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Ozone Depleting Substances

Project Protocol

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Abbreviations and Acronyms

A/C	Air conditioning
AHRI	Air-Conditioning, Heating and Refrigeration Institute
CAA	Clean Air Act
CEMS	Continuous emissions monitoring system
CFC	Chlorofluorocarbons
CH_4	Methane
CO_2	Carbon dioxide
CPT	Comprehensive Performance Test
CRT	Climate Reserve Tonne
DOT	United States Department of Transportation
DRE	Destruction and removal efficiency
EPA	United States Environmental Protection Agency
GWP	Global warming potential
HBFC	Hydrobromofluorocarbons
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
HWC	Hazardous waste combustor
MACT	Maximum available control technology
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology
ODS	Ozone depleting substances
PU	Polyurethane
RAL	RAL Quality Assurance Association
RCRA	Resource Conservation and Recovery Act
REFPROP	Reference Fluid Thermodynamic and Transport Properties Database
Reserve	Climate Action Reserve
TEAP	Technology and Economic Assessment Panel
WEEE	Waste Electrical and Electronic Equipment Directive

1 Introduction

The Climate Action Reserve U.S. Ozone Depleting Substances Project Protocol provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with the destruction of high global warming potential ozone depleting substances (ODS) sourced from and destroyed within the U.S. that would have otherwise been released to the atmosphere. This project category includes ODS used in foam blowing agent and refrigerant applications. All destroyed ODS must be fully documented, chemically analyzed, and destroyed at a qualifying facility to be eligible for crediting under this protocol. All ODS must originate in the United States; potential project developers wishing to generate credits from the destruction of ODS originating outside of the United States must use the Climate Action Reserve's Article 5 Ozone Depleting Substances Project Protocol.

As the premier carbon offset registry for the North American carbon market, the Climate Action Reserve works to ensure environmental benefit, integrity and transparency in market-based solutions that reduce greenhouse gas emissions. It establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies, issues carbon credits generated from such projects and tracks the transaction of credits over time in a transparent, publicly-accessible system. By facilitating and encouraging the creation of GHG emission reduction projects, the Climate Action Reserve program promotes immediate environmental and health benefits to local communities, allows project developers access to additional revenues and brings credibility and value to the carbon market. The Climate Action Reserve is a private 501c(3) nonprofit organization based in Los Angeles, California.

ODS project developers must use this document to quantify, verify and report GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all projects must submit to annual, independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve's Verification Program Manual and Section 8 of this protocol.

This project protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with an ODS destruction project.[1]

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[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

The term "ozone depleting substances" refers to a large group of chemicals known to destroy the stratospheric ozone layer when released into the atmosphere. ODS were historically used in a wide variety of applications including refrigerants, foam blowing agents, solvents, and fire suppressants. In addition to their potency as ozone depleting substances, the ODS addressed by this protocol also exhibit high global warming potentials (GWP). The GWP of these ODS range from several hundred to several thousand times that of carbon dioxide (see Table 5.1).

The adoption of the Montreal Protocol on Substances that Deplete the Ozone Layer[2] in 1987 laid out a global framework for the phase-out of the production of certain known ODS. The Montreal Protocol differentiated two separate phase-out schedules: one for the developing Article 5 countries[3] and a more rapid phase-out for the developed Non-Article 5 countries[4], including the United States. The current phase-out schedule for Class I and Class II ODS for the United States, as dictated by the Montreal Protocol, is presented below in Table 2.1. The United States incorporated this phase-out schedule in domestic regulations and also applied a "worst first" approach to HCFC (i.e. prioritizing production phase-outs according to the destructive potential of HCFC in the ozone layer). The U.S. schedule is also presented below in Table 2.1.

Table 2.1. Production Phase-Out Schedule of the Montreal Protocol[5,6]

Ozone Depleting Substance	Non-Article 5 Countries	U.S.
CFC (chlorofluorocarbons)	January 1, 1996	January 1, 1996
Halons	January 1, 1994	January 1, 1994
Carbon tetrachloride	January 1, 1996	January 1, 1996
Methyl chloroform	January 1, 1996	January 1, 1996
Methyl bromide	January 1, 2005	January 1, 2005
HBFC (Hydrobromofluorocarbons)	January 1, 1996	January 1, 1996
HCFC (hydrochlorofluorocarbons)	January 1, 1996: Freeze at baseline	January 1, 1996: Freeze at baseline
	January 1, 2004: cut by 35%	January 1, 2003: No production and no importing of HCFC-141b
	January 1, 2010: cut by 75%	January 1, 2010: No production and no importing of HCFC-142b and HCFC-22, except for use in equipment manufactured before 1/1/2010

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[2] http://ozone.unep.org/Ratification_status/montreal_protocol.shtml, and subsequent revisions and amendments.

[3] See http://ozone.unep.org/Ratification_status/list_of_article_5_parties.shtml for a list of countries operating under Article 5.

[4] See http://ozone.unep.org/Ratification_status/ for a list of all countries that have ratified the Montreal Protocol.

[5] U.S. EPA, Phase-out of Class I Ozone Depleting Substances, available at: http://www.epa.gov/ozone/title6/phaseout/classone.html.

[6] U.S. EPA, Phase-out of Class II Ozone Depleting Substances, available at: http://www.epa.gov/ozone/title6/phaseout/classtwo.html.

Ozone Depleting Substance	Non-Article 5 Countries	U.S.
	January 1, 2015: cut by 90%	January 1, 2015: No production and no importing of any HCFC, except for use as refrigerants in equipment manufactured before 1/1/2020
	January 1, 2020: cut by 99.5% (can only be used for refrigerator/AC servicing after this date)	January 1, 2020: No production and no importing of HCFC-142b and HCFC-22
	January 1, 2030: full phase-out	January 1, 2030: No production and no importing of any HCFC

The Montreal Protocol and the U.S. Clean Air Act[7] (CAA) control the production of ODS in the United States. However, neither framework requires the destruction of extant stocks of ODS. Rather, these stocks may leak to the atmosphere or may be recovered, recycled, reclaimed, and reused indefinitely, often in equipment with very high leak rates. Because the Montreal Protocol and Title VI of the CAA do not forbid the use of existing or recycled controlled substances beyond the phase-out dates, even properly managed ODS banks will eventually be released as fugitive emissions to the atmosphere.

Refrigerants

Prior to the 1996 production phase-out in the United States, equipment utilizing ODS refrigerants was preferred in a wide variety of applications. These applications include industrial and commercial refrigeration, cold storage, comfort cooling equipment (i.e. air conditioning), and various consumer applications. While the production of ODS refrigerants has been phased out (with the exception of certain HCFC), these substances are continually recovered, reclaimed and recycled to service old equipment. As such, use of these ODS is still widespread, and can be found everywhere from vehicle air conditioners to industrial chillers.

Despite regulations prohibiting their intentional release through servicing, use, and end of life, refrigerant ODS may be inadvertently released to the atmosphere at rates of up to 35 percent per year.[8]

Foams

The ODS CFC-11, CFC-12, HCFC-141b, and HCFC-22 were used as blowing agents in the production of foam prior to their mandated production phase-out in the United States. Many of the applications for which this foam was used, such as refrigeration or A/C units and building insulation, have extended lifetimes and these foams containing ODS will therefore be present in the waste stream for many years to come. When foam is disposed of, ODS blowing agent is released from the foam during shredding[9] and/or degradation in the landfill.[10]

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[7] CAA, Title VI, Section 604(a).

[8] IPCC/TEAP. (2005). Special report: Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons.

[9] Scheutz et al. (2007). Release of fluorocarbons from insulation foam in home appliances during shredding. *Journal of the Air & Waste Management Association.*

[10] Scheutz et al. (2007). Attenuation of fluorocarbons released from foam insulation in landfills. *Environmental Science & Technology*, *41*: 7714-7722.

2.2 Project Definition

For the purposes of this protocol, a project is defined as any set of activities undertaken by a single project developer resulting in the destruction[11] of eligible ODS at a single qualifying destruction facility within a 12-month period. Destruction may take place under one or more Certificates of Destruction. Each Certificate of Destruction must document the ODS destroyed. The ODS destroyed may come from a single origin (e.g. one supermarket) or from numerous sources. However, the entire quantity of eligible ODS destroyed must be documented on one or more Certificates of Destruction issued by a qualifying destruction facility.

Although project developers may engage in ongoing recovery, aggregation and destruction activities, destruction events that fall outside of the 12-month window designated for a project may only be counted as part of a separately registered project. Project developers may choose a shorter time horizon for a single project (e.g. 3 months or 6 months), but no project may run longer than 12 months.

In order for multiple Certificates of Destruction to be included under a single project, all of the following conditions must be met:

- The project developer and owner of emission reductions are the same for all ODS destroyed
- The qualifying destruction facility is the same for all Certificates of Destruction
- Project activities span a timeframe of no more than 12 months from the project's start date to completion of the last ODS destruction event
- No Certificate of Destruction is included as part of another project

For all projects, the end fate of the ODS must be destruction at either an approved Hazardous Waste Combustor (HWC) subject to the Resource Conservation and Recovery Act (RCRA), CAA, and the National Emissions Standards for Hazardous Air Pollutants (NESHAP) standards, or any other transformation or destruction facility that meets or exceeds the Montreal Protocol's Technology and Economic Assessment Panel (TEAP) standards provided in the *Report of the Task Force on Destruction Technologies*.[12] Non-RCRA permitted facilities cannot receive and destroy ODS materials that are classified as hazardous waste and must demonstrate compliance with the Title VI requirements of the CAA for destruction of ODS, as well as demonstrate destruction and removal efficiency (DRE) of 99.99 percent and emission levels consistent with the guidelines set forth in the aforementioned TEAP report (see Appendix C).

2.3 Eligible ODS

This protocol provides requirements and guidance for the accounting of GHG reductions from two general sources of ODS eligible under the project definition:

- **Refrigerants:** A project may recover or aggregate eligible ODS refrigerant (see Section 2.3.1) from industrial, commercial or residential equipment, systems, and appliances or stockpiles, and destroy it at a qualifying destruction facility.

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[11] In this protocol, the term "destruction" is used to describe any activity that results in the elimination of ODS with an efficiency of 99.99 percent or higher. This definition incorporates both destruction and transformation technologies as defined by the EPA and the Clean Air Act (40 CFC 82).

[12] TEAP. (2002). Report of the Task Force on Destruction Technologies. *Volume 3B*.

- **Foams:** A project may extract eligible ODS blowing agent (see Section 2.3.2) from appliance foams and destroy the concentrated ODS foam blowing agent at a qualifying destruction facility; or, a project may destroy intact foam sourced from building insulation at a qualified destruction facility.

A single project may incorporate ODS obtained from one or both of these ODS source categories. Tracking procedures and calculation methodologies differ depending on the source of ODS. ODS sources not in one of the above categories, such as ODS that were used as or produced for use as solvents, medical aerosols or other applications are not eligible under this protocol.

2.3.1 Refrigerant Sources

This source category consists of ODS material produced prior to the U.S. production phase-out that could legally be sold into the U.S. refrigerant market.[13] The ODS must originate from domestic U.S. supplies; imported refrigerant is not eligible under this protocol. Project developers seeking to register projects involving the domestic destruction of imported refrigerant must use the Reserve's Article 5 Ozone Depleting Substances Project Protocol.

In the absence of a GHG reduction project, this material may be illegally vented or recovered for re-sale into the refrigerant recharge market. As described in Section 5, for GHG reduction calculation purposes, this protocol conservatively assumes that the refrigerant would be reclaimed.

Only destruction of the following ODS refrigerants is eligible for crediting under this protocol:

- CFC-11
- CFC-12
- CFC-13
- CFC-113
- CFC-114
- CFC-115

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 foam source.

ODS sourced from the federal government is eligible if it meets the point of origin requirements detailed in Section 6.2.

Additionally, all refrigerant recovery, handling, and destruction must be performed in accordance with the reporting and operation requirements of Section 6.

2.3.2 Foam Sources

This source category consists of ODS blowing agent entrained in foams that, absent a GHG reduction project, would have been released at end-of-life. The ODS blowing agent must originate from U.S. foam sources; imported foams are not eligible under this protocol.

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[13] Any ODS produced in association with a critical use or as by-product is ineligible.

Only the following ODS foam blowing agents are eligible to generate reductions under this protocol:

- CFC-11
- CFC-12
- HCFC-22
- HCFC-141b

To be eligible for crediting, the ODS blowing agent must be destroyed in one of two ways:

1. **ODS blowing agent extracted from appliance foam and destroyed.** The ODS blowing agent must be extracted from the foam to a concentrated form prior to destruction. This must be done under negative pressure to ensure that fugitive release of ODS cannot occur. The recovered ODS blowing agent must be aggregated, stored, and transported in cylinders or other hermetically sealed containers.

2. **Intact foam containing ODS blowing agent from buildings destroyed intact.** When the intact foam is separated from building panels, it must be stored, transported, and destroyed in sealed containers.

All blowing agent and foam collection, handling, extraction, and destruction must be performed in accordance with the reporting and operation requirements of Section 6.

2.4 The Project Developer

The "project developer" may be any entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers may be ODS aggregators, facility owners, facility operators, or GHG project financiers. The project developer must have clear ownership of the project's GHG reductions. Ownership of the GHG reductions must be established by clear and explicit title, and the project developer must attest to such ownership each time the project is verified by signing the Reserve's Attestation of Title form.[14]

Neither the federal government nor a federal government agency is eligible to be a project developer under this protocol, but material sourced from the federal government may be eligible if it meets all protocol requirements (see Section 6.2).

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[14] Attestation of Title form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/. Verification activities not related to confirming the Attestation of Title (such as site visits or project material eligibility confirmation) may commence prior to this form being uploaded to the Reserve.

3 Eligibility Rules

Projects that meet the definition of a GHG reduction project in Section 2.2 must fully satisfy the following eligibility rules in order to register with the Reserve.

Eligibility Rule I:	Location	⟶	*U.S. and its territories*
Eligibility Rule II:	Project Start Date	⟶	*No more than six months prior to project submission*
Eligibility Rule III:	Additionality	⟶	*Exceed legal requirements*
		⟶	*Meet performance standard*
Eligibility Rule IV:	Regulatory Compliance	⟶	*Compliance with all applicable laws*

3.1 Location

For ODS destruction to be eligible as a project under this protocol, all ODS must be sourced from stocks in the United States or its territories and destroyed within the United States or its territories. Project developers seeking to register projects involving the domestic destruction of imported ODS must use the Reserve's Article 5 Ozone Depleting Substances Project Protocol.

3.2 Project Start Date

The project start date is defined according to the commencement of project activities.

- For concentrated (non-mixed) ODS projects[15] that are not aggregated at the destruction facility, the project start date is the day that the project ODS departs the final storage or aggregation facility for transportation to the destruction facility.
- For concentrated (non-mixed) ODS projects where eligible material is aggregated at the destruction facility, the project start date is the day when destruction commences, as documented by a Certificate of Destruction.
- For mixed ODS projects, the project start date is the day that mixing procedures begin.

To be eligible, the project must be submitted to the Reserve no more than six months after the project start date.[16] Projects may always be submitted for listing by the Reserve prior to their start date.

3.3 Project Crediting Period

An ODS project includes a discrete series of destruction events over a 12-month period, beginning on the project start date. No destruction events may occur more than 12 months after the project start date. For the purposes of this protocol, it is assumed that, absent the project, the avoided ODS emissions would have occurred over a longer time horizon.

Under this protocol, the project crediting period is the period of time over which avoided emissions are quantified for the purpose of determining creditable GHG reductions. Specifically,

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[15] As defined in Section 6.6.

[16] Projects are considered submitted when the project developer has fully completed and filed the required documents, available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

ODS projects will be issued CRTs for the quantity of ODS that would have been released over a ten-year period following a destruction event. At the time the project is verified, CRTs are issued for all ODS emissions avoided by a project over the 10-year crediting period.

3.4 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have otherwise occurred in the absence of a GHG market.

Projects must satisfy both of the following tests to be considered additional:

1. The Legal Requirement Test
2. The Performance Standard Test

3.4.1 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to international, federal, state or local regulations, or other legally binding mandates. A project passes the Legal Requirement Test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, or other legally binding mandates requiring the destruction of ODS. To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form[17] each time the project is verified (see Section 8).[18] In addition, the project's Monitoring and Operations Plan (Section 6) must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test.

3.4.2 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e. a standard of performance applicable to all ODS destruction projects, established on an *ex ante* basis by this protocol.[19]

For this protocol, the Reserve uses a Performance Standard Test based on an evaluation of U.S. "common practice" for privately managed ODS. Because the Reserve has determined that destruction of ODS is not common practice in the United States (see Appendix B), all ODS destruction activities that meet the project definitions and other eligibility requirements pass the Performance Standard Test.

The Reserve will periodically re-evaluate the appropriateness of the Performance Standard Test, and if necessary, amend this protocol accordingly. Projects that meet the Performance Standard Test and other requirements of the version of this protocol in effect at the time of their submission are eligible to generate CRTs.

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[17] Attestation of Voluntary Implementation form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

[18] Verification activities not related to confirming the Attestation of Voluntary Implementation (such as site visits or project material eligibility confirmation) may commence prior to this form being uploaded to the Reserve.

[19] A summary of the study to establish the Performance Standard Test is provided in Appendix B.

3.5 Regulatory Compliance

Projects must be in material compliance with all applicable laws (e.g. air, water quality, and safety) at all times during each reporting period, as defined in Section 5. The regulatory compliance requirement extends to the operation of destruction facilities where the ODS is destroyed, as well as the facilities where mixed ODS projects are mixed and sampled, and the transportation of the ODS to the destruction facility. These facilities and transportation events must meet applicable regulatory requirements during implementation of project activities. For example, any upsets or exceedances of permitted emission limits at a destruction facility must be managed in keeping with an authorized startup, shutdown, and malfunction plan.[20]

Project developers must attest that the project has met this requirement by signing the Reserve's Attestation of Regulatory Compliance[21] for each reporting period.[22] Projects are not eligible to receive CRTs for GHG reductions that occur as the result of project activities that are not in material compliance with regulatory requirements. Non-compliance solely due to administrative or reporting issues, or due to "acts of nature," will not affect CRT crediting.

