatives for the remaining exempted products.

If remaining stockpiles of medical aerosol CFCs are destroyed in the U.S., there would be commensurate additional production and use of alternative propellants to meet overall patient needs.

For purposes of this Methodology, it is assumed that additional production of propellants, and atmospheric emissions, will be divided amongst HFC-134a and HFC-227ea according to their current market share in the United States for use in MDIs. Table 21 provides the calculations of emissions of the CFC substitutes associated with destruction of CFC medical aerosols. U.S. market shares for CFC-substitute propellants used in MDIs along with their GWPs are derived from Tope (2015).

Table 21: Medical Aerosol Substitute Emissions

APPLI- CATION	CFC MAR- KET SHA RE	CFC SUBSTI- TUTE	MARKET SHARE RELATIVE TO SUB- SECTOR (BY WEIGHT)	OVER- ALL CFC MAR- KET SHARE	GWP	RELA- TIVE CHARGE SIZE (LB SUB/ LB ODS)	SUB USED TO REPLACE ONE LB CFC (LBS)	LOSS RATE OF SUB (%/YR)	10-YR LBS CO ₂ E/ ODS DE- STROYED
Self- Pressur- ized Medical Products	10%	HFC- 134a	95%	9.50%	1430	1	0.095	100%	135.85
		HFC- 227ea	5%	0.50%	3320	1	0.005	100%	16.60
	ODS Sub Emissions (lb CO ₂ e/lb ODS destroyed)								152.45

D.4 ODS FIRE SUPPRESSANTS

D.4.1 Atmospheric Impacts and Applications of Halons and Substitutes

Similar to CFCs and HCFCs, halon fire suppressants are controlled under the Montreal Protocol. Halons contain bromine, which destroys stratospheric ozone at a rate many times higher than chlorine. Because of their high ozone depleting potentials, halons were phased out of production in the U.S. as of January 1, 1994, prior to CFCs. As of January 1, 2010, halon production in developing countries ended.

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Halon 1211 is contained in older portable “streaming” fire extinguishers, and halon 1301 is contained in older “total flooding” systems ranging in size from large computer rooms, bank vaults, libraries, oil and gas extraction facilities and submarines, to the engine nacelle on jets (HTOC, 2014). There are several alternative non-ODS fire suppression agents now in wide use, many with significantly lower GWPs (e.g., water mist, CO₂, nitrogen, fluoroketone) compared to halons, while others have comparable GWPs (HFC-227ea, HFC-236fa).

As of a decade ago, 75% of original halon use had been switched to agents with little or no climate impact; 4% of the original halon applications continued to employ halons. Most of the remaining 21% had been switched to HFCs and to a limited extent, PFCs (IPCC/TEAP, 2006). Table 22 lists the GWPs of ODS fire suppression agents and their substitutes.

Table 22: ODS Fire Suppression Agents and Substitutes¹⁹

ODS AGENT	GWP	NON-ODS ALTERNATIVE	GWP
Halon 1211	1860	HFC-23	14,310
Halon 1301	7030	HFC-227ea	3,350
HCFC Blend B	650	HFC-125	3,170
		HFC-236fa	9,500
		Dry chemical	1 ²⁰
		CO ₂	1
		FK-5-1-12	<1
		Inert Gas	0
		Water mist	0

¹⁹ EPA SNAP Substitutes for Total Flooding Agents and Streaming Agents
www.epa.gov/snap/fire-suppression-and-explosion-protection

²⁰ Dry chemical in some cases releases CO₂

D.4.2 Conditions for Halon Destruction Credits and Additionality

This Methodology enables offset credits for destruction of halons recovered from fire suppression equipment under the condition that the equipment is subsequently de-commissioned as part of the project. Similar to HCFC-22 refrigerant, destruction of halons recovered from end-of-life equipment will have the following impacts:

- Prevention of the inevitable emissions of halons from the older equipment via leaks, testing, accidental discharges, or release during fire extinguishing; and
- Incentivization of the continued transition to safe and effective halon alternatives, including many with little or no climate impact.