Project developers are required to disclose in writing to the verifier any and all instances of non-compliance of the project with any law. If a verifier finds that a project is in a state of material non-compliance or non-compliance that is the result of negligence or intent, then CRTs will not be issued for GHG reductions that occurred during the period of non-compliance.

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[20] 40 CFR 63.1206.

[21] Attestation of Regulatory Compliance form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

[22] Verification activities not related to confirming the Attestation of Regulatory Compliance (such as site visits or project material eligibility confirmation) may commence prior to this form being uploaded to the Reserve.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that shall be assessed by project developers in order to determine the total net change in GHG emissions caused by an ODS project.[23]

Figure 4.1, Figure 4.2, and Figure 4.3 below provide a general illustration of the GHG Assessment Boundaries for different types of ODS destructions projects, indicating which SSRs are included or excluded from the boundary.

Table 4.1 gives greater detail on each SSR and provides justification for all SSRs and gases that are excluded from the GHG Assessment Boundary.

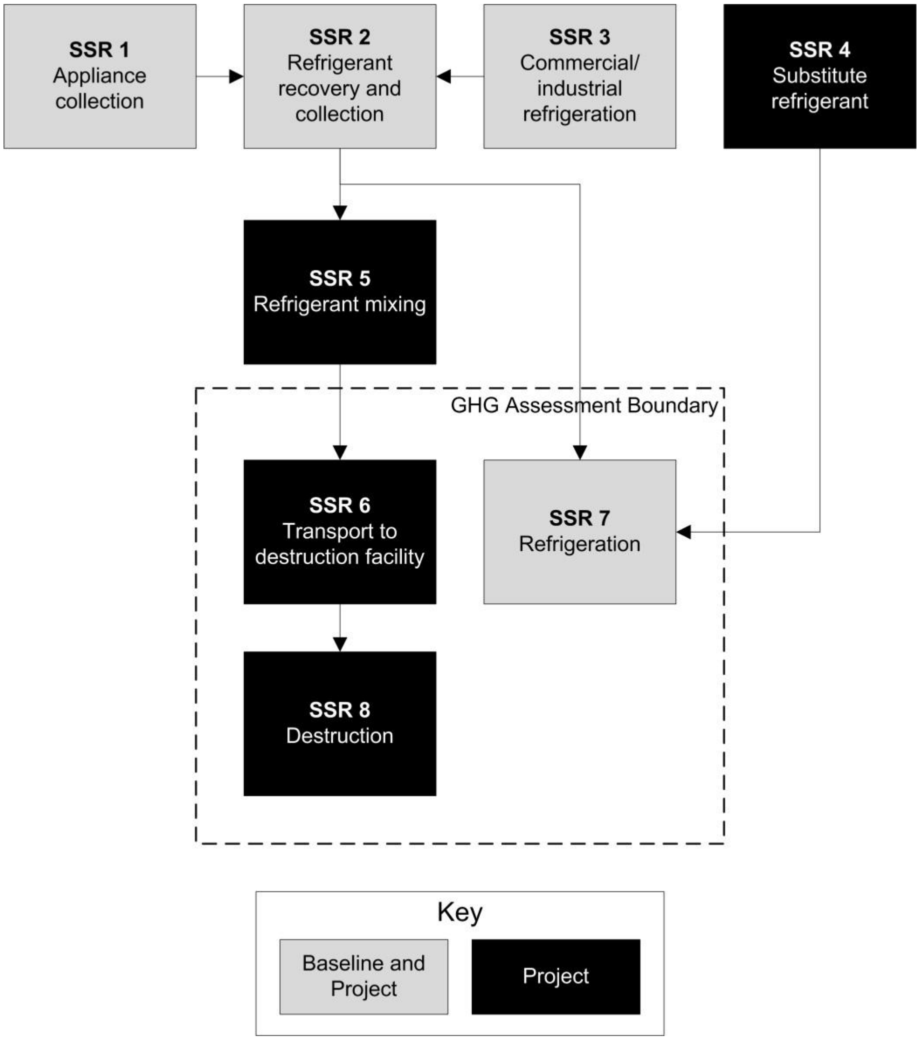

Figure 4.1. Illustration of the GHG Assessment Boundary for Refrigerant Projects

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[23] The definition and assessment of SSRs is consistent with ISO 14064-2 guidance.

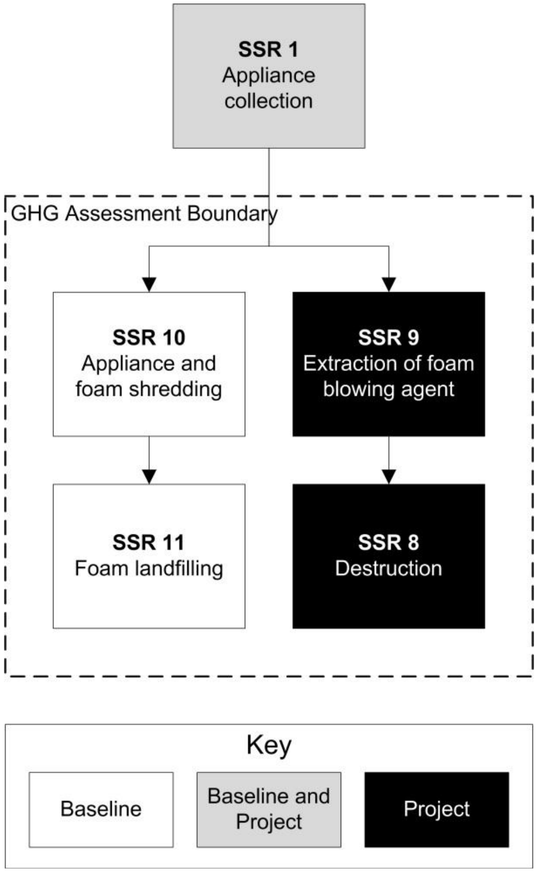

Figure 4.2. Illustration of the GHG Assessment Boundary for Appliance Foam Projects

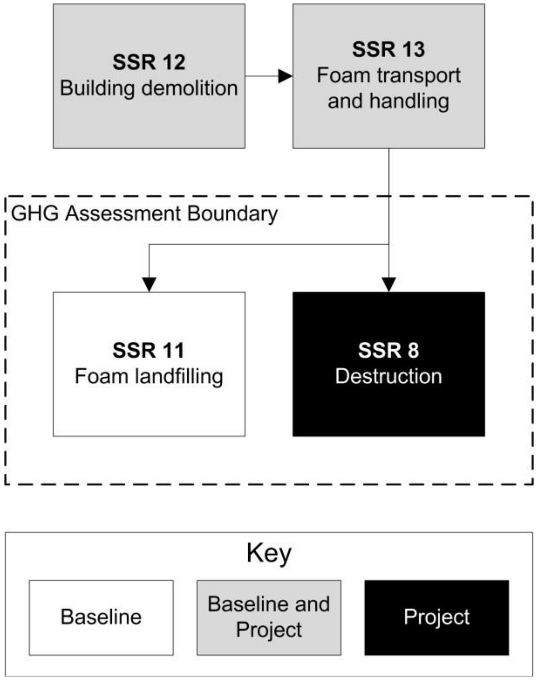

Figure 4.3. Illustration of the GHG Assessment Boundary for Building Foam Projects

Table 4.1. Summary of Identified Sources, Sinks, and Reservoirs

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
1	Appliance collection	Fossil fuel emissions from the collection and transport of end-of-life residential appliances	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
2	Refrigerant recovery and collection	Emissions of ODS from the recovery and aggregation of refrigerant at end-of-life or servicing	ODS	E	N/A	Excluded, as project activity is likely to decrease these emissions. Therefore, exclusion is conservative
		Fossil fuel emissions from the recovery and aggregation of refrigerant at end-of-life or servicing	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
3	Commercial/ Industrial refrigeration	Emissions of ODS from equipment leak and servicing	ODS	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
		Fossil fuel emissions from the operation of refrigeration and A/C equipment	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
4	Substitute refrigerant production	▪ Emissions of substitute refrigerant occurring during production ▪ Fossil fuel emissions from the production of substitute refrigerants	CO_2e	E	N/A	Excluded, as this emission source is assumed to be very small
			CO_2	E	N/A	Excluded, as this emission source is assumed to be very small
			CH_4	E	N/A	Excluded, as this emission source is assumed to be very small
			N_2O	E	N/A	Excluded, as this emission source is assumed to be very small
5	Refrigerant mixing	Fossil fuel emissions from ODS mixing activities at mixing facility	CO_2 CH_4 N_2O	E	N/A	Excluded, as these emission sources are assumed to be very small
6	Transport to destruction facility	Fossil fuel emissions from the vehicular transport of ODS from aggregation point to final destruction facility	CO_2	I	**Baseline:** N/A **Project:** Estimated based on distance and weight transported	Project emissions will be small, and can be calculated using the default factor provided
			CH_4	E	N/A	Excluded, as this emission source is assumed to be very small
			N_2O	E	N/A	Excluded, as this emission source is assumed to be very small
7	Refrigeration	Emissions of ODS from leaks and servicing through continued operation of equipment	ODS	I	**Baseline:** Estimated based on market-weighted emission rates **Project:** N/A	Baseline equipment emissions will be significant for refrigerant sources, but are not applicable for foam sources
		Emissions of substitute from leaks and servicing through continued operation of equipment	CO_2e	I	**Baseline:** N/A **Project:** Estimated based on market-weighted emissions	Project equipment emissions will be significant for refrigerant sources, but are not applicable for foam sources

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
		Indirect emissions from grid-delivered electricity	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
8	Destruction	Emissions of ODS from incomplete destruction at destruction facility	ODS	I	**Baseline:** N/A **Project:** Estimated based on ODS destroyed, or included in default deduction	Project emissions will be small, and can be calculated using the default factor provided
		Emissions from the oxidation of carbon contained in destroyed ODS	CO_2	I	**Baseline:** N/A **Project:** Estimated based on ODS destroyed, or included in default deduction	Project emissions will be small, and can be calculated using the default factor provided
		Fossil fuel emissions from the destruction of ODS at destruction facility	CO_2	I	**Baseline:** N/A **Project:** Estimated based on ODS destroyed, or included in default deduction	Project emissions will be small, and can be calculated using the default factor provided
			CH_4	E	N/A	Excluded, as this emission source is assumed to be very small
			N_2O	E	N/A	Excluded, as this emission source is assumed to be very small

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
		Indirect emissions from the use of grid-delivered electricity	CO_2	I	**Baseline:** N/A **Project:** Estimated based on ODS destroyed, or included in default deduction	Project emissions will be small, and can be calculated using the default factor provided
			CH_4	E	N/A	Excluded, as this emission source is assumed to be very small
			N_2O	E	N/A	Excluded, as this emission source is assumed to be very small
9	Extraction of ODS blowing agent from appliance foam	Emissions of ODS released during the separation of foam from appliance	ODS	I	**Baseline:** N/A **Project:** Estimated based on recovery efficiency	Project emissions may be significant. Site specific recovery efficiency shall be used
10	Appliance and foam shredding	Emissions of ODS from the shredding of appliances for materials recovery, releasing ODS from foam	ODS	I	**Baseline:** Estimated based on total quantity of ODS destroyed and default shredding factors **Project:** N/A	Baseline shredding emissions will be significant for foam sources, but are non-applicable for refrigerant sources
11	Foam landfilling	Emissions of ODS released from foam disposed of in landfills	ODS	I	**Baseline:** Estimated based on release and degradation of ODS in landfill **Project:** N/A	Baseline emissions will be significant for foam sources, but are not applicable for refrigerant sources
		Emissions of ODS degradation products from foam disposed of in landfills	HFC, HCFC	E	N/A	Excluded, as this baseline emission source is assumed to be very small. This exclusion is conservative
		Fossil fuel emissions from the transport and placement of	CO_2	E	N/A	Excluded, as project activity is likely to decrease these emissions. Therefore, exclusion is conservative

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
		shredded foam waste in landfill	CH_4	E	N/A	Excluded, as project activity is likely to decrease these emissions. Therefore, exclusion is conservative
			N_2O	E	N/A	Excluded, as project activity is likely to decrease these emissions. Therefore, exclusion is conservative
12	Building demolition	Emissions of ODS from the demolition of buildings and damage to foam insulation panels	ODS	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
		Fossil fuel emissions from the demolition of buildings	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
13	Foam transport and handling	Emissions of ODS released from foam during transport and handling	ODS	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
		Fossil fuel emissions from the transport and handling of building foam	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity

5 Quantifying GHG Emission Reductions

GHG emission reductions from an ODS project are quantified by comparing actual project emissions to calculated baseline emissions. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the ODS destruction project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

A project may not span more than 12 months, and GHG emission reductions must be quantified and verified at least once for the entire project time length. The length of time over which GHG emission reductions are quantified and verified is called a "reporting period." Project developers may choose to have multiple reporting periods within a project or a project time length shorter than 12 months, if desired. The quantification methods presented below are specified for a single reporting period, which may be less than or equal to the entire project time length.

Equation 5.1. Total Emission Reductions

$$ER_t = BE_t - PE_t$$

Where,

			Units
ER_t	=	Total quantity of emission reductions during the reporting period	tCO_2e
BE_t	=	Total quantity of baseline emissions during the reporting period	tCO_2e
PE_t	=	Total quantity of project emissions during the reporting period	tCO_2e

5.1 Quantifying Baseline Emissions

Total baseline emissions must be estimated by calculating and summing the calculated baseline emissions for all relevant SSRs (as indicated in Table 4.1) using Equation 5.2 and the supporting equations presented below. This includes emissions from continued use of ODS in the secondary recharge market for refrigerants, and the emissions from end-of-life disposal for foams. Note that emissions shall be quantified in pounds throughout this section and converted into metric tons in Equation 5.2 below.

Equation 5.2. Total Baseline Emissions

$$BE_t = \frac{BE_{refr} + BE_{foam}}{2204.623}$$

Where,

			Units
BE	=	Total quantity of baseline emissions	tCO_2e
BE_{refr}	=	Total quantity of baseline emissions from refrigerant ODS	lb CO_2e
BE_{foam}	=	Total quantity of baseline emissions from ODS blowing agent	lb CO_2e
2204.623	=	Conversion from pounds to metric tons	lbs/t

Baseline emissions for an ODS destruction project include the total calculated baseline emissions from each eligible source category – ODS refrigerant and ODS blowing agent. If a project does not destroy any ODS from a particular source category, baseline emissions for that source category are assumed to be zero.

Table 5.1 provides the applicable GWP to be used for calculating baseline emissions in units of CO_2-equivalent tonnes.

Table 5.1. Global Warming Potential of Eligible ODS

ODS Species	100-year Global Warming Potential (CO_2e)[24]
CFC-11	4,750
CFC-12	10,900
CFC-13	14,400
CFC-113	6,130
CFC-114	10,000
CFC-115	7,370
HCFC-22	1,810
HCFC-141b	725

If, during verification, the verification body cannot confirm that a portion of the ODS that was sent for destruction was eligible, this portion of the material shall be considered ineligible. This ineligible ODS shall be excluded from baseline emission calculations. The quantity of ineligible ODS sent for destruction shall be subtracted from $Q_{refr,i}$, $BA_{app,i}$ or $BA_{build,i}$ prior to the calculation of Equation 5.3 or Equation 5.4 in order to calculate baseline emissions only for ODS that was confirmed to be eligible by the verification body. This quantity shall be determined by one of the following methods:

Option A: Confirmed weight and composition

If the project developer can produce data that, based on the verifier's professional judgment, confirm the weight and composition for the specific ODS that is deemed to be ineligible (or whose eligibility cannot be confirmed), these data shall be used to adjust the value of $Q_{refr,i}$, $BA_{app,i}$ or $BA_{build,i}$ accordingly.

Option B: Default values

If sufficient data are not available to satisfy the Option A requirements, then the most conservative estimate of the weight and composition of the ineligible container of ODS shall be used. Specifically, the composition of the ineligible container of ODS shall be assumed to be 100 percent of the ODS species with the highest GWP based on the composition analysis, and the relevant container that was deemed ineligible shall be assumed to have been full. If the project developer has only some of the data required for Option A (i.e. weight or composition, but not both), this may be used in place of the conservative assumptions above, as long as the data can be confirmed by the verification body. The resulting estimate of the weight of ineligible ODS shall be subtracted from the total weight of that ODS species destroyed in the project, not to exceed the actual amount of that ODS species destroyed. See Box 5.1 for an example of Option B.

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[24] IPCC, Errata: Climate Change 2007, The Physical Science Basis, The Working Group I contribution to the IPCC Fourth Assessment Report, available at http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-errata.pdf.

Box 5.1. Applying Option B to Adjust for Ineligible ODS After Destruction

This option shall be applied when multiple containers of ODS are combined into a single container for destruction, but the eligibility of the ODS in one or more of the original containers cannot be verified.

Example:

A refrigerant aggregator receives shipments of three different containers (A, B, and C), which are combined into one project container (Z) for destruction. During verification, the project developer is unable to produce documentation to verify the eligibility of container C.

Original Containers from Point of Origin	Maximum Container Volume	Composition
A	1000 L	unknown
B	500 L	unknown
C	500 L	unknown
Project container	**Weight**	**Composition**
Z	5000 lbs	50% CFC-11 50% CFC-12

Based on Option B above, the project developer must assume that the composition of container C was 100 percent CFC-12 and that the container was completely full. Using the temperature recorded on the composition analysis (62°F for this example), the maximum amount of ODS would be equal to the volume of the container (500 L) multiplied by the density of CFC-12 at 62°F (2.9553 lb/L), or 1,478 lbs. This amount is subtracted from the total amount of eligible ODS prior to quantification of emission reductions.

Resulting eligible ODS:

CFC-11: 2500 lbs
CFC-12: 2500 – 1478 = 1022 lbs

5.1.1 Calculating Baseline Emissions from Refrigerant Recovery and Resale

There are several emissions pathways for refrigerant ODS in the United States. At end-of-life and servicing, a significant portion of ODS may be lost through fugitive releases and low recovery efficiencies. However, a portion of the ODS refrigerant in the U.S. is recovered for resale in the secondary market for recharge of existing equipment. Whereas fugitive release and low recovery results in immediate release of the ODS to the atmosphere, recovery and reuse results in a more gradual release of ODS. To ensure that actual GHG reductions from ODS destruction are not overestimated, this protocol requires estimating baseline emissions according to the assumption that refrigerant ODS would be entirely recovered and resold (i.e. there would have been zero emissions from fugitive releases and low recovery).