Destruction of halons under the conditions specified in the Methodology meets the additionality criteria because:

- As is the case for refrigerants, halons recovered from end-of-life equipment can be expected to be re-used to recharge other older equipment and systems. While fire suppression equipment is typically well maintained and monitored, releases occur during testing, transfers, and accidental discharges. The intended use of these agents is for release in the event of a fire or explosion. Ultimately, these agents are emitted.
- There is no requirement in the U.S. that halons recovered from equipment be destroyed; and
- Destruction of the halons will not trigger any additional halon production because of the complete phaseout of halons worldwide.

D.4.3 Halon Stockpiles

This Methodology does not allow credits for destruction of halon 1301 stockpiles because any remaining halon 1301 stockpiles likely include strategic reserves that are being maintained for fire suppression systems in aviation, shipping, oil and gas, computer rooms, and other critical applications.²¹ Even though all projects under this Methodology would be voluntary activities, there is concern that the potential availability of carbon offset credits would incentivize premature destruction of important halon 1301 stockpiles.

²¹ As of a decade ago, stockpiles of halon 1211 for portable fire extinguishers were maintained in lesser quantities (HTOC, 2006).

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D.4.4 Emission Rates

In contrast to refrigerants that slowly leak from air conditioning and refrigeration equipment, halons are used in equipment and systems that are designed to discharge completely when deployed. Halon-based fire suppression systems and equipment that are properly maintained retain their charges with relatively low leak rates in order to deliver critical fire protection. However, in addition to system deployment for actual fires or explosions, significant releases do occur during routine testing, accidental discharges, and in some operations, for example, fighter jet fuel tank inerting during combat conditions (Klein, 1981).

One approach would be to assume a 100% emission rate to account for the fact that halons in fire suppression systems will eventually be released under business as usual. This would be a departure from the standard approach used for ODS refrigerants elsewhere in this Methodology and would be a departure from other ACR methodologies that only calculate GHG emission reductions over a 10-year crediting period. For halon projects, this Methodology will continue to calculate emission reductions within the 10-year crediting period, and use annual emission rates as a starting point.

When averaged over all applications, halon emission rates have been estimated to range between 1.5% to 5% per year for halon 1301, and 2% to 11% per year for halon 1211 (IPCC/TEAP, 2006). The 2006 IPCC Guidelines for National Greenhouse Gas Inventories cites a study that indicates average annual emissions from installed flooding systems are in the range of 1 to 3% (Verdonik and Robin, 2004), and cites a range of emissions rates between 2 and 6% per year for halon 1211 portable extinguishers (HTOC, 2003).

The estimated rates for halon 1211 emissions from portable fire extinguishers cited above remain useful because under a baseline scenario, any recovered halon 1211 would be used for similar streaming applications to recharge halon 1211-based portable fire extinguishers. In the case of halon 1301, however, using estimated emission rates averaged across all types of “total flooding” systems is not the most accurate approach. Under a baseline scenario, any halon 1301 recovered from de-commissioned systems would most likely be used to service “legacy” systems in civil aviation which are considered to be the most dependent on continued availability of halon 1301 stockpiles and the most demanding (HTOC, 2014). This dependency is magnified because even today, newly manufactured commercial aircraft in the U.S., with 25-30 year lifespans, use halon 1301 for engine compartments and auxiliary power units, and cargo bays (HTOC, 2014). (Beginning in the early 1990s, military aircraft have successfully transitioned to non-halon alternatives for engine fire protection and cargo bays and all other fire protection applications.)

Recent Montreal Protocol TEAP assessments estimate that halon 1301 emissions from civil aviation applications in the year 2020 will range between 6.1% to 8.1% per year (HTOC, 2006). Given the continuing reliance on halon 1301 in civil aviation to maintain systems in the oldest

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aircraft remaining in service, this Methodology uses the upper end of this range (8.1% per year) for the default annual emission rate for halon.