Because of this simplified and conservative baseline assumption, there is no need to determine why refrigerants were removed from equipment, why equipment may have been decommissioned, or why a stockpile was not utilized. Instead, Equation 5.3 shall be used to estimate the baseline emissions that would have occurred over ten years had the destroyed ODS been used in existing refrigeration or air conditioning equipment. This equation requires the use of the ODS-specific GWP provided in Table 5.1, and emission rate (inclusive of both leak rate and servicing emissions) provided in Table 5.2.[25]

Equation 5.3. Baseline Emissions from Refrigerant ODS

$$BE_{refr} = \left[\sum_i \left(Q_{refr,i} \times ER_{refr,i} \times GWP_i \right)_i \right] \times (1 - VR)$$

Where, Units

			Units
BE_{refr}	=	Total quantity of refrigerant baseline emissions during the reporting period	lb CO_2e
$Q_{refr,i}$	=	Total quantity of eligible, pure refrigerant ODS *i* sent for destruction by the project	lb ODS
$ER_{refr,i}$	=	10-year cumulative emission rate of refrigerant ODS *i* (see Table 5.2)	%
GWP_i	=	Global warming potential of ODS *i* (see Table 5.1)	lb CO_2e/ lb ODS
VR	=	Deduction for vapor composition risk (see Section 5.3)	%

Table 5.2. Baseline Emission Rates for ODS Refrigerants

ODS Species	Annual Weighted Average Emission Rate (%/yr)[26]	10-year Cumulative Emission Rate (%/10 years)[27] (ER_{refr})
CFC-11	20%	89%
CFC-12	26%	95%
CFC-13	9%	61%
CFC-113	20%	89%
CFC-114	14%	78%
CFC-115	9%	61%

5.1.2 Calculating Baseline Emissions from Shredding and/or Landfilling ODS Foam Blowing Agents

Depending on the origin of the foam, there are two different predominant baseline practices applicable to foams containing ODS blowing agent. The two baseline practices identified by the Reserve are as follows:

Origin	Baseline Practice
Insulation foam recovered from appliances	The foam is shredded, and subsequently landfilled
Foam recovered from building demolition	The foam is landfilled

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[25] See Appendix D for a summary of how these emissions rates were determined.

[26] EPA. (2011). EPA Vintaging Model. *Version VM IO file_v4.4_3.23.11*. CFC-12 estimates include data from private parties on mobile sources.

[27] 10-year cumulative emissions = 1-(1-leak rate)^{10}, or the percent of a given substance which will be released over ten years at a constant leak rate.

Equation 5.4 shall be used to calculate the ODS emissions that would have resulted from the assumed baseline practice applied to foams in the absence of the project. Baseline emissions include the total emissions that would have occurred as a result of foam shredding and landfilling.[28] In order to calculate total baseline emissions, projects destroying blowing agent extracted from appliance foam must calculate a project-specific recovery efficiency for use in Equation 5.4. Guidance on developing the recovery efficiency can be found in Appendix E.

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[28] Temperatures achieved by landfill gas flares and engines are not high enough to achieve significant ODS destruction.

Equation 5.4. Baseline Emissions from ODS Blowing Agent

$$BE_{foam} = \sum_{i,j} \left[\left(BA_{app,i} + BA_{build,i} \right) \times ER_{i,j} \times GWP_i \right]$$

Where,

			Units
BE_{foam}	=	Total quantity of ODS blowing agent baseline emissions	lb CO_2e
$BA_{app,i,}$	=	Total quantity of eligible ODS blowing agent *i* from appliance foam prior to treatment or processing, including blowing agent lost during processing	lb ODS
$BA_{build,i}$	=	Total quantity of eligible ODS blowing agent *i* from building foam sent for destruction	lb ODS
$ER_{i,j}$	=	Lifetime emission rate of ODS blowing agent *i* from application *j* at end-of-life (see Table 5.3)	%
GWP_i	=	Global warming potential of ODS *i* (see Table 5.1)	lb CO_2e/ lb ODS

$$BA_{app,i} = Q_{recover} + Q_{recover} \left(\frac{1 - RE}{RE} \right)$$

Where,

			Units
$BA_{app,i}$	=	Total quantity of ODS foam blowing agent in foam prior to treatment or processing, including ODS foam blowing agent lost during processing	lb ODS
$Q_{recover}$	=	Total quantity of eligible ODS foam blowing agent recovered during processing and sent for destruction, as determined according to Section 6.6	lb ODS
RE	=	Recovery efficiency of the ODS foam blowing agent recovery process[29] (see Appendix E for calculation of RE)	%

$$BA_{build} = Q_{foam} \times BA\%$$

Where,

			Units
BA_{build}	=	Total quantity of ODS blowing agent *i* from building foam sent for destruction	lb ODS
Q_{foam}	=	Total weight of eligible foam with entrained ODS blowing agent sent for destruction	lbs
BA%	=	Mass ratio of ODS blowing agent entrained in building foam, as determined according to Section 6.4	% (0-1)

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[29] RE is similar to the RDE defined in TEAP (2005) Report of the Task Force on Foam End-of-Life Issues, Table 6.1. RE, however, does not extend to the ODS destruction efficiency, which is handled separately under this protocol.

The total percent of ODS foam blowing agent that would be released throughout the end-of-life processing (i.e. 10-year emission rates) for each ODS foam blowing agent and foam origin is presented in Table 5.3. These values include emissions from:

1. ODS blowing agent released during foam shredding,[30] plus
2. ODS blowing agent released during foam compaction, plus
3. Landfilled ODS blowing agent that is released during anaerobic conditions (but is not degraded).

The Reserve recognizes that there is considerable uncertainty regarding the extent of anaerobic degradation of ODS foam blowing agents in U.S. landfills. According to TEAP (2005), the "extent to which [anaerobic degradation] needs to be stimulated in the landfill environment is still under review, but there is a possibility of some degradation occurring under non-optimized conditions."[31] Accordingly, the Reserve has incorporated a factor for anaerobic degradation to be conservative. The factors are drawn from Scheutz et al. (2007)[32] laboratory tests using degradation rates approximating those measured by the researchers in un-inoculated soil from a U.S. landfill. Because Scheutz et al. examined degradation rates under ideal conditions, however, the degradation rates used in this protocol are the lowest of the results reported. The degradation rates selected reflect the parameters derived from actual landfill conditions in the U.S., and more realistically estimate degradation in U.S. landfills; the higher values presented in Scheutz et al. reflect results based on parameters where degradation has been optimized through inoculation of the samples. While lower, the results used in this protocol are a conservative estimate based on laboratory analysis in a controlled environment.

Table 5.3. 10-Year Emission Rates of Appliance and Building Foam at End-of-Life

ODS Blowing Agent	Appliance ODS Blowing Agent 10-Year Emission Rate ($ER_{i,j}$)	Building ODS Blowing Agent 10-Year Emission Rate ($ER_{i,j}$)
CFC-11	44%	20%
CFC-12	55%	36%
HCFC-22	75%	65%
HCFC-141b	50%	29%

The values provided in Table 5.3 have been calculated based on the values in Table 5.4. These values are re-produced here for reference, but are not used directly in any of the calculations within this section.

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[30] Note that the emissions from foam shredding have only been factored into the emission rates from appliance ODS blowing agents in Table 5.3, as building foam is not typically shredded before being landfilled.

[31] TEAP. (2005). Report of the Task Force on Foam End-of-Life Issues. *United Nations Environment Programme*, page 39.

[32] Scheutz, C., et al. (2007). Attenuation of insulation foam released fluorocarbons in landfills. *Environmental Science & Technology*, *41*: 7714-7722.

Table 5.4. Emissions from Shredding and Landfilling ODS Foam Blowing Agents

ODS Blowing Agent	Percent of ODS Blowing Agent Released During Shredding[a] (set to zero for demolition debris)	Percent of ODS Blowing Agent Released During Compaction[b]	Percent of Remaining ODS Blowing Agent Released During Anaerobic Conditions[c]	Percent of Released ODS Blowing Agent Not Degraded in Anaerobic Landfill Conditions[c]
CFC-11	24%	19%	35%	5%
CFC-12	24%	19%	52%	40%
HCFC-22	24%	19%	100%	57%
HCFC-141b	24%	19%	41%	29%

[a] Scheutz, C., et al. (2007). Release of fluorocarbons from insulation foam in home appliances during shredding. *Journal of the Air & Waste Management Association*, *57*: 1452-1460.
[b] Fredenslund, A., et al. (2005). Disposal of Refrigerators-Freezers in the U.S. : State of the Practice. *Technical University of Denmark*.
[c] Scheutz, C., et al. (2007). Attenuation of insulation foam released fluorocarbons in landfills. *Environmental Science & Technology*, *41*: 7714-7722.

5.2 Quantifying Project Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary as a result of project activities.

As shown in Equation 5.5, project emissions equal:

- Emissions from non-ODS substitutes (applicable only to refrigerant projects), plus
- Emissions from ODS foam blowing agent extraction (applicable only to appliance foam projects), plus
- Emissions from the transportation of ODS, plus
- Emissions from the destruction of ODS

Note that emissions shall be quantified in pounds throughout this section and converted into metric tons in Equation 5.5 below.

Equation 5.5. Total Project Emissions

$$PE = \frac{Sub_{ref} + BA_{pr} + Tr + Dest}{2204.623}$$

Where,

			Units
PE	=	Total quantity of project emissions during the reporting period	tCO_2e
Sub_{ref}	=	Total emissions from substitute refrigerant	lb CO_2e
BA_{pr}	=	Total quantity of ODS blowing agent from appliance foam released during ODS extraction	lb CO_2e
Tr	=	Total emissions from transportation of ODS (calculated using either the default value in Equation 5.8 or Equation 5.14)	lb CO_2e
Dest	=	Total emissions from the process associated with destruction of ODS (calculated using either the default value in Equation 5.8 or Equation 5.9 through Equation 5.13)	lb CO_2e
2204.623	=	Conversion from pounds to metric tons	lbs/t

5.2.1 Calculating Project Emissions from the Use of Refrigerant Substitutes

When refrigerant ODS are destroyed, continued demand for refrigeration will lead to the production and consumption of other refrigerant chemicals whose production is still legally allowed. Projects that destroy refrigerant ODS must therefore estimate the emissions associated with the non-ODS substitute chemicals that are assumed to be used in their place. Like the estimates of baseline emissions, substitute emissions shall be accounted for based on the projected emissions over a ten year crediting period.

Project emissions from the use of substitute refrigerants shall be calculated for all ODS refrigerant projects according to Equation 5.6 using the emission factors from Table 5.5. The use of site-specific substitute parameters (refrigerant, GWP, and leak rate) is not permitted.

Equation 5.6. Project Emissions from the Use of Non-ODS Refrigerants

$$Sub_{refr} = \sum_i \left(Qref_i \times SE_i \right)$$

Where, Units

Sub_{refr}	=	Total quantity of refrigerant substitute emissions	lb CO_2e
$Q_{refr,i}$	=	Total quantity of eligible, pure refrigerant *i* sent for destruction	lbs
SE_i	=	Emission factor for substitute(s) for refrigerant *i*, per Table 5.5	lb CO_2e/ lb ODS destroyed

ODS substitute emissions presented in Table 5.5 are based on the weighted average of expected new refrigerant supplies into the refrigeration market. These substitute refrigerants were modeled using the EPA Vintaging Model and data provided by industry sources. A summary of the ODS substitute emission rates analysis and calculations is provided in Appendix D. The analysis identified substitute emission factors for each ODS refrigerant covered under this protocol (see Appendix D).

Table 5.5. Refrigerant Substitute Emission Factors[33]

ODS Refrigerant	Substitute Emission Factors (lb CO_2e/lb ODS) (SE_i)
CFC-11	202
CFC-12	777
CFC-13	7144
CFC-113	220
CFC-114	659
CFC-115	1689

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[33] See Appendix D for a summary of the development of these factors.

5.2.2 Calculating Project Emissions from ODS Blowing Agent Extracted from Appliance Foam

Projects that extract ODS blowing agent from appliance foam must account for the emissions of ODS that occur during processing, separation, and extraction using Equation 5.7. These emissions are calculated in Equation 5.7 based on the quantity of ODS blowing agent sent for destruction ($BA_{app,i}$, as calculated in Equation 5.4), and a project-specific recovery efficiency that represents the percentage of ODS that is *not* lost during these steps. The recovery efficiency must be calculated once per project according to the guidance provided in Appendix E. Although not required under this protocol, well-executed projects should be capable of keeping these emissions to no more than 10 percent of ODS blowing agent contained in the foam, per the recommendations of the TEAP *Report of the Task Force on Foam End-of-Life Issues*.[34]

Equation 5.7. Calculating Project Emissions from the Release of ODS Blowing Agent during Processing

$$BA_{pr} = \sum_i \left(BA_{app,i} \times (1 - RE) \times GWP_i \right)$$

Where,

			Units
BA_{pr}	=	Total quantity of ODS blowing agent from appliance foam released during ODS extraction	lb CO_2e
$BA_{app,i}$	=	Total quantity of appliance ODS foam blowing agent in foam prior to treatment or processing, including ODS foam blowing agent lost during processing (see Equation 5.4 to calculate this term)	lb ODS
RE	=	Recovery efficiency of the ODS foam blowing agent recovery process (see Appendix E to calculate RE)	%
GWP_i	=	Global warming potential of ODS *i* (see Table 5.1)	lb CO_2e/ lb ODS

5.2.3 Calculating Default Project Emissions from Transportation and Destruction

Projects must account for emissions that result from the transportation and destruction of ODS. Because these emission sources are both individually and in aggregate very small, the Reserve has developed default emission factors for ODS projects based on conservative assumptions and the SSRs outlined in Table 4.1[35]:

- 7.5 pounds CO_2e per pound ODS for refrigerant or extracted ODS blowing agent projects
- 75 pounds CO_2e per pound ODS for intact building foam projects

These emission factors aggregate both transportation and destruction emissions. Project developers have the option of using the default emission factors or using the guidance in Sections 5.2.4 and 5.2.5 to calculate project-specific emissions. Equation 5.8 shall be used to calculate ODS transportation and destruction emissions if default emission factors are used. If a project developer elects not to use the default emission factors, emissions associated with transportation and destruction of ODS must be calculated separately.

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[34] TEAP. (2005). Report of the Task Force on Foam End-of-Life Issues*. United Nations Environment Programme*.

[35] See Appendix F for an explanation of how these default emission factors were derived.

Equation 5.8. Project Emissions from Transportation and Destruction Using the Default Emission Factors

$$Tr + Dest = \sum_i \left(Q_{ODS,i} \times EF_i\right)$$

Where,

			Units
Tr+Dest	=	Total emissions from project transportation and destruction, as calculated using default emission factors	lb CO_2e
$Q_{ODS,i}$	=	Total quantity of ODS *i* sent for destruction in the project, including eligible and ineligible material	lb ODS
EF_i	=	Default emission factor for transportation and destruction of ODS *i* (7.5 for refrigerant or extracted ODS blowing agent projects, 75 for intact building foam projects)	lb CO_2e/ lb ODS

5.2.4 Calculating Site-Specific Project Emissions from ODS Destruction

Under this protocol, ODS must be destroyed at destruction facilities that demonstrate compliance with the TEAP recommendations.[36] These facilities are required to demonstrate their ability to achieve destruction efficiencies upwards of 99.99 percent for substances with thermal stability ratings higher than the ODS included under this protocol.[37] Associated with the operation of these facilities are emissions of CO_2 from the fuel and electricity used to power the destruction, as well as emissions of undestroyed ODS. Equation 5.9 through Equation 5.13 provide requirements for calculating emissions from ODS destruction in cases where project developers opt not to use the default factors provided in Section 5.2.3.

Equation 5.9. Project Emissions from the Destruction of ODS

$$Dest = FF_{dest} + EL_{dest} + ODS_{emissions} + ODS_{CO_2}$$

Where,

			Units
Dest	=	Total emissions from the destruction of ODS	lb CO_2e
FF_{dest}	=	Total emissions from fossil fuel used in the destruction facility (Equation 5.10)	lb CO_2
EL_{dest}	=	Total indirect emissions from grid electricity used at the destruction facility (Equation 5.11)	lb CO_2
$ODS_{emissions}$	=	Total emissions of undestroyed ODS (Equation 5.12)	lb CO_2e
ODS_{CO2}	=	Total emissions of CO_2 from ODS oxidation (Equation 5.13)	lb CO_2

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[36] TEAP: http://uneptie.org/ozonaction/topics/disposal.htm.

[37] ICF International. (2009). ODS Destruction in the United States of America and Abroad. *U.S. EPA*.