D.4.5 Halon Substitute Emissions

Halon substitute emissions for the halon destruction project scenarios are calculated in Tables 23 and 24. Substitute emissions for halon 1211 and halon 1301 are based on the average market share of substitutes, their emission rates and relative charge sizes as specified in the EPA Vintaging Model (US EPA, 2015a)). Market share of PFC-based fire suppressants are adjusted downward to account for proposed restrictions under the U.S. EPA SNAP program. It is possible that the SNAP program will also restrict the use of high-GWP HFC fire suppressants, similar to actions taken in other sectors (EPA SNAP Rule 21, September 26, 2016). This Methodology will be revised to conform to future SNAP regulations that are relevant to the quantification of substitute emissions. Similarly, market share of HCFC-based fire suppressants will be adjusted to account for the ongoing HCFC phase-out in the United States.

Table 23: Calculation of Substitute Emissions for Halon 1211

APPLI- CATION	HAL ON 1211 MAR- KET SHA RE	HALON 1211 SUBSTI- TUTE	MARKET SHARE RELATIVE TO SUB- SECTOR (BY WEIGHT)	OVER- ALL HALON 1211 MAR- KET SHARE	GWP	RELA- TIVE CHARG E SIZE (LB SUB/ LB ODS)	SUB USED TO REPLACE ONE LB HALON 1211 (LBS)	LOSS RATE OF SUB (%/YR)	10-YR LBS CO ₂ E/ HALON DE- STROYED
Streami ng Fire Sup- pres- sion	5%	HFC- 236fa	2%	0.1%	9810	0.5	0.000	6.0%	2.18
		HCFC Blend B (Hal- otron)	5%	0.25%	650	1	0.003	6.0%	0.75
		Non- ODP/G WP	93%	4.65%	0	1	0.047	6.0%	0.00
		Halon 1211-Sub Emissions (lb CO ₂ e/lb Halon 1211 destroyed)							2.93

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Table 24: Calculation of Substitute Emissions for Halon 1301

APPLI- CATION	HAL ON 1301 MAR- KET SHA RE	HALON 1301 SUBSTI- TUTE	MARKET SHARE RELATIVE TO SUB- SECTOR (BY WEIGHT)	OVER- ALL HALON 1301 MAR- KET SHARE	GWP	RELA- TIVE CHARGE SIZE (LB SUB/ LB ODS)	SUB USED TO REPLACE ONE LB HALON 1211 (LBS)	LOSS RATE OF SUB (%/YR)	10-YR LBS CO ₂ E/ HALON DE- STROYED
Total Flood- ing Fire Sup- pres- sion	4%	HFC- 227ea	47%	1.88%	3220	0.6	0.275	3.0%	232.56
		FK-5-1- 12	40%	1.60%	1	1.0	0.400	3.0%	0.11
		HFC- 125	3%	0.12%	3500	0.8	0.024	3.0%	21.62
		Non- ODP/G WP	10%	0.40%	0	1.0	0.100	3.0%	0.00
	Halon 1301 Sub Emissions (lb CO ₂ e/lb Halon 1301 destroyed)								

APPENDIX E: REFERENCES

ASTM International. (2014). ASTM Method D 7132-14, Standard Test Method for Determination of Retained Blowing Agent in Extruded Polystyrene Foam, West Conshohocken, PA.

California Air Resources Board. (2014). Compliance Offset Protocol, Ozone Depleting Substances Projects, Destruction of U.S. Ozone Depleting Substances Banks, November 14, 2014.

California Air Resources Board, Research Division. (2009). California Facilities and Greenhouse Gas Emissions Inventory; High-Global Warming Potential Stationary Source Refrigerant Management Program.