Equation 5.10. Fossil Fuel Emissions from the Destruction of ODS

$$FF_{dest} = \frac{\sum_{k}\left(FF_{PR,k} \times EF_{FF,k}\right)}{0.454}$$

Where,

			Units
FF_{dest}	=	Total carbon dioxide emissions from the destruction of fossil fuel used to destroy ODS	lb CO_2
$FF_{PR,k}$	=	Total fossil fuel *k* used to destroy ODS	volume fossil fuel
$EF_{FF,k}$	=	Fuel specific emission factor (see Appendix G)	kg CO_2/ volume fossil fuel
0.454	=	Conversion from kilograms to pounds	kg CO_2/ lb CO_2

Equation 5.11. Electricity Emissions from the Destruction of ODS

$$EL_{dest} = \left(EL_{PR} \times EF_{EL}\right)$$

Where,

			Units
EL_{dest}	=	Total carbon dioxide emissions from the consumption of electricity from the grid used to destroy ODS	lb CO_2
EL_{PR}	=	Total electricity consumed to destroy ODS	MWh
EF_{EL}	=	CO_2 emission factor for electricity used[38]	lb CO_2/ MWh

Equation 5.12. Calculating Project Emissions from ODS Not Destroyed

$$ODS_{emissions} = \sum_{i} Q_{ODS,i} \times 0.0001 \times GWP_{i}$$

Where,

			Units
$ODS_{emissions}$	=	Total emissions of undestroyed ODS	lb CO_2e
$Q_{ODS,i}$	=	Total quantity of ODS *i* sent for destruction in the project	lb ODS
0.0001	=	Maximum allowable percent of ODS fed to destruction that is not destroyed (0.01 percent)	
GWP_i	=	Global warming potential of ODS *i* (see Table 5.1)	lb CO_2e/ lb ODS

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[38] Refer to the version of the EPA eGRID that most closely corresponds to the time period during which the electricity was used. Project shall use the annual total output emission rates for the subregion where the destruction facility is located, not the non-baseload output emission rates. The eGRID tables are available at http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

Equation 5.13. Calculating Project Emissions of CO_2 from the Oxidation of ODS

$$ODS_{CO_2} = \sum_i Q_{ODS,i} \times 0.9999 \times CR_i \times \frac{44}{12}$$

Where,

			Units
ODS_{CO2}	=	Total emissions of CO_2 from ODS oxidation	lb CO_2
$Q_{ODS,i}$	=	Total quantity of ODS *i* sent for destruction in the project	lb ODS
0.9999	=	Minimum destruction efficiency of destruction facility	% (0-1)
CR_i	=	Carbon ratio of ODS *i* CFC-11: 12/137 CFC-12: 12/121 CFC-13: 12/104 CFC-113: 24/187 CFC-114: 24/171 CFC-115: 24/154 HCFC-22: 12/87 HCFC-141b: 24/117	mole C/ mole ODS
44/12	=	Ratio of CO_2 to C	mole CO_2/ mole C

5.2.5 Calculating Site-Specific Project Emissions from ODS Transportation

As part of any ODS destruction project, ODS will be transported from aggregators to destruction facilities, and emissions from this transportation must be accounted for under this protocol. Equation 5.14 must be used to calculate CO_2 emissions associated with the transport of ODS in cases where project developers choose not to use the default emission factors presented in Section 5.2.3. Emissions shall be calculated for each leg of the transportation process separately, and then summed according to Equation 5.14 below.

Equation 5.14. Calculating Project Emissions from the Transportation of ODS[39]

$$Tr = \sum_i \left(TMT_i \times EF_{TMT} \right)$$

Where,

			Units
Tr	=	Total emissions from transportation of ODS	lb CO_2e
PMT_i	=	Pound-miles-traveled[40] for ODS *i* destroyed (to be calculated including the ODS, any accompanying material, and containers from point of aggregation to destruction)	pound-miles
EF_{PMT}	=	CO_2 emissions per pound-mile-traveled On-road truck transport = 0.000297 Rail transport = 0.0000252 Waterborne craft = 0.000048 Aircraft = 0.001527	lb CO_2 / pound-mile

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[39] Derived from: U.S. EPA Climate Leaders, (2008). Optional emissions from business travel, commuting, and product transport.

[40] A pound-mile is defined as the product of the distance traveled in miles and the mass transported in pounds. Therefore, 500 lbs transported four miles is equal to 2,000 pound-miles.

5.3 Deduction for Vapor Composition Risk

For any given container of ODS, a portion of the container will be filled with liquid, and the remaining space will be filled with vapor. This protocol only requires that a liquid sample be taken for composition analysis. For containers that hold a mixture of ODS, the composition of ODS in the vapor may be different from the composition of ODS in the liquid due to differences in the thermodynamic properties of the chemicals. If the container holds chemicals that are not eligible for crediting, the quantification of emission reductions based on the analysis of liquid sample could overstate the actual reductions from the destruction of the material.

To address this risk, projects that destroy containers which contain more than one chemical must use Table 5.7 to determine their risk category and applicable value of *VR* to be applied to the calculation of baseline emissions for that container (Equation 5.3). Table 5.6 classifies the eligible ODS species as low or high pressure. For the purposes of this protocol, any ineligible chemical with a boiling point less than 32°F at 1 atm is considered high pressure.

The densities of the liquid and vapor phase components of the project container will be determined by the testing laboratory at the time that the composition analysis is carried out. The testing laboratory will calculate the densities of the liquid phase and vapor phase contents within the container. To support this calculation, the project developer shall provide the laboratory with the temperature of the project container (internal temperature if available, otherwise ambient temperature) at the time of sampling, as well as the volumetric capacity of the project container. Once the weight of the contents of the project container is known, the liquid fill level of the container may be determined using Equation 5.15.

Table 5.6. Eligible Low Pressure and High Pressure ODS

Low Pressure ODS	High Pressure ODS
CFC-11	CFC-12
CFC-113	CFC-13
CFC-114	CFC-115

Table 5.7. Determining the Deduction for Vapor Composition Risk

If the value of $Fill_{liquid}$ is:	AND the concentration of eligible low pressure ODS is:	AND the concentration of ineligible high pressure chemical is:	Then the vapor risk deduction factor (VR) for that container shall be:
> 0.70	N/A	N/A	0
0.50 – 0.70	> 1%	> 10%	0.02
< 0.50	> 1%	> 5%	0.05

The presence of eligible, high pressure ODS may mitigate the risk of over-crediting, so there are two scenarios where a container is exempt from a deduction otherwise required in Table 5.7:

1. The container holds an eligible, high pressure ODS (in any concentration) which has a lower boiling point than the ineligible, high pressure chemical, or
2. The container holds an eligible, high pressure ODS in a concentration greater than that of the ineligible, high pressure chemical.

If the container holds multiple eligible, high pressure ODS, the applicability of the above scenarios will be determined based on the ODS with the highest percent concentration. If the container holds multiple ineligible, high-pressure chemicals, the applicability of the above scenarios will be determined based on the chemical with the highest percent concentration.

This deduction applies to both mixed and non-mixed ODS projects as defined in Section 6.6.

Equation 5.15. Determining Liquid Fill Level in Project Container

$$Fill_{liquid} = \frac{M_{destroyed} - (\rho_{vapor} \times V_{container})}{(\rho_{liquid} - \rho_{vapor}) \times V_{container}}$$

Where,

			Units
$Fill_{liquid}$	=	Fill level of the liquid in the project container	fraction
$V_{container}$	=	Total volume of the project container	gal
$M_{destroyed}$	=	Total mass of the contents of the project container	lbs
ρ_{liquid}	=	Modeled density of the liquid material in the project container at the measured temperature	lbs/gal
ρ_{vapor}	=	Modeled density of the vapor material in the project container at the measured temperature	lbs/gal

6 Project Monitoring and Operation

The Reserve requires a Monitoring and Operations Plan to be established for all monitoring, operational, and reporting activities associated with ODS destruction projects. The Monitoring and Operations Plan will serve as the basis for verification bodies to confirm that the monitoring, operational, and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing for the project. The Monitoring and Operations Plan must cover all aspects of monitoring, operations, and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.2 (below) will be collected and recorded.

At a minimum the Monitoring and Operations Plan shall stipulate the frequency of data acquisition; a record keeping plan (see Section 7.3 for minimum record keeping requirements); and the role of individuals performing each specific monitoring or operational activity. The Monitoring and Operations Plan shall also contain a project diagram that illustrates the project ODS point(s) of origin, any reclamation facilities used, information on ODS transportation mode and transportation companies, mixing/sampling facilities, testing laboratories and the destruction facility (see Appendix H for a sample project diagram). The Monitoring and Operations Plan should also include QA/QC provisions to ensure that operations, data acquisition, and ODS analyses are carried out consistently and with precision.

Project developers are responsible for monitoring the performance of the project and ensuring that there is no double-counting of GHG reductions associated with ODS destruction. To achieve this, the Monitoring and Operations Plan must also include a description of how data will be provided to the Reserve ODS tracking system (Section 6.1).

Finally, the Monitoring and Operations Plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test (Section 3.4.1).

6.1 Reserve ODS Tracking System

For the purposes of ensuring the integrity of ODS destruction projects, the Reserve maintains an online database of all destruction activities for which CRTs are registered and issued. Entries into this system within the Reserve software must be made by the project developer prior to the beginning of verification activities related to confirming that reductions have not been claimed by other parties for the destruction activity in question.[41]

All projects are required to have one or more Certificate(s) of Destruction accounting for all eligible ODS destroyed as part of that project. The following information shall be entered by the project developer into the Reserve software from the Certificate(s) of Destruction issued by the destruction facility, and a copy of the certificate(s) must be provided to the project verifier:

- Project developer (project account holder)
- Destruction facility
- Generator name
- Certificate of Destruction ID number

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[41] Other verification activities (such as site visits) may commence prior to submission of information into the ODS tracking system.

- Start destruction date
- End destruction date
- Total weight of material destroyed (including eligible and ineligible material)

6.2 Point of Origin Documentation Requirements

Project developers are responsible for collecting data on the point of origin of each quantity of ODS, as defined in Table 6.1. The project developer must maintain detailed acquisition records of all quantities of ODS destroyed under the project. Project developers must be able to document the point of origin for all ODS that will be included in the project as defined below.

Table 6.1. Identification of Point of Origin

ODS	Defined Point of Origin
1. Refrigerant ODS stockpiled prior to February 3, 2010	Location of stockpile
2. Refrigerant ODS quantities less than 500 lbs	Location where ODS is first aggregated with other ODS to greater than 500 lbs
3. Refrigerant ODS quantities greater than 500 lbs	Site of installation where ODS is recovered
4. Refrigerant ODS purchased from U.S. Defense Logistics Agency (DLA) Disposition Services[42] auction	Location at the time of sale through a DLA Disposition Services auction
5. ODS blowing agent extracted from foam	Facility where ODS blowing agent is extracted
6. ODS blowing agent in building foam	Location of building from which foam was taken

For destroyed ODS where the point of origin is a reservoir-style stockpile (i.e. ODS was not stored in sealed containers), the date on which the ODS was stockpiled is established using "first-in/first-out" accounting. Specifically, the date on which a quantity of ODS was "stockpiled" is defined as the furthest date in the past on which the quantity of ODS contained in the reservoir was greater than or equal to the total quantity of all ODS removed from the reservoir since that date (including any ODS removed and destroyed as part of the project). The date must be established using management systems and logs that verify the quantities of ODS placed into and removed from the reservoir throughout the relevant period. Provided these conditions are met, and the stockpile follows the "first-in/first-out" accounting, the date on which a quantity of ODS was stockpiled may be established.

For stockpiles, documentation must confirm that the stockpile has been stored at the point of origin prior to February 3, 2010.

For ODS recovered by service technicians in individual quantities less than 500 pounds, the point of origin is defined as the facility where two or more containers were combined and exceeded 500 pounds in a single container. Those handling quantities less than 500 pounds in a single container need not provide the documentation required below. However, once smaller quantities are aggregated and exceed 500 pounds in a single container, tracking is required at that location and point in time forward.

For containers of ODS greater than 500 pounds (determined as the weight of eligible ODS within a single container), the project developer must provide documentation as to the origin of

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[42] See Appendix B for more information.

the ODS within that container and when it was recovered. If it is shown that, prior to aggregation in the project container, the ODS was contained as a quantity greater than 500 pounds, then the documentation must extend back to this previous container and its point of origin. The project developer must provide documentation tracking the ODS back to a point in time and location where it was either a) contained or recovered as a quantity of less than 500 pounds, or b) recovered by a service technician as a quantity of greater than 500 pounds.

For refrigerant ODS purchased from a U.S. Defense Logistics Agency (DLA) Disposition Services auction, the point of origin is defined as the facility where the ODS is stored at the time of sale through the auction. Tracking is required from that location and point in time forward. Documentation must show that the ODS was purchased from a DLA Disposition Services auction and include a bill of sale with specifications about the amount and type of ODS purchased. It is possible that the point of origin documentation may not be generated at the point of origin as required below, but rather at the auction location, which is allowable. Refrigerant ODS sourced directly from federal government agencies or installations is not eligible under the protocol.

All data must be generated at the point of origin, except in the case of ODS purchased through DLA Disposition Services auction noted above. Documentation of the point of origin of ODS shall include the following:

- Facility name and physical address, including zip code
- For quantities greater than 500 pounds, identification of the system by serial number, if available, or description, location, and function, if serial number is unavailable
- Serial or ID number of containers used for storage and transport

6.3 Custody and Ownership Documentation Requirements

In conjunction with establishing the point of origin for each quantity of ODS, project developers must also document the custody and ownership of ODS beginning from the point of origin. These records shall include names, addresses, and contact information of persons/entities buying/selling material for destruction and the quantity of the material (the combined mass of refrigerant and contaminants) bought/sold. Such records may include Purchase Orders, Purchase Agreements, packing lists, bills of lading, lab test results, transfer container information, receiving inspections, freight bills, transactional payment information, and any other type of information that will support previous ownership of the material and the transfer of that ownership. The verifier will review these records and will perform other tests necessary to authenticate the previous owners of the material, the physical transfer of the product, and the title transfer of ownership rights of all emissions and emission reductions associated with destroyed ODS to the project developer, as documented through contracts, agreements or other legal documents.

6.4 Building Foam Requirements

The following information shall be collected and recorded related to ODS blowing agents from building insulation foam destroyed by the project:

- Building address
- Date of construction
- Blowing agent used
- Approximate building dimensions

All recovered foam pieces must be placed in air- and water-tight storage for transport to the destruction facility.

ODS blowing agent from building insulation foam may be destroyed intact without extraction of the blowing agent if the following procedures are followed to characterize the mass of foam and type(s) and mass ratio of ODS blowing agent contained in that foam.

1. The mass of the foam shall be determined through weight measurements taken at the destruction facility on a scale which has its calibration tested quarterly by a licensed service company, using certified test weights. A scale is considered calibrated if it is within the maintenance tolerance of the relevant National Institute of Standards and Technology (NIST) Handbook 44 accuracy class. If a scale is found to be outside of this tolerance it must be recalibrated.

2. The composition and mass ratio of the ODS foam blowing agent(s) present in the building insulation foam shall be determined based on a selection of a minimum two samples per building surface taken prior to demolition. Accordingly, a building with four exterior walls and a roof would be required to analyze a total of 10 samples: two for each wall, and two for the roof.

3. All samples must be collected and analyzed according to the following requirements:

   - Each foam sample shall be at a minimum two inches in length, two inches in width, and two inches thick
   - Each sample shall be placed and sealed in a separate waterproof, air-tight container, that is at minimum two millimeters thick for storage and transport
   - The analysis of ODS foam blowing agent content and mass ratio shall be done at an independent laboratory unaffiliated with the project developer
   - The analysis shall be done using the heating method to extract ODS foam blowing agent from the foam samples described in Scheutz et al. (2007):[43]
     - Each sample shall be prepared to a thickness no greater than one centimeter, placed in a 1123 mL glass bottle, weighed using a calibrated scale, and sealed with Teflon-coated septa and aluminum caps
     - To release the ODS blowing agent from the foam, the samples must be incubated in an oven for 48 hours at 140°C
     - When cooled to room temperature, gas samples must be redrawn from the headspace and analyzed using gas chromatography
     - The lids must be removed after analysis, and the headspace must be flushed with atmospheric air for approximately five minutes using a normal compressor. Afterwards, septa and caps must be replaced and the bottles subjected to a second 48-hour heating step to drive out the remaining ODS blowing agent from the sampled foam
     - When cooled down to room temperature after the second heating step, gas samples must be redrawn from the headspace and analyzed using gas chromatography

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[43] Scheutz, C., Fredenslund, A.M., Tant, M., & Kjeldsen, P. (2007). Release of fluorocarbons from insulation foam in home appliances during shredding. *Journal of the Air & Waste Management Association*, *57:* 1452-1460.

  - The mass of ODS 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 ODS foam blowing agent present

4. The results from all samples from a single building shall be averaged to determine the mass ratio of blowing agent to foam, and this value multiplied by the weight of destroyed foam. The result shall represent the total quantity of ODS blowing agent from building foams destroyed for that building, and shall be used for the quantity as BA_{build} in Equation 5.4.

These practices shall be documented in Monitoring and Operations Plan, and must be demonstrated during verification activities (see Section 8.6).

6.5 Appliance Foam Requirements

The following information shall be collected and recorded related to ODS blowing agent from appliance foams destroyed by the project:

- Number of appliances processed
- Facility at which ODS foam blowing agent is extracted to concentrated form
- Facility at which appliance de-manufacture occurs, if applicable

All appliance foam must be processed to recover and destroy concentrated ODS blowing agent. The following requirements must be met:

- The ODS blowing agent must be extracted from the foam to a concentrated form prior to destruction
- ODS blowing agent must be extracted under negative pressure to ensure that fugitive release of ODS is limited
- The recovered ODS blowing agent must be aggregated, stored, and transported in containers meeting U.S. Department of Transportation (DOT) standards for refrigerants

Extraction of the foam blowing agent may be performed using any technology capable of recovering concentrated ODS foam blowing agent. The processes, training, QA/QC, and management systems must be documented in the Monitoring and Operations Plan. The same process, as documented in the Monitoring and Operations Plan must be followed during project implementation and during the calculation of the project-specific recovery efficiency, as described in Appendix E.

Concentrated ODS blowing agent shall be measured according to the procedures provided in Section 6.6.

6.6 Concentrated ODS Composition and Quantity Analysis Requirements

The requirements of this section must be followed to determine the quantities of both ODS refrigerants and concentrated ODS blowing agent. Prior to destruction, the precise mass and composition of ODS to be destroyed must be determined. The following analysis must be conducted:

Mass shall be determined by individually measuring the weight of each container of ODS: (1) when it is full prior to destruction; and (2) after it has been emptied and the contents have been fully purged and destroyed. The mass of ODS and any contaminants is equal to the difference between the full and empty weight, as measured. The following requirements must be met when weighing the containers of ODS:

1. A single scale must be used for generating both the full and empty weight tickets at the destruction facility
2. The scale used must have its calibration tested quarterly by a licensed service company, using certified test weights. A scale is considered calibrated if it is within the maintenance tolerance of the relevant NIST Handbook 44 accuracy class. If a scale is found to be outside of this tolerance, it must be recalibrated
3. The full weight must be measured no more than two days prior to commencement of destruction per the Certificate of Destruction
4. The empty weight must be measured no more than two days after the conclusion of destruction per the Certificate of Destruction

Composition and concentration of ODS shall be established for each individual container by taking a sample from each container of ODS and having it analyzed for composition and concentration at an Air-Conditioning, Heating and Refrigeration Institute (AHRI) certified laboratory using the AHRI 700-2006 standard,[44] or its successor. The laboratory performing the composition analysis must not be affiliated with the project developer or the project beyond performing these services.

The following requirements must be met for each sample:

1. The sample must be taken while ODS is in the possession of the company that will destroy the ODS
2. Samples must be taken by a technician unaffiliated with the project developer[45]
3. Samples must be taken with a clean, fully evacuated sample bottle that meets applicable U.S. DOT requirements with a minimum capacity of one pound
4. The technician must ensure that the sample is representative of the contents of the container. All valves between the interior of the container and the sample port must be opened for a minimum of 15 minutes before the sample is taken
5. Each sample must be taken in liquid state
6. A minimum sample size of one pound must be drawn for each sample
7. Each sample must be individually labeled and tracked according to the container from which it was taken, and the following information recorded:
    a) Time and date of sample
    b) Name of project developer
    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[46]
8. Chain of custody for each sample from the point of sampling to the AHRI laboratory must be documented by paper bills of lading or electronic, third-party tracking that includes proof of delivery (e.g. FedEx, UPS)

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[44] AHRI. (2006). Standard 700-2006: Standard for Specifications for Fluorocarbon Refrigerants.

[45] For instances where the project developer is the destruction facility itself, an outside technician must be employed for taking samples.

[46] Projects that destroy ODS prior to the adoption date of this protocol may use proxy data from NOAA recording stations in the area.

All project samples shall be analyzed using AHRI 700-2006 or its successor to confirm the mass percentage and identity of each component of the sample. The analysis shall provide:

1. Identification of the refrigerant
2. Purity (%) of the ODS mixture by weight using gas chromatography
3. Moisture level in parts per million. The moisture content of each sample must be less than 75 percent of the saturation point for the ODS based on the temperature recorded at the time the sample was taken. For containers that hold mixed ODS, the sample's saturation point shall be assumed to be that of the ODS species in the mixture with the lowest saturation point that is at least 10 percent of the mixture by mass
4. Analysis of high boiling residue, which must be less than 10 percent by mass
5. Analysis of other ODS in the case of mixtures of ODS, and their percentage by mass

If any of the requirements above are not met, no GHG reductions may be verified for ODS destruction associated with that container. If a sample is tested and does not meet one of the requirements as defined above, the project developer may elect to have the material re-sampled and re-analyzed. While there is no limit to the number of samples that may be taken, the analysis results of all samples must be disclosed to the verification body, and the most conservative composition analysis from these samples shall be used for the quantification. If a project developer elects to have the material dried prior to resampling, the previous samples (prior to drying) may be disregarded.

Note that the threshold for moisture saturation will be difficult to achieve at very low temperatures, and it is recommended that sampling not occur if the ambient air temperature is below 32°F. Project developers may sample for moisture content and perform any necessary de-watering prior to the required sampling and laboratory analysis.

If the container holds non-mixed ODS (defined as greater than 90 percent composition of a single ODS species) no further information or sampling is required to determine the mass and composition of the ODS.

If the container holds mixed ODS, which is defined as less than 90 percent composition of a single ODS species, the project developer must meet additional requirements as provided in Section 6.6.1.

6.6.1 Analysis of Mixed ODS

If a container holds mixed ODS, its contents must also be processed and measured for composition and concentration according to the requirements of this section (in addition to the requirements of Section 6.6). The sampling required under this section may be conducted at the final destruction facility or prior to delivery to the destruction facility. However, the circulation and sampling activities must be conducted by a third-party organization (i.e. not the project developer), and by individuals who have been properly trained for the functions they perform. Circulation and sampling may be conducted at the project developer's facility, but all activities must be directed by a properly trained and contracted third-party. The project's Monitoring and Operations Plan must specify the procedures by which mixed ODS are analyzed. If the mixing and sampling are conducted at the destruction facility, then the most conservative result of the two samples shall be used to satisfy the requirements of Section 6.6. If the mixing and sampling do not occur at the destruction facility, then the most conservative composition analysis from the mixing facility samples shall be used for the quantification of emission reductions.

The composition and concentration of ODS on a mass basis must be determined using the results of the analysis of this section for each container. The results of the composition analysis in Section 6.6 shall be used by verifiers to confirm that the destroyed ODS is in fact the same ODS that is sampled under these requirements.

Prior to sampling, the ODS mixture must be circulated in a container that meets all of the following criteria:

1. The container has no solid interior obstructions[47]
2. The container was fully evacuated prior to filling
3. The container must have mixing ports to circulate liquid and gas phase ODS
4. The liquid port intake shall be at the bottom of the container, and the vapor port intake shall be at the top of the container. For horizontally-oriented mixing containers, the intakes shall be located in the middle third of the container.
5. The container and associated equipment can circulate the mixture via a closed loop system from the liquid port to the vapor port

If the original mixed ODS container does not meet these requirements, the mixed ODS must be transferred into a temporary holding tank or container that meets all of the above criteria. The weight of the contents placed into the temporary container shall be calculated and recorded. During transfer of ODS into and out of the temporary container, ODS shall be recovered to the vacuum levels required by the U.S. EPA for that ODS (see 40 CFR 82.156).[48]

Once the mixed ODS is in a container or temporary storage unit that meets the criteria above, circulation of mixed ODS must be conducted as follows:

1. Liquid mixture shall be circulated from the liquid port to the vapor port
2. A volume of the mixture equal to two times the volume in the container shall be circulated
3. Circulation must occur at a rate of at least 30 gallons/minute. Alternatively, circulation may occur at a rate that is less than 30 gallons/minute, as long as criterion #2 is achieved within the first 6 hours of mixing
4. Start and end times shall be recorded

Within 30 minutes of the completion of circulation, a minimum of two samples shall be taken from the bottom liquid port according to the procedures in Section 6.6. Both samples shall be analyzed at an AHRI approved laboratory per the requirements of Section 6.6. The mass composition and concentration of the mixed ODS shall be equal to the lesser of the two GWP-weighted concentrations.

6.7 Destruction Facility Requirements

Destruction of ODS must occur at a facility that meets all of the guidelines provided in Appendix C of this protocol and by the TEAP Task Force on Destruction Technologies[49]

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[47] Mesh baffles or other interior structures that do not impede the flow of ODS are acceptable.

[48] EPA. Required Levels of Evacuation. Retrieved December 21, 2009, from http://www.epa.gov/Ozone/title6/608/608evtab.html.

[49] http://www.uneptie.org/ozonaction/topics/disposal.htm.

Any destruction facility that is regulated by U.S. EPA as a RCRA-permitted HWC is automatically considered a qualifying destruction facility under this protocol; no further testing for TEAP compliance is required.

Non-RCRA permitted facilities may also be deemed qualifying destruction facilities if they meet the pertinent guidelines reproduced in Appendix C. Destruction facilities must provide third-party certified results indicating that the facility meets all performance criteria set forth in Appendix C. Following the initial performance testing, project developers must demonstrate that the facility has conducted comprehensive performance testing at least every three years to validate compliance with the TEAP DRE and emissions limits as reproduced in Appendix C. No ODS destruction credits shall be issued for destruction that occurs at a facility that has failed to undergo comprehensive performance testing according to the required schedule, or has failed to meet the requirements of such performance testing.

At the time of ODS destruction, all destruction facilities 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. Facilities must document compliance with all monitoring and operational requirements associated with the destruction of ODS materials, as dictated by these permits, including emission limits, calibration schedules, and training. Any upsets or exceedances must be managed in keeping with an authorized startup, shutdown, and malfunction plan. Non-RCRA facilities must further document operation consistent with the TEAP requirements, as defined in this section and Appendix C.

Operating parameters during destruction of ODS material shall be monitored and recorded as described in the Code of Good Housekeeping[50] approved by the Montreal Protocol. This data will be used in the verification process to demonstrate that during the destruction process, the destruction unit was operating similarly to the period in which the DRE[51] was calculated. The DRE is determined by using the Comprehensive Performance Test (CPT)[52] as a proxy for DRE and is disclosed to the public in the destruction facility's Title V operating permit.

To monitor that the destruction facility operates in accordance with applicable regulations and within the parameters recorded during DRE testing, the following parameters must be tracked continuously during the entire ODS destruction process:

- The ODS feed rate
- The amount and type of consumables used in the process (not required if default project emission factor for transportation and destruction is used)
- The amount of electricity and amount and type of fuel consumed by the destruction unit (not required if default project emission factor for transportation and destruction is used)
- Operating temperature and pressure of the destruction unit during ODS destruction
- Effluent discharges measured in terms of water and pH levels
- Continuous emissions monitoring system (CEMS) data on the emissions of carbon monoxide during ODS destruction

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[50] TEAP. (2006). Code of Good Housekeeping. *Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer, 7th Edition*.

[51] DRE disclosed in Title V operating permit.

[52] CPT must have been conducted with a less combustible chemical than the ODS in question.

The project developer must maintain records of all of these parameters for review during the verification process.

Destruction facilities shall provide valid Certificate(s) of Destruction for all ODS destroyed as part of the project. The Certificate of Destruction shall include:

- Project developer (project account holder)
- Destruction facility
- Generator name
- Certificate of Destruction ID number
- Serial, tracking or ID number of all containers for which ODS destruction occurred
- Weight of material destroyed from each container (including eligible and ineligible material)
- Type of material destroyed from each container (including all materials listed on laboratory analysis of ODS composition from sampling at the destruction facility)
- Start destruction date
- End destruction date

6.8 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.2 below. In addition to the parameters below that are used in the calculations provided in Section 5, project developers are responsible for maintaining all records required under Sections 6 and 7.

Table 6.2. ODS Project Monitoring Parameters

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Comment
		Legal Requirement Test	N/A	For each reporting period		Must be monitored and determined for each reporting period
		Mass of ODS (or ODS mixture) in each container	mass of mixture	Per container	M	Must be determined for each container destroyed
		Concentration of ODS (or ODS mixture) in each container	mass ODS/ mass of mixture	Per container	M	Must be determined for each container destroyed
Equation 5.1	ER_t	Total quantity of emission reductions during the reporting period	tCO_2e	For each reporting period	C	
Equation 5.1, Equation 5.2	BE_t	Total quantity of baseline emissions during the reporting period	tCO_2e	For each reporting period	C	
Equation 5.1, Equation 5.5	PE_t	Total quantity of project emissions during the reporting period	tCO_2e	For each reporting period	C	
Equation 5.2, Equation 5.3	BE_{refr}	Total quantity of baseline emissions from refrigerant ODS	lb CO_2e	For each reporting period	C	
Equation 5.2, Equation 5.4	BE_{foam}	Total quantity of baseline emissions from ODS blowing agent	lb CO_2e	For each reporting period	C	
Equation 5.3, Equation 5.6	$Q_{refr,i}$	Total quantity of eligible refrigerant ODS *i* sent for destruction	lb ODS	For each reporting period	M	
Equation 5.3	$ER_{refr,i}$	10-year cumulative emission rate of refrigerant ODS *i*	0 - 1.0	N/A	R	See Table 5.1
Equation 5.3, Equation 5.4, Equation 5.7, Equation 5.12	GWP_i	Global warming potential of ODS *i*	lb CO_2e/ lb ODS	N/A	R	See Table 5.1

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Comment
Equation 5.3	VR	Vapor risk deduction factor	% (0-1)	For each reporting period	R	See Table 5.7
Equation 5.4, Equation 5.7	$BA_{app,i,}$	Total quantity of ODS blowing agent *i* from appliance foam prior to treatment or processing, including blowing agent lost during processing	lb ODS	For each reporting period	C	
Equation 5.4	$BA_{build,i}$	Total quantity of ODS blowing agent *i* from building foam sent for destruction.	lb ODS	For each reporting period	C	
Equation 5.4	$ER_{i,j}$	Lifetime emission rate of ODS blowing agent *i* from application *j* at end-of-life (see Table 5.3)	% (0-1)	N/A	R	
Equation 5.4	$Q_{recover}$	Total quantity of ODS foam blowing agent recovered during processing and sent for destruction	lb ODS	For each reporting period	M	
Equation 5.4, Equation 5.7	RE	Recovery efficiency of the ODS foam blowing agent recovery process	% (0-1)	Once per project	C	See Appendix E for calculation of RE
Equation 5.4	Q_{foam}	Total weight of foam with entrained ODS blowing agent sent for destruction	lb	For each reporting period	M	
Equation 5.4	BA%	Mass ratio of ODS blowing agent entrained in building foam, as determined according to Section 6.4	% (0-1)	For each reporting period	M	
Equation 5.5, Equation 5.6	Sub_{refr}	Total emissions from substitute refrigerant	lb CO_2e	For each reporting period	C	
Equation 5.5, Equation 5.7	$BA_{pr,i}$	Total quantity of ODS foam blowing agent *i* from appliance foam released during ODS extraction	lb CO_2e	For each reporting period	C	

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Comment
Equation 5.5, Equation 5.8, Equation 5.14	Tr	Total emissions from project transportation	lb CO_2e	For each reporting period	C	
Equation 5.5, Equation 5.8, Equation 5.9	Dest	Total emissions from the destruction process associated with destruction of ODS	lb CO_2e	For each reporting period	C	
Equation 5.6	SE_i	Emission factor for substitute emissions of refrigerant *i*	lb CO_2e/ lb ODS destroyed	Per container	R	See Table 5.5 for values and Appendix D for summary of the development of SE
Equation 5.8, Equation 5.12, Equation 5.13	$Q_{ODS,i}$	Total quantity of ODS *i* sent for destruction, including eligible and ineligible material	lb ODS	For each reporting period	M	
Equation 5.8,	EF_i	Default emission factor for transportation and destruction of ODS *i*	lb CO_2e/ lb ODS	N/A	R	Equal to 7.5 for refrigerant projects, and 75 for foam projects
Equation 5.9, Equation 5.10	FF_{dest}	Total emissions from fossil fuel used in the destruction facility	lb CO_2e	For each reporting period	C	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.9, Equation 5.11	EL_{dest}	Total emissions from grid electricity at the destruction facility	lb CO_2e	For each reporting period	C	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.10	$FF_{PR,k}$	Total fossil fuel *k* used to destroy ODS	lb CO_2e	For each reporting period	M	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.10	$EF_{FF,k}$	Fuel specific emission factor	kgCO_2/ volume fuel	N/A	R	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.11	EL_{PR}	Total electricity consumed to destroy ODS	MWh	For each reporting period	M	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.11	EF_{EL}	Carbon emission factor for electricity used	lb CO_2/ MWh	N/A	R	Use only if calculating site-specific project emissions from ODS destruction

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Comment
Equation 5.9, Equation 5.12	$ODS_{emissions}$	Total emissions of un-destroyed ODS	lb CO_2e	For each reporting period	C	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.9, Equation 5.13	ODS_{CO2}	Total emissions of CO_2 from ODS oxidation	lb CO_2	For each reporting period	C	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.13	CR_i	Carbon ratio of ODS *i*	mole C/ mole ODS	N/A	R	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.14	PMT_i	Pound-miles-traveled for ODS *i* destroyed	pound-miles	For each reporting period	M	Use only if calculating site-specific project emissions from ODS transportation
Equation 5.14	EF_{PMT}	Mode-specific emission factor	$kgCO_2$/ pound-mile	N/A	R	Use only if calculating site-specific project emissions from ODS transportation
Equation 5.15	$Fill_{liquid}$	Liquid fill level in project container	% (0-1)	For each reporting period	C	
Equation 5.15	$V_{container}$	Volumetric capacity of project container	gallons	For each reporting period	O	
Equation 5.15	$M_{destroyed}$	Total mass of material destroyed in the project container	lbs	For each reporting period	M	
Equation 5.15	ρ_{liquid}	Density of the liquid phase material in the project container	lb/gal	For each reporting period	C	
Equation 5.15	ρ_{vapor}	Density of the vapor phase material in the project container	lb/gal	For each reporting period	C	

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure by project developers. Project developers must submit verified emission reduction reports to the Reserve at the conclusion of every project reporting period.

7.1 Project Documentation

Project developers must provide the following documentation to the Reserve in order to register an ODS destruction project.

- Project Submittal form
- Certificate(s) of Destruction (not public)
- Laboratory analysis of ODS composition from sampling at destruction facility (not public)
- Laboratory analysis of ODS composition from sampling at mixing facility, if applicable (not public)
- Project diagram from Monitoring and Operations Plan – see Appendix H (not public)
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form
- Verification Report
- Verification Statement

Project developers must provide the following documentation each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Statement
- Certificate(s) of Destruction (not public)
- Laboratory analysis of ODS composition from sampling at destruction facility (not public)
- Laboratory analysis of ODS composition from sampling at mixing facility, if applicable (not public)
- Project diagram from Monitoring and Operations Plan – see Appendix H (not public)
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form

Unless otherwise specified, the above project documentation will be available to the public via the Reserve's online registry with the Certificate of Destruction tracking information from Section 6.1. Further disclosure and other documentation may be made available by the project developer on a voluntary basis. Project submittal forms can be found at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

7.2 Joint Verification

If desired, it is possible for a single project developer to register multiple concurrent ODS destruction projects at a single destruction facility (e.g. one involving domestically sourced ODS and a second involving ODS sourced from Article 5 countries). In such instances, the concurrent projects may be eligible for joint verification (see Section 8.1 for more detail).

Regardless of whether the project developer chooses to verify multiple projects through a joint project verification or pursue verification of each project separately, the documents and records for each project must be retained according to this section.

7.3 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after verification. This information will not be publicly available but may be requested by the verification body or the Reserve.

System information the project developer should retain includes:

- All data inputs for the calculation of the project emission reductions, including all required sampled data
- Copies of all permits, Notices of Violations (NOVs), and any relevant administrative or legal consent orders dating back at least three years prior to the project start date
- Executed Attestation of Title forms, Attestation of Regulatory Compliance forms and Attestation of Voluntary Implementation forms
- Destruction facility monitor information (CEMS data, DRE documentation, scale readings, calibration procedures, and permits)
- Verification records and results
- Chain of custody and point of origin documentation
- ODS composition and quantity lab reports

7.4 Reporting Period and Verification Cycle

ODS destruction projects may be no greater than 12 months in duration, measured from the project start date to completion of ODS destruction. As stated in Section 2.2, project developers may choose a shorter time horizon for their project (e.g. three months or six months), but no project may run longer than 12 months. At the project developer’s discretion, a project may have one or more reporting periods as defined in Section 5.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions from ODS destruction projects developed to the standards of this protocol. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities in the context of ODS destruction projects.