Fredenslund, A. M., Scheutz, C., and Kjeldsen, P. (2005). Disposal of Refrigerators - Freezers in the US: State of the Practice - Determination of Content of Blowing Agent in Pre-And Post-Shredded Foam and Modeling. Report by Environment & Resources, Technical University of Denmark, Lyngby.

ICF International. (2011). Lifecycle Analysis of High-Global Warming Potential Greenhouse Gas Destruction. Prepared for the California Air Resources Board.

Ingenieurguppe RUK. (2012). Landfill behaviour of CFCs in foams recovered from end-of-life refrigeration equipment – Application of results to specific waste disposal scenarios.

Intergovernmental Panel on Climate Change (IPCC) and Montreal Protocol on Substances that Deplete the Ozone Layer United Nations Environment Programme Technology and Economic Assessment Panel. (2006). Special Report: Safeguarding the Ozone Layer and the Global Climate System.

Japanese Technical Centre for Construction Materials (JTCCM). (2004). Research on the Recovery and Processing of CFCs/HCFs Contained in Thermal Insulation.

Klein, J.K. (1981). Proceedings from the AIAA Aircraft Systems and Technology Conference: The F-16 Halon Tank Inerting System, Aeronautical Systems Division, Wright-Patterson Air Force Base, Dayton Ohio.

Montreal Protocol on Substances that Deplete the Ozone Layer United Nations Environment Programme Halons Technical Options Committee (HTOC). (2003). *Assessment Report of the Halons Technical Options Committee*.

Montreal Protocol on Substances that Deplete the Ozone Layer United Nations Environment Programme Halons Technical Options Committee. (2011). *Report of the Halons Technical Options Committee*.

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Montreal Protocol on Substances that Deplete the Ozone Layer United Nations Environment Programme Halons Technical Options Committee. (2014). Report of the Halons Technical Options Committee.

Montreal Protocol on Substances that Deplete the Ozone Layer United Nations Environment Programme Technology and Economic Assessment Panel (TEAP). (2005). Report of the Task Force on Foam End-of-Life Issues.

Scheutz, C., Dote, Y., Fredenslund, A.M., Mosbaek, H., and Kjeldsen, P. (2007). Attenuation of Fluorocarbons Released from Foam in Insulation in Landfills. *Environmental Science & Technology*, 41, 7714-7722.

Tope. (2015). *Montreal Protocol Technology and Economics Assessment Panel, Workshop on HFC Management, Technical Issues*, April 21, 2015.

United States Environmental Protection Agency (2015a) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1999-2013, Industrial Processes and Product Use, Annex 3.9.

United States Environmental Protection Agency. (2015b). Federal Register. Volume 80, Number 138, 42870. Air Programs – Protection of Stratospheric Ozone.

United States Environmental Protection Agency. (2016). Significant New Alternatives Policy (SNAP) Program, Rule 21, New listing of safer substitutes and prohibition on the use of certain high-GWP alternatives (September 26, 2016).

United States Environmental Protection Agency. (2014). The U.S. Phaseout of HCFCs: Projected Servicing Needs in the U.S. Air-Conditioning, Refrigeration, and Fire Suppression Sectors, Updated for 2015 to 2025.

United States National Archives and Records Administration. Code of Federal Regulations. Title 40. Air Programs – Protection of Stratospheric Ozone, sec. 82.16.

Verdonik, D.P. and Robin, M.L. (2004). Proceedings of the Earth Technology Forum: *Analysis of Emission Data, Estimates, and Modelling of Fire Protection Agents*, Washington, D.C.

World Meteorological Organization (WMO), Global Ozone Research and Monitoring Project. (2011). Ozone Depletion Potentials from the Scientific Assessment of Ozone Depletion: 2010. Report No. 52.

Yesiller, N., Hanson, J.L., Bogner, J.E. (2016). *Emissions of Potent Greenhouse Gases from Appliance and Building Waste in Landfills*. Draft Final Report, California Air Resources Board and the California Environmental Protection Agency.