Verification bodies trained to verify ODS projects must conduct verifications to the standards of the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve U.S. Ozone Depleting Substances Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

In cases where the Program Manual and/or Verification Program Manual differ from the guidance in this protocol, this protocol takes precedent.

Only ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify ODS destruction project reports. Verification bodies approved under other project protocol types are not permitted to verify ODS destruction projects. Information about verification body accreditation and Reserve project verification training can be found in the Verification Program Manual.

8.1 Joint Project Verification

Because of the possibility for a project developer to have projects under both the U.S. and Article 5 ODS Project Protocols occurring at a single destruction facility, project developers have the option to hire a single verification body to verify multiple projects under a joint project verification. This may provide economies of scale for the project verifications and improve the efficiency of the verification process. Joint project verification is only available as an option for a single project developer; joint project verification cannot be applied to multiple projects registered by different project developers at the same destruction facility.

Provided that the following elements are met, the verifier may, at his or her discretion, conduct a joint verification of two or more projects:

- The project developer has contracted with a single verification body for all projects involved
- All projects involved have an approved NOVA/COI form with designated site visit dates prior to the commencement of joint verification activities
- An appropriate verification plan covering all aspects of the individual projects involved has been prepared prior to any shared site visits or verification activities
- Project activities associated with all involved projects have commenced prior to the shared site visit or verification activity

Under joint project verification, each project, as defined by the protocol and the project developer, must still be registered separately in the Reserve system and each project requires its own verification process and Verification Statement (i.e. each project is assessed by the verification body separately as if it were the only project at the destruction facility). However, all projects may be verified together by a single site visit to the destruction facility or other common locations. Furthermore, a single Verification Report may be filed with the Reserve that summarizes the findings from multiple project verifications.

Finally, the verification body may submit one Notification of Verification Activities/Conflict of Interest (NOVA/COI) Assessment form that details and applies to all of the projects at a single destruction facility that it intends to verify.

If, during joint project verification, the verification activities of one project are delaying the registration of another project, the project developer can choose to forego joint project verification. There are no additional administrative requirements of the project developer or the verification body if a joint project verification is terminated.

8.2 Standard of Verification

The Reserve's standard of verification for ODS destruction projects is the U.S. Ozone Depleting Substances Project Protocol (this document), the Reserve Program Manual, and the Reserve Verification Program Manual. To verify an ODS destruction project report submitted by a project developer, verification bodies must apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Section 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, operational requirements, performance monitoring requirements, and procedures for reporting project information to the Reserve.

8.3 Monitoring and Operations Plan

The Monitoring and Operations Plan serves as the basis for verification bodies to confirm that the monitoring, operational, and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record-keeping has been conducted. Verification bodies shall confirm that the Monitoring and Operations Plan covers all aspects of monitoring, operations, and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.2 are collected and recorded.

8.4 Verifying Project Eligibility

Verification bodies must affirm an ODS destruction project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for an ODS destruction project. This table does not represent all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.3.

Table 8.1. Summary of Eligibility Criteria

Eligibility Rule	Eligibility Criteria	Verification Frequency
Start Date	No more than six months prior to project submission	Once per project
Location of Destruction	United States and its territories	Once per project

Eligibility Rule	Eligibility Criteria	Verification Frequency
Point of Origin of ODS	Unites States and its territories	Each verification
Project Definition	▪ Project developer and GHG ownership is the same for all ODS destroyed ▪ A single destruction facility has been used for all ODS destruction ▪ All project activities span no more than 12 months from the project start date to the conclusion of destruction activities ▪ Eligible refrigerant ODS include CFC-11, CFC-12, CFC-13, CFC-113, CFC-114, CFC-115 ▪ Eligible ODS blowing agents include CFC-11, CFC-12, HCFC-22, HCFC-141b	Each verification
Performance Standard	Project destroys ODS refrigerant or ODS blowing agent that meet project definitions	Each verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures that lay out procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test	Each verification
Regulatory Compliance Test	Signed Attestation of Regulatory Compliance form and disclosure of non-compliance to verifier; project must be in material compliance with all applicable laws	Each verification
Exclusions	▪ ODS sourced from outside of the U.S. ▪ ODS destroyed outside of the U.S. ▪ Solvents and medical aerosols ▪ Destruction of intact appliance foam ▪ ODS sourced from the federal government, except through DLA Disposition Services auction	Each verification

8.5 Core Verification Activities

The U.S. Ozone Depleting Substances Project Protocol provides explicit requirements and guidance for quantifying GHG reductions associated with the destruction of ODS sourced from the United States. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. These activities are summarized below in the context of an ODS destruction project, but verification bodies shall also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emissions sources, sinks and reservoirs

2. Reviewing operations, GHG management systems, and estimation methodologies
3. Verifying emission reductions and estimates

Identifying emission sources, sinks, and reservoirs

The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, such as the ODS baseline emissions, substitute emissions, emissions from transportation, and emissions from the destruction of ODS.

Reviewing operations, GHG management systems and estimation methodologies

The verification body reviews and assesses the appropriateness of the operations, methodologies and management systems that the ODS project developer employs to perform project activities, to gather data on ODS collected and destroyed and to calculate baseline and project emissions.

Verifying emission reduction estimates

The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the ODS management, sampling and destruction systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body must recalculate a representative sample of the ODS destruction or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.6 Verification Site Visits

Project verifiers shall conduct one or more site visits for each project to assess operations, management systems, QA/QC procedures, personnel training, and conformance with the requirements of this protocol. Each of the sites identified in Table 8.2 shall be visited at least once every 12 months by the project verification body. If one verification body is contracted by multiple projects that involve a single facility, the verification body must only visit that facility once per 12 month period. However, the verification body may visit a facility more frequently if they deem it necessary. For each reporting period, the site visits required in Table 8.2 must have occurred no more than 12 months prior to the end date of the reporting period.

Table 8.2. Verification Site Visit Requirements

Project	Site Visit(s) Required
Refrigerant recovery and destruction: pure ODS	▪ Destruction facility ▪ One additional project facility[a]
Refrigerant recovery and destruction: mixed ODS	▪ Destruction facility ▪ ODS mixing & sampling facility ▪ One additional project facility[a]
Appliance foam collection, ODS foam blowing agent extraction, and destruction	▪ Facility where ODS foam blowing agent is extracted ▪ Destruction facility ▪ One additional project facility[a]
Building foam collection and destruction	▪ Lab performing ODS blowing agent mass ratio analysis ▪ Destruction facility ▪ One additional project facility[a]

[a] The verification body shall visit one additional facility within the project diagram, including but not limited to: a point of recovery, reclamation or aggregation, the project developer's offices, a point of origin, etc. The verification body shall choose this additional facility based upon the project specific risk assessment.

In addition to the site visits specified above, verification bodies may visit any additional sites deemed necessary to verify the project in the context of the project specific risk assessment. In the instance that multiple sampling facilities or foam processing facilities were employed in a single project, verification bodies must determine the appropriate number of facilities to visit, but a minimum of one visit per type of facility is required.

8.7 ODS Verification Items

The following tables provide lists of items that a verification body needs to address while verifying an ODS destruction project. The tables include references to the section in the protocol where requirements are further described. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to ODS destruction projects that must be addressed during verification.

8.7.1 Project Eligibility and CRT Issuance

Table 8.3 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for ODS destruction projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the ODS destroyed. If any one requirement is not met, either the project may be determined ineligible or the GHG reductions from the ODS destroyed (or sub-set of the ODS destroyed) may be ineligible for issuance of CRTs.

Table 8.3. Project Eligibility Verification Items

Protocol Section	Project Eligibility Qualification Item	Apply Professional Judgment?
2.4	Verify that credits for destroyed ODS have not been claimed on the Reserve or any other registry, using Attestation of Title and Reserve tracking software	No
2.2	Verify that the project meets the definition of a U.S. ODS project	No
2.2	Verify that the destroyed ODS is sourced from the U.S.	Yes
2.2	Verify that the destroyed ODS has been phased out in the U.S.	No
2.2	Verify that the ODS was not used as or produced for use as solvents, medical aerosols or other ODS applications	Yes
2.4	Verify ownership of the reductions by reviewing Attestation of Title	No
2.2	Verify that the project activities involve a single project developer and a single qualifying destruction facility	No
Appendix C	Verify that the destruction facility meets the requirements of this protocol; if the facility is not a RCRA approved HWC, verify that it has been third-party certified as meeting the requirements of the TEAP *Report on the Task Force on HCFC Issues* in Appendix C and has successfully completed the comprehensive performance testing in Appendix C within the three years prior to the end date of destruction	No

Protocol Section	Project Eligibility Qualification Item	Apply Professional Judgment?
	activities	
3.2	Verify eligibility of project start date	No
3.2	Verify project start date based on records	No
2.2	Verify that project activities span no more than 12 months	No
2.3	Verify that the project was correctly characterized as a foam or refrigerant project	No
5.1	Verify that the appropriate baseline scenario was applied for each quantity of ODS destroyed	No
3.4.1	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
6	Verify that the project Monitoring and Operations Plan contains procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times	Yes
3.4.2	Verify that the project meets the Performance Standard Test	No
3.5	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
6	Verify that monitoring plans and procedures meet the requirements of the protocol; if they do not, verify that a variance has been approved for monitoring variations	Yes
6	Verify the Monitoring and Operations Plan includes a project diagram, and that the project diagram is complete, accurate, and up-to-date	No
	If any variances were granted, verify that variance requirements were met and properly applied	No

8.7.2 Conformance with Operational Requirements and ODS Eligibility

Table 8.4 lists the verification items to determine the project's conformance with the operational and monitoring requirements of this protocol, and the eligibility of discrete ODS sources. A subset of destroyed ODS may be deemed ineligible if it was obtained in a manner inconsistent with this protocol, or if documentation is insufficient. If any of Table 8.4 is not met, no CRTs may be issued for that quantity of ODS.

Table 8.4. Operational Requirement and ODS Eligibility Verification Items

Protocol Section	Operational Requirement and ODS Eligibility Items	Apply Professional Judgment?
6.1	For all ODS, verify that information has been correctly entered in Reserve tracking system and that the Certificate of Destruction entry is unique to this project	No
6.2	For all ODS, verify that the point of origin is correctly identified and documented	Yes
6.2, 6.6	For all ODS, verify that the point of origin documentation agrees with the data reported at the destruction facility (weight and composition) with no significant discrepancies	Yes
6.3	For all ODS, verify that the ODS can be tracked through retained chain of custody documentation from the Certificate of Destruction back to the point of origin	Yes
6.4, 6.5	For ODS blowing agents, verify that required data has been collected, per Section 6.4 and 6.5	No

Protocol Section	Operational Requirement and ODS Eligibility Items	Apply Professional Judgment?
6.4	For foam ODS blowing agent, verify that that the recovery efficiency has been calculated correctly per Appendix E	Yes
6.6	Verify that the scales used for measuring mass of ODS destroyed are properly maintained and tested for calibration quarterly	No
6.6	Verify that the weight of full and empty ODS containers was measured 48 hours prior to destruction commencing and 48 hours following completion, respectively	No
6.6	Verify that all ODS samples were taken by a third-party technician while in the possession of the destruction facility	No
6.6	Verify the chain of custody by which ODS sample was transferred from the destruction facility to the lab	No
6.6	Verify that all ODS was analyzed for composition and concentration at a lab approved under the AHRI 700-2006 standard or its successor	No
6.6	Verify that the calculation of ODS composition and mass concentration correctly accounted for moisture, mixing, and high boiling residue	No
6.6	For mixed refrigerants, verify that credits are only claimed for refrigerants eligible under this protocol	No
6.6.1	For mixed refrigerants, verify that proper recirculation occurred	No
6.6.1	For mixed refrigerants, verify that recirculation and sampling were performed by properly trained technicians	Yes
6.4	Verify that for destruction of ODS blowing agent from building foam, the correct procedures have been followed for determining the type and mass ratio of ODS in the foam	No
6.7	Verify that all permits are current at the destruction facility	No
6.7, Appendix C	Verify that the destruction facility where the ODS was destroyed has a documented destruction and removal efficiency greater than 99.99 percent, and that CPT was conducted with a material less combustible than the ODS destroyed	No
6.7, Appendix C	Verify that the destruction facility operated within the parameters under which it was tested to achieve a 99.99 percent or greater destruction and removal efficiency	No
6.7	Verify that the destruction facility monitored the parameters identified in Section 6.7	No
6.7	Verify that the Certificate of Destruction contains all required information	No

8.7.3 Quantification of GHG Emission Reductions

Table 8.5 lists the items that verification bodies shall include in their risk assessment and re-calculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.5. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that SSRs included in the GHG Assessment Boundary correspond to those required by the protocol and those represented in the project documentation	No
6.7	Verify that all destroyed ODS for which CRTs are claimed appear on a valid Certificate of Destruction	No

Protocol Section	Quantification Item	Apply Professional Judgment?
5.1	Verify that the baseline emissions were calculated with the appropriate emission rate(s) and aggregated correctly	No
5.2.1	Verify that the substitute emissions have been properly characterized, calculated, and aggregated correctly	No
5.1.2, 5.2.2	Verify that the recovery efficiency has been correctly applied for concentrated ODS blowing agent projects	No
5.2.3, 5.2.4	Verify that the project developer correctly quantified and aggregated electricity use, or that the default factor was applied	Yes
5.2.3, 5.2.4	Verify that the project developer correctly quantified and aggregated fossil fuel use, or that the default factor was applied	Yes
5.2.3, 5.2.4	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity, or that the default factors were applied	Yes
5.2.3, 5.2.5	Verify that the project developer correctly quantified and aggregated transportation emissions, or that the default factor was applied	Yes
5.2.3, 5.2.4	Verify that emissions from incomplete ODS destruction and oxidation of ODS carbon have been correctly quantified and aggregated, or that the default factor was applied	Yes

8.7.4 Risk Assessment

Verification bodies will review the following items in Table 8.6 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.6. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project Monitoring and Operations Plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	Yes
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform these functions	Yes
6.5	Verify that the required data on appliances from which foam was sourced has been collected and managed correctly	Yes
6	Verify that appropriate training was provided to personnel assigned to operations, record-keeping, sample-taking, and other project activities	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer and that there is internal oversight to assure the quality of the contractor's work	Yes
7	Verify that all required records have been retained by the project developer	No

8.8 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Certificate of Destruction	An official document provided by the destruction facility certifying the date, quantity, and type of ODS destroyed.
Commencement of destruction process	When the ODS waste-stream is hooked up to the destruction chamber.
Commercial refrigeration equipment	The refrigeration appliances used in the retail food, cold storage warehouse or any other sector that requires cold storage. Retail food includes the refrigeration equipment found in supermarkets, grocery and convenience stores, restaurants, and other food service establishments. Cold storage includes the refrigeration equipment used to house perishable goods or any manufactured product requiring refrigerated storage.
Container	An air- and water-tight unit for storing and/or transporting ODS material without leakage or escape of ODS.
Destruction	Destruction of ozone depleting substances by qualified destruction, transformation or conversion plants achieving greater than 99.99 percent destruction and removal efficiency, in order to avoid their emissions. Destruction may be performed using any technology, including transformation, that results in the complete breakdown of the ODS into either a waste or usable by-product.
Destruction facility	A facility that destroys, transforms or converts ozone depleting substances using a technology that meets the standards defined by the UN Environment Programme Technology and Economic Assessment Panel Task Force on Destruction Technologies.[53]
Emission rate	The rate at which refrigerant is lost to the atmosphere, including emissions from leaks during operation and servicing events.
Generator	The facility from which the ODS material on a single Certificate of Destruction departed prior to receipt by the destruction facility. If the material on a single Certificate of Destruction was aggregated as multiple shipments to the destruction facility, then the destruction facility shall be the Generator.
Ozone Depleting Substances (ODS)	Ozone depleting substances are substances known to deplete the stratospheric ozone layer. The ODS controlled under the Montreal Protocol and its Amendments are chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC), halons, methyl bromide (CH_3Br), carbon tetrachloride (CCl_4), methyl chloroform (CH_3CCl_3), hydrobromofluorocarbons (HBFC) and bromochloromethane (CHBrCl). [54]

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[53] United Nations Environment Programme. (2003). Report of the Fifteenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer. *OzL.Pro.15/9*. Nairobi, November 11, 2003.

[54] Source: IPCC - http://www.mnp.nl/ipcc/pages_media/SROC-final/SROC_A2.pdf

Recovery efficiency	The percent of total ODS blowing agent that is recovered during the process of ODS blowing agent extraction.
Recharge	Replenishment of refrigerant agent (using reclaimed or virgin material) into equipment that is below its full capacity because of leakage or because it has been evacuated for servicing or other maintenance.
Reclaim	Reprocessing and upgrading of a recovered ozone depleting substance through mechanisms such as filtering, drying, distillation and chemical treatment in order to restore the ODS to a specified standard of performance. Chemical analysis is required to determine that appropriate product specifications are met. It often involves processing off-site at a central facility.
Recovery	The removal of ozone depleting substances from machinery, equipment, containment vessels, etc., into an external container during servicing or prior to disposal without necessarily testing or processing it in any way.
Reuse/recycle	Reuse of a recovered ozone depleting substance following a basic cleaning process such as filtering and drying. For refrigerants, recycling normally involves recharge back into equipment and it often occurs ‘on-site’.
Startup, shutdown, and malfunction plan	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 location. These quantities may be composed of many small containers or a single large container.
Substitute refrigerant	Those refrigerants that will be used to fulfill the function that would have been filled by the destroyed ODS refrigerants. These refrigerants may be drop-in replacements used in equipment that previously used the type of ODS destroyed or may be used in new equipment that fulfills the same market function.
Substitute emissions	A term used in this protocol to describe the greenhouse gases emitted from the use of substitute refrigerants in technologies that are used to replace the ODS destroyed in a project.
Transportation system	A term used to encompass the entirety of the system that moves the ODS from the point of aggregation to the destruction facility.

10 References

Air-Conditioning, Heating, and Refrigeration Institute. (2006). Standard 700-2006: Standard for Specifications for Fluorocarbon Refrigerants.

ARGE Energy Changes Projektentwicklung GmbH, Tanzer Consulting Gmbh and USG Umweltservice GmbH. (2008). Emission reductions due to controlled recovering of Chlorofluorocarbons (CFC) from end-of-life refrigerator and freezer appliances.

California Climate Action Registry. (2009). *General Reporting Protocol, Version 3.1*.

Clean Air Act, Title VI, Section 604(a).

Climate Action Reserve. (2011). Climate Action Reserve Program Manual. October 26, 2011.

Climate Action Reserve. (2010). Climate Action Reserve Verification Program Manual. December 20, 2010.

EOS Climate. (2008). Methodology for Ozone Depleting Substances Destruction Projects.

Fredenslund, A. et al. (2005). Disposal of Refrigerators-Freezers in the U.S.: State of the Practice. Technical University of Denmark.

HR 2454, American Clean Energy and Security Act of 2009.

ICF International. (2009). ODS Destruction in the United States of America and Abroad. *U.S. Environmental Protection Agency, Stratospheric Protection Division*.

International Organization for Standardization (ISO) 14064-2. (2006). Greenhouse Gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements.

IPCC/TEAP. (2005). Special report: Safeguarding the ozone layer and the global climate system: issues related to hydrofluorocarbons and perfluorocarbons.

National Institute of Standards and Technology. (2012). Specifications, Tolerance, and Other Technical Requirements for Weighing and Measuring Devices*. NIST Handbook 44.*

RAL Deutsches Institut für Gütesicherung und Kennzeichnung e.V. (2007). Quality Assurance and Test Specifications for the Demanufacture of Refrigeration Equipment.

Scheutz et al. (2007). Attenuation of fluorocarbons released from foam insulation in landfills. *Environmental Science & Technology, 41*: 7714-7722.

Scheutz et al. (2007). Release of fluorocarbons from insulation foam in home appliances during shredding. *Journal of the Air & Waste Management Association*.

U.S. Clean Air Act. Title VI: Protection of Stratospheric Ozone. Section 604(a).

U.S. Code of Federal Regulations. Protection of Stratospheric Ozone. 40 CFR 82.

U.S. Environmental Protection Agency, Climate Leaders. (2007). Greenhouse Gas Inventory Protocol Core Module Guidance: Direct Emissions from Stationary Combustion Sources.

U.S. Environmental Protection Agency, Climate Leaders. (2008). Greenhouse Gas Inventory Protocol Core Module Guidance: Optional emissions from business travel, commuting, and product transport.

U.S. Environmental Protection Agency. (2008). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007.

United Nations Environment Programme, Ozone Secretariat. (1987, and subsequent amendments). The Montreal Protocol on Substances that Deplete the Ozone Layer.

United Nations Environment Programme, Ozone Secretariat. Data Access Center. Retrieved September 22, 2009, from http://ozone.unep.org/Data_Reporting/Data_Access/.

United Nations Environment Programme, Ozone Secretariat. Status of Ratification. Retrieved September 24, 2009, from http://ozone.unep.org/Ratification_status/montreal_protocol.shtml.

United Nations Environment Programme, Ozone Secretariat. List of Parties categorized as operating under Article 5 paragraph 1 of the Montreal Protocol. Retrieved September 24, 2009, from http://ozone.unep.org/Ratification_status/list_of_article_5_parties.shtml.

United Nations Environment Programme, Technology and Economic Assessment Panel. (2005). Report of the Task Force on Foam End-of-Life Issues.

United Nations Environment Programme, Technology and Economic Assessment Panel. (2005). Special report: Safeguarding the ozone layer and the global climate system: issues related to hydrofluorocarbons and perfluorocarbons.

United Nations Environment Programme, Technology and Economic Assessment Panel. (2006). Progress Report.

United Nations Environment Programme, Technology and Economic Assessment Panel. (2007). Report of the Task Force on HCFC Issues.

United Nations Environment Programme, Technology and Economic Assessment Panel. (2002). Report of the Task Force on Destruction Technologies.

WEEE Forum. (2007) Requirements for the Collection, Transportation, Storage, Handling and Treatment of Household Cooling and Freezing Appliances containing CFC, HCFC, or HFC.

World Meteorological Organization and United Nations Environment Programme, Intergovernmental Panel on Climate Change (IPCC). 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

World Resources Institute and World Business Council for Sustainable Development. (2005). The Greenhouse Gas Protocol for Project Accounting.

Appendix A Summary of Legal Requirement Test Development

Management activities for ozone depleting substances are dictated in the United States by both the Montreal Protocol, to which the U.S. is a party, and the U.S. Clean Air Act. This appendix provides background information on both of these regulatory frameworks. Further, this appendix demonstrates that neither framework requires the destruction of ODS, and destruction therefore meets the Legal Requirement Test under the Climate Action Reserve U.S. Ozone Depleting Substances Project Protocol.

A.1 Montreal Protocol

The original Montreal Protocol, signed in 1987, was the first international treaty with binding commitments to protect stratospheric ozone. Since that time, the Montreal Protocol has been repeatedly strengthened by both controlling additional ODS as well as by moving up the date by which previously controlled substances must be phased out. The Montreal Protocol controls only production and consumption (production plus imports minus exports) and not emissions of ODS. There is no mandatory requirement to destroy ODS in the Montreal Protocol. Therefore, for analyses prepared under the Montreal Protocol, it is assumed that all ODS that are produced will eventually be released to the atmosphere, even though some developed countries have voluntary and/or mandatory requirements to destroy ODS.

Under the original Montreal Protocol agreement (1987), non-Article 5 countries were required to begin phasing out CFC in 1993 and achieve a 50 percent reduction relative to 1986 consumption levels by 1998. Under this agreement, CFC were the only ODS addressed. The London Amendment (1990) changed the ODS emission schedule by requiring the complete phase-out of CFC, halons, and carbon tetrachloride by 2000 in developed countries, and by 2010 in developing countries. Methyl chloroform was also added to the list of controlled ODS, with phase-out in developed countries targeted in 2005, and in 2015 for developing countries.

The Copenhagen Amendment (1992) significantly accelerated the phase-out of ODS and incorporated an HCFC phase-out for developed countries, beginning in 2004. Under this agreement, CFC, halons, carbon tetrachloride, methyl chloroform, and HBFC were targeted for complete phase-out in 1996 in developed countries. In addition, methyl bromide consumption was capped at 1991 levels.

The Montreal Amendment (1997) included the phase-out of HCFC in developing countries, as well as the phase-out of methyl bromide in developed and developing countries in 2005 and 2015, respectively.

The Beijing Amendment (1999) included tightened controls on the production and trade of HCFC. Bromochloromethane was also added to the list of controlled substances with phase-out targeted for 2002.

At the 19th Meeting of the Parties in Montreal in September 2007, the Parties agreed to an adjustment that more aggressively phases out HCFC in both developed and developing countries. Developed countries must reduce HCFC production and consumption by 75 percent of their baseline by 2010, 99.5 percent by 2020, and 100 percent by 2030. The 0.5 percent during the period 2020-2030 is restricted to the servicing of existing refrigeration and air-conditioning equipment and is subject to review in 2015. Developing countries must freeze production and consumption of HCFC in 2013 at their baseline and then reduce it by 10 percent in 2015, 35 percent by 2020, 67.5 percent by 2025, 97.5 percent by 2030 and 100 percent by 2040. The 2.5 percent during the period 2030-2039 is the average over that time frame (e.g. it can be five percent for five years and zero percent for the other five years), is restricted to the servicing of existing refrigeration and air-conditioning equipment, and is subject to review in 2015.

The result of the Montreal Protocol with its amendments and adjustments is that as of January 1, 2010, CFC, halons, methyl chloroform, carbon tetrachloride, methyl bromide, and bromochloromethane will be phased out of production in both developed and developing countries. Therefore any ongoing uses of these substances must be supplied from already existing stocks that were never used, or from recycled or reclaimed material. However, it should be noted that there are allowances for some ongoing limited production of these substances for certain essential uses and critical uses approved by the Montreal Protocol Parties (e.g. as process agents and for quarantine and pre-shipment uses). Also, production and use of these substances as feedstock is not considered production since they are consumed in the feedstock process. Destruction of ODS from these sources is not eligible under this protocol.

The Reserve’s review of the U.S. commitment under the Montreal Protocol and its amendments indicates that destruction of ODS is not required in the U.S. at this time. Further, review of the Montreal Protocol makes clear that destruction is not required. The scope of the Montreal Protocol is limited to the production end of ODS management, and does not require destruction of extant stocks. As such, in reference to the Montreal Protocol and international law, destruction of U.S. sources of ODS meets the Legal Requirement Test.

A.2 Title VI of the Clean Air Act and 40 CFR 82

In 1988, the United States ratified the Montreal Protocol. By ratifying the Montreal Protocol and its subsequent amendments, the United States committed to a collaborative, international effort to regulate and phase out ODS, including CFC, HCFC, halons, carbon tetrachloride, methyl chloroform, methyl bromide, bromochloromethane, and HBFC.

The Montreal Protocol led to the inclusion of Title VI, Stratospheric Ozone Protection in the Clean Air Act Amendments of 1990. Title VI authorizes the EPA to manage the phase-out of ODS. Among the regulations established by EPA are requirements for the safe handling of ODS and prohibitions on the known venting or release of ODS into the atmosphere for the majority of applications, including refrigerants and fire suppressants. Therefore, as ODS are phased out, surplus ODS must be stored, reused (after recycling or reclamation) or destroyed.

EPA regulations issued under Sections 601-607 of the CAA phase out the production and import of ODS, consistent with the schedules developed under the Montreal Protocol. However, in the case of HCFC, EPA has used a “worst-first” approach to meet the Montreal Protocol required reduction caps. Under this approach, those HCFC with the highest ozone depletion potential (ODP) are phased out first. As of January 1, 2003, EPA banned production and import of HCFC-141b, the HCFC with the highest ODP. This action allowed the United States to reduce its consumption by 35 percent below the cap by the January 1, 2004 deadline and meet its obligations under the Montreal Protocol. As such, HCFC-141b is now entirely phased out and therefore eligible per this protocol.

In 2003 EPA issued baseline allowances for production and import of HCFC-22 and HCFC-142b, the two HCFC with the next highest ODP. The United States plans to meet the rest of the Montreal Protocol phase-out schedule through the following actions:

January 1, 2010	Ban on production and import of HCFC-22 and HCFC-142b except for on-going servicing needs in equipment manufactured before January 1, 2010.*
January 1, 2015	Ban on introduction into interstate commerce or use of HCFC except where the HCFC are used as a refrigerant in appliances manufactured prior to January 1, 2020.*
January 1, 2020	Ban on remaining production and import of HCFC-22 and HCFC-142b.*
January 1, 2030	Ban on remaining production and import of all other HCFC.*

* Certain additional exemptions apply, including exemptions for (1) HCFC used in processes resulting in their transformation or destruction, or (2) pre-authorized import of HCFC that are recovered and either recycled or reclaimed.

The Reserve's review of the CAA indicates that destruction of ODS is not required in the U.S. at this time. The CAA dictates a phase-out schedule for the production of ODS, and proffers guidance on handling, disposal, and other requirements but does not dictate that destruction of ODS occur. As such, in reference to the U.S. CAA and domestic law, destruction of U.S. sources of ODS meets the Legal Requirement Test.

Appendix B Summary of Performance Standard Development

The Reserve assesses the additionality of projects through application of a Performance Standard Test and a Legal Requirement Test. The purpose of a performance standard is to establish a standard of performance applicable to all ODS projects that is significantly better than average ODS management practice, which, if met or exceeded by a project developer, satisfies the criterion of "additionality."[55]

The sections below describe the analysis that forms the basis of the performance standard for each of the ODS sources within this protocol. The analysis included an examination of current practice related to 1) the destruction of ODS refrigerant and ODS foam blowing agent, and 2) the end-of-life treatment of foam.

B.1 Destruction of ODS from Refrigerants and Foam

Appendix A described the regulatory framework surrounding the end-of-life treatment of refrigerant and foam ODS and demonstrated that destruction is not required by law in the U.S. However, the Reserve looks not only at what the regulatory requirements are, but also at the prevailing practices in the industry. Therefore, with the project defined as destruction of ODS refrigerant or ODS blowing agent, the question remains: is destruction of ODS refrigerant and ODS blowing agent sourced within the U.S. standard practice or does it exceed standard practice?

For this analysis, the Reserve assessed common practice for CFC refrigerants and foams that have been phased out of U.S. production under the Montreal Protocol and U.S. Clean Air Act. This was done by comparing the proportion of recoverable ODS in the U.S. within a given year to the amount that was destroyed during that same time period to determine to what extent available ODS was being destroyed.

The Reserve's starting point for this assessment was U.S. EPA data records, including a report produced by ICF International entitled *ODS Destruction in the United States of America and Abroad* (2009). In addition to providing information on ODS destruction techniques and practices, the report supplies the specific quantity of ODS destroyed for the years 2003 and 2004 in the U.S.

The years 2003 and 2004 are particularly useful as they represent common practice before the initiation of carbon offset projects in the U.S. Subsequent to 2004, several ODS destruction projects were conducted for carbon credits on the Chicago Climate Exchange (CCX), and in possible anticipation of other offset programs. As such, destruction numbers from this post-2004 time period may artificially inflate the amount of ODS that is destroyed due to standard industry practice. The goal of this analysis is to determine what happened *in the absence* of a carbon incentive. Therefore, the 2003 to 2004 data represents a balance of current data on common practice *after* the CAA phase-out of ODS went into effect but *prior* to the availability of a carbon incentive.

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[55] See the Climate Action Reserve's Program Manual for further discussion of the Reserve's general approach to determining additionality.

Table B.1. Destruction of ODS in the U.S.

CFC	2003 Destroyed (kg)	2004 Destroyed (kg)
CFC-11	58,846	109,884
CFC-12	23,709	62,364
CFC-114	464	4,044
CFC-115	4,401	6,737

Source: Reproduced from ICF, ODS Destruction in the United States of America and Abroad (2009), prepared for U.S. EPA.

While the 2003-2004 data above is useful because it is not yet influenced by the carbon market, it does nonetheless over-state the amount of destruction that took place during this time period because of the inclusion of ODS sourced from outside the U.S.

The applicability of this protocol is limited to ODS sourced from within the U.S. Therefore, the analysis of common practice must include only destroyed ODS that originated within the U.S. Several countries, including Canada and Australia, have taken a proactive approach to managing ODS and have strong ODS destruction programs that regularly send material to the U.S. for destruction. The Reserve compiled data from destruction facilities to determine the amount of destruction that could be attributed to these imports and subsequently subtracted from total U.S. destruction. Table B.2 presents this analysis including the resulting net U.S. destruction. To protect proprietary company data, Table B.2 provides only the aggregate amounts of ODS that was destroyed from imported stocks.

Table B.2. ODS Destroyed from Ineligible Imported Sources

ODS	Destroyed in U.S. (kg)		Imported for Destruction (kg)[56]		Net U.S. Sourced ODS Destroyed (kg)	
	2003	2004	2003[57]	2004	2003	2004
CFC-11	58,846	109,884	-	55,113	58,846	54,771
CFC-12	23,709	62,364	-	25,611	23,709	36,753
CFC-114	464	4,044	-	2,316	464	1,728
CFC-115	4,401	6,737	-	1,710	4,401	5,027

The goal of the performance standard is to determine the market penetration of a given activity. In order to determine the extent to which destruction occurred relative to the amount of ODS available in the U.S. prior to carbon incentives, the Reserve obtained data from U.S. EPA on the amount of ODS from refrigerant and foam that could be recovered for re-use and/or destruction in 2003 to 2004. The data source is U.S. EPA's Vintaging Model that tracks the type, age, refrigerant, leak rates, and other information for equipment and ODS applications within the U.S. market. By tracking this data through cooperation with industry, the U.S. EPA Vintaging Model is able to approximate when stocks of ODS will reach end-of-life.

At the Reserve's request, the U.S. EPA provided estimates of the quantity of ODS refrigerant that was contained in equipment reaching end-of-life in 2003-2004.[58] In addition to determining the amount of ODS that could be made available from refrigerants, the U.S. EPA provided

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[56] Data provided by industry is presented anonymously to protect proprietary information.

[57] Data on imports could not be obtained for 2003. This results in a conservative performance standard analysis.

[58] The use of data from the U.S. EPA Vintaging Model into this protocol does not constitute an endorsement by EPA of the Climate Action Reserve or its methodology. Where actual measurements or other data was made available to and used by the Reserve in this protocol in lieu of the Vintaging Model data, this has been indicated in the protocol.

estimates of the number of residential refrigerators reaching end-of-life in 2003 and 2004. U.S. EPA assumed an ODS content of one pound CFC-11 foam blowing agent per refrigerator to establish the total amount ODS that could be made available for destruction from these appliances.

Table B.3. Recoverable ODS from End-of-Life Refrigeration Equipment and Foam Appliances in the U.S., 2003-2004[59]

ODS	Recoverable Refrigerant (kg)		Residential Refrigerator Foam at End of Life (kg)		Total Available for Destruction (kg)	
	2003	2004	2003	2004	2003	2004
CFC-11	717,140	700,310	3,499,545	3,516,364	4,216,685	4,216,674
CFC-12	12,725,841	10,997,307			12,725,841	10,997,307
CFC-114	154,710	154,710			154,710	154,710
CFC-115	1,833,654	2,207,326			1,833,654	2,207,326

Using the destruction data compiled by ICF International and the data on recoverable ODS refrigerants and ODS blowing agent from the U.S. EPA Vintaging Model, the Reserve derived the percentage of recoverable ODS that was destroyed in 2003-2004 (see Table B.4). Because the percentage of recoverable ODS destroyed was very low, the Reserve concluded that the destruction of refrigerant ODS without the incentive from the carbon market is not common practice. Therefore, any project that destroys the refrigerants listed in Table B.4 exceeds the performance standard.

Table B.4. Destruction of Recoverable, U.S. Sourced End-of-Life ODS

ODS	Total Available for Destruction (kg)		Domestic Sourced Destroyed (kg)		Performance Standard (Destroyed/Available)	
	2003	2004	2003	2004	2003	2004
CFC-11	4,216,685	4,216,674	58,846	54,771	1.40%	1.30%
CFC-12	12,725,841	10,997,307	23,709	36,753	0.19%	0.33%
CFC-114	154,710	154,710	464	1,728	0.30%	1.12%
CFC-115	1,833,654	2,207,326	4,401	5,027	0.24%	0.23%

The Reserve consulted with representatives from government, industry, and the destruction facilities responsible for ODS destruction to characterize the limited ODS destruction that did occur in 2003 to 2004. Although these representatives were unable to provide records indicating a precise breakdown of destruction purposes, they indicated that the destroyed ODS was primarily solvent that was deemed hazardous waste and required destruction, ODS destroyed by the U.S. government , and medical grade ODS. None of these sources are eligible under this protocol. Only a very small amount of highly contaminated ODS was sent for destruction by industry.

Under Version 1.0, ODS sourced from federal government installations or stockpiles was deemed ineligible. One reason for this decision was because some ODS sourced from the federal government was already being destroyed and it was suggested that this destruction was undertaken voluntarily as part of its existing commitment to responsible waste disposal. Since the issuance of Version 1.0, the Reserve has learned that the only ODS destroyed by the federal government is through a small number of demonstration projects and is not required by

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[59] U.S. EPA. (2008). EPA Vintaging Model. *Version VM IO file_v4.2_10.07.08*.

any responsible waste disposal policies. While there is an executive order[60] that sets forth the following policy on ODS management, it does not mandate destruction:

"Each agency shall amend its personal property management policies and procedures to preclude the disposal of ODSs removed or reclaimed from its facilities or equipment, including disposal as part of a contract, trade, or donation, without prior coordination with the Department of Defense (DoD)."

The DoD operates an ODS Reserve to ensure adequate supplies of halons and refrigerants for weapons use. Communications with the staff at the DoD ODS Reserve have confirmed that there is no mandate or policy in place requiring or recommending the federal government destroy ODS. In fact, if there is excess refrigerant available from federal installations beyond the inventory needs of the DoD ODS Reserve, the refrigerant is turned over to the U.S. Defense Logistics Agency Disposition Services for resale to the public.

It is important to note that the federal government also comes to possess refrigerants through seizures of illegal material by U.S. Customs. This seized material would not be available through the U.S. Defense Logistics Agency Disposition Services, but rather through separate auctions conducted by U.S. Customs. ODS sourced from illegal seizures is not eligible under this protocol because it was not produced in the United States.

B.2 End-of-Life Treatment of Foam

The Reserve also reviewed separately the common practice in the end-of-life treatment of foams containing ODS blowing agents. Whereas U.S. EPA regulations prohibit the intentional release of ODS refrigerants to the atmosphere, there is no preclusion against disposal practices that result in release of ODS blowing agents.

According to the 2005 TEAP *Report of the Task Force on Foam End-of-Life Issues*, there is little or no experience with the recovery of foams from buildings or of the ODS contained within the foams. This is mainly because few buildings containing foam with ODS blowing agent have been demolished, deconstructed, or renovated yet. The average overall lifecycle of buildings in North America and other developed countries ranges from 30 to 50 years. Meanwhile, the common use of foam in insulation only really began in the mid 1970s after the energy crisis led to increased use of insulation. With an average turnover rate of building stock in North America of less than one percent per year, buildings with foam insulation are only just beginning to enter the waste stream. As a result, the management of ODS from building foam has not yet become a focus of regulators. Other factors that have prevented the recovery and destruction of building foam include challenges involved with separating foam from the building structure, the common practice of landfilling construction waste without any pretreatment (only 20 to 30 percent of building materials are recycled or sold in the United States), the very small proportion of ODS foam compared to overall construction waste, and a lack of regulations in the United States governing recovery of building foam insulation and the ODS contained therein.

The destruction of ODS from foam in appliances and equipment is also very limited in the U.S. The 2005 TEAP *Report of the Task Force on Foam End-of-Life Issues* describes the results of an AHAM survey which provides the following breakdown of common appliance disposal practices in the United States:

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[60] Executive Order 13423 - "Strengthening Federal Environmental, Energy, and Transportation Management", March 29, 2007.

- 90 percent appliances shredded without blowing agent recovery and landfilled
- 7.5 percent appliances crushed whole and landfilled
- 1.5 percent appliances shredded with blowing agent recovery or destruction
- One percent appliances abandoned

As noted in the survey results, only 1.5 percent of appliances are being shredded with the containing foam blowing agent either being recovered for reuse in the refrigeration market or destroyed. This foam shredding and recovery is being driven mainly by state, local and utility energy efficiency initiatives with some program administrators adding a second requirement that the blowing agent must be recovered as well. Most of these programs are voluntary and meet their objectives by incentivizing early appliance retirement and recycling through rebates or discounts on new units. As noted in the TEAP report, the process for recovering ODS from appliance foam is costly and is currently not self-sustaining unless outside sponsorship is provided. Although U.S. EPA and others track information on the amount of foam that is being shredded and the blowing agent that is being recovered, there is no data available on the share of blowing agent that is being reused versus destroyed. According to industry analysts, most of the recovered blowing agent is being resold into the refrigeration market because of the economic incentive to do so. Destruction will only occur in cases where the utility or other entity participating in the appliance program specifically requests that this must take place. As a result, the destruction of ODS blowing agent is likely significantly less than the 1.5 percent share of appliances where the disposal includes management of the blowing agent.

Because the destruction of blowing agent from building foam does not occur and the destruction from appliances is very low, the Reserve concluded that the destruction of foam blowing agent is not common practice.

Appendix C Rules Governing ODS Destruction

This protocol requires that all ODS be destroyed at a destruction facility that is compliant with both the international standards specified in the TEAP *Report of the Task Force on Destruction Technologies*,[61] as well as the requirements of domestic law. This appendix provides a brief summary of the U.S. rules for destruction of ODS, and the criteria that must be met for a destruction facility to qualify under this protocol.

All ODS destruction is regulated under stratospheric ozone protection regulations under the Clean Air Act (CAA) (40 CFR 82). Additionally, because some ODS are classified as hazardous wastes (such as CFC-113, methyl chloroform, and carbon tetrachloride), facilities that handle these ODS are regulated under the Resource Conservation and Recovery Act (RCRA). Hazardous waste combustors (HWCs, e.g. incinerators) that destroy ODS classified as hazardous waste are also regulated by the Maximum Achievable Control Technology (MACT) standard under the CAA.

Under the authority of the CAA, the stratospheric ozone protection regulations (40 CFR Part 82, Subpart A) require that ODS be destroyed using one of the following destruction technologies approved by the Montreal Protocol Parties:

1. Liquid injection incineration
2. Reactor cracking
3. Gaseous/fume oxidation
4. Rotary kiln incineration
5. Cement kiln
6. Radio frequency plasma
7. Municipal waste incinerators (only for the destruction of foams)
8. Argon arc plasma

Additionally, if the substance is to be considered “completely destroyed” as defined in the regulations, it must be destroyed to a 98 percent destruction efficiency (DE). This is slightly different from the Montreal Protocol Technology and Economic Assessment Panel which recommends a destruction and removal efficiency (DRE) limit of 99.99 percent. DE is a more comprehensive measure of destruction than DRE as it includes emissions of undestroyed chemical from all points (e.g. stack gases, fly ash, scrubber, water, bottom ash), while DRE includes emissions of undestroyed chemical from the stack gas only. However, because of the relatively volatile nature of ODS and because, with the exception of foams, they are generally introduced as relatively clean fluids, one would not expect a very significant difference between DRE and DE.

Any destruction facility that is regulated by U.S. EPA as a RCRA-permitted HWC is automatically considered a qualifying destruction facility under this protocol.

Non-RCRA permitted facilities may also be deemed qualifying destruction facilities if they meet the pertinent guidelines provided by the TEAP *Report of the Task Force on Destruction Technologies*, and reproduced below. By inclusion here, the recommendations of the excerpted section of the TEAP report shall be binding on all non-RCRA destruction facilities. Destruction

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[61] TEAP. (2002). Report of the Task Force on Destruction Technologies. *Volume 3B*.

facilities must provide third-party certified results indicating that the facility meets all performance criteria set forth below. Following the initial performance testing, project developers must demonstrate that the facility has conducted comprehensive performance testing at least every three years to validate compliance with the TEAP DRE and emissions limits as reproduced below.

(Reproduced in full from TEAP *Report of the Task Force on Destruction Technologies*, Chapter 2 (2002). References in the following section pertain to the *Report* document, not this protocol.)

CHAPTER 2

2.0 TECHNOLOGY SCREENING PROCESS

2.1 Criteria for Technology Screening

The following screening criteria were developed by the UNEP TFDT. Technologies for use by the signatories to the Montreal Protocol to dispose of surplus inventories of ODS were assessed on the basis of:

1. Destruction and Removal Efficiency (DRE)
2. Emissions of dioxins/furans
3. Emissions of other pollutants (acid gases, particulate matter, and carbon monoxide)
4. Technical capability

The first three refer to technical performance criteria selected as measures of potential impacts of the technology on human health and the environment. The technical capability criterion indicates the extent to which the technology has been demonstrated to be able to dispose of ODS (or a comparable recalcitrant halogenated organic substance such as PCB) effectively and on a commercial scale.

For convenience, the technical performance criteria are summarized in Table 2-1. These represent the minimum destruction and removal efficiencies and maximum emission of pollutants to the atmosphere permitted by technologies that qualify for consideration by the TFDT for recommendation to the Parties of the Montreal Protocol for approval as ODS destruction technologies. The technologies must also satisfy the criteria for technical capability as defined in Section 2.1.4.

Table 2-1: Summary of Technical Performance Qualifications[62]

Performance Qualification	Units	Diluted Sources	Concentrated Sources
DRE	%	95	99.99
PCDDs/PCDFs	ng-ITEQ/Nm^3	0.5	0.2
HCl/Cl_2	mg/Nm^3	100	100
HF	mg/Nm^3	5	5
HBr/Br_2	mg/Nm^3	5	5
Particulates (TSP)	mg/Nm^3	50	50
CO	mg/Nm^3	100	100

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[62] All concentrations of pollutants in stack gases and stack gas flow rates are expressed on the basis of dry gas at normal conditions of 0ºC and 101.3 kPa, and with the stack gas corrected to 11 percent O_2.

2.1.1 Destruction and Removal Efficiency

Destruction Efficiency (DE)[63] is a measure of how completely a particular technology destroys a contaminant of interest – in this case the transformation of ODS material into non-ODS by-products. There are two commonly used but different ways of measuring the extent of destruction – DE and Destruction and Removal Efficiency (DRE).[64] For a more detailed explanation of how DRE is calculated, see section 4.2.1. The terms are sometimes interchanged or used inappropriately. DE is a more comprehensive measure of destruction than DRE, because DE considers the amount of the chemical of interest that escapes destruction by being removed from the process in the stack gases and in all other residue streams. Most references citing performance of ODS destruction processes only provide data for stack emissions and thus, generally, data is only available for DRE and not DE.

Because of the relatively volatile nature of ODS and because, with the exception of foams, they are generally introduced as relatively clean fluids, one would not expect a very significant difference between DRE and DE.

For these reasons this update of ODS destruction technologies uses DRE as the measure of destruction efficiency.

For the purposes of screening destruction technologies, the minimum acceptable DRE is:

- 95 percent for foams; and,
- 99.99 percent for concentrated sources.

It should be noted that measurements of the products of destruction of CFC, HCFC and halons in a plasma destruction process have indicated that interconversion of ODS can occur during the process. For example, under some conditions, the DRE of CFC-12 (CCl_2F_2) was measured as 99.9998 percent, but this was accompanied by a conversion of 25 percent of the input CFC-12 to CFC-13 ($CClF_3$), which has the same ozone-depleting potential. The interconversion is less severe when hydrogen is present in the process, but can nonetheless be significant.[65] For this reason, it is important to take into account all types of ODS in the stack gas in defining the DRE.

For the reasons described in the previous paragraph, the Task Force recommends that future calculations of DRE use the approach described below.[66]

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[63] Destruction Efficiency (DE) is determined by subtracting from the mass of a chemical fed into a destruction system during a specific period of time the mass of that chemical that is released in stack gases, fly ash, scrubber water, bottom ash, and any other system residues and expressing that difference as a percentage of the mass of the chemical fed into the system.

[64] Destruction and Removal Efficiency (DRE) has traditionally been determined by subtracting from the mass of a chemical fed into a destruction system during a specific period of time the mass of that chemical alone that is released in stack gases, and expressing that difference as a percentage of the mass of that chemical fed into the system.

[65] Deam, R. T., Dayal, A. R., McAllister, T., Mundy, A. E., Western, R. J., Besley, L. M., Farmer, A. J. D., Horrigan, E. C., & Murphy, A. B. (1995). Interconversion of chlorofluorocarbons in plasmas. *J. Chem. Soc.: Chem. Commun. No. 3,* 347-348; Murphy, A. B., Farmer, A. J. D., Horrigan, E. C., & McAllister, T. (2002). Plasma destruction of ozone depleting substances, *Plasma Chem. Plasma Process, 22,* 371-385.

[66] Since different ODS have different ODP, consideration should be given to taking into account the ODP of each type of ODS present in the stack gas in calculating the DRE. An appropriate definition that takes into account the differences in ODP is: *DRE of an ODS is determined by subtracting from the number of moles of the ODS fed into a destruction system during a specific period of time, the total number of moles of all types of ODS that are released in*

DRE of an ODS should be determined by subtracting from the number of moles of the ODS fed into a destruction system during a specific period of time, the total number of moles of all types of ODS that are released in stack gases, and expressing that difference as a percentage of the number of moles of the ODS fed into the system.

In mathematical terms, $$\mathrm{DRE} = \frac{N_1^{\mathrm{in}} - \sum_i N_i^{\mathrm{out}}}{N_1^{\mathrm{in}}}$$

Where N_1^{in} is the number of moles of the ODS fed into the destruction system, and N_i^{out} is the number of moles of the *i*th type of ODS that is released in the stack gases.

2.1.2 Emissions of Dioxins and Furans

Any high temperature process used to destroy ODS has associated with it the potential formation (as by-products) of polychlorinated dibenzo-paradioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). These substances are among the products of incomplete combustion (or PICs) of greatest concern for potential adverse effects on public health and the environment. The internationally recognized measure of the toxicity of these compounds is the toxic equivalency factor (ITEQ),[67] which is a weighted measure of the toxicity for all the members of the families of these toxic compounds that are determined to be present.

The task force members note that the World Health Organization has developed a new system for calculating TEQs, however, most of the existing data on emissions is expressed in the former ITEQ system established in 1988.

For purposes of screening destruction technologies, the maximum concentration of dioxins and furans in the stack gas from destruction technologies is:

- 0.5 ng-ITEQ/Nm^3 for foams; and,
- 0.2 ng-ITEQ/Nm^3 for concentrated sources.

These criteria were determined to represent a reasonable compromise between more stringent standards already in place in some industrialized countries [for example, the Canada-Wide Standard of 0.08 ng/m^3 (ITEQ)], and the situation in developing countries where standards may be less stringent or non-existent. Although a previous standard of 1.0 ng/m^3 (ITEQ) had been

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stack gases, weighted by their ODP relative to that of the feed ODS, and expressing that difference as a percentage of the number of moles of the ODS fed into the system.

[67] There are 75 chlorinated dibenzo-p-dioxins and 135 chlorinated dibenzofurans that share a similar chemical structure but that have a wide range in degree of chlorination and a corresponding wide range in toxicity. Of these, one specific dioxin [2,3,7,8-Tetrachlorodibenzo-p-dioxin, or (TCDD)] is the most toxic and best characterized of this family of compounds. Since PCDDs and PCDFs are generally released to the environment as mixtures of these compounds, the scientific community has developed a system of toxic equivalency factors (TEFs) which relate the biological potency of compounds in the dioxin/furan family to the reference TCDD compound. The concentration of each specific compound is multiplied by its corresponding TEF value, and the resulting potency-weighted concentration values are summed to form an expression of the mixture's overall toxic equivalence (TEQ). The result of this exercise is a standardized expression of toxicity of a given mixture in terms of an equivalent amount of TCDD (the reference compound). The internationally accepted protocol for determining TEQ – i.e. ITEQ – was established by NATO in 1988. [North Atlantic Treaty Organization/Committee on the Challenge of Modern Society. (1988). Scientific Basis for the Development of International Toxicity Equivalency Factor (I-TEF), Method of Risk Assessment for Risk Assessment of Complex Mixtures of Dioxins and Related Compounds. *Report No. 176*, Washington, D.C.]

suggested in the UNEP 1992 report, advances in technology in recent years, and the level of concern for emissions of these highly toxic substances justified a significantly more stringent level.

2.1.3 Emissions of Acid Gases, Particulate Matter and Carbon Monoxide

Acid gases are generally formed when ODS are destroyed and these must be removed from the stack gases before the gases are released to the atmosphere. The following criteria for acid gases have been set for purposes of screening destruction technologies:

- a maximum concentration in stack gases of 100 mg/Nm^3 HCl/Cl_2;
- a maximum concentration in stack gases of 5 mg/Nm^3 HF; and,
- a maximum concentration in stack gases of 5 mg/Nm^3 HBr/Br_2.

Particulate matter is generally emitted in the stack gases of incinerators for a variety of reasons and can also be emitted in the stack gases of facilities using non-incineration technologies. For the purposes of screening technologies, the criterion for particulate matter is established as:

- a maximum concentration of total suspended particulate (TSP) of 50 mg/Nm^3.

Carbon monoxide (CO) is generally released from incinerators resulting from incomplete combustion and may be released from some ODS destruction facilities because it is one form by which the carbon content of the ODS can exit the process. Carbon monoxide is a good measure of how well the destruction process is being controlled. For the purposes of screening technologies, the following criterion has been established:

- a maximum CO concentration in the stack gas of 100 mg/Nm^3.

These maximum concentrations apply to both foams and concentrated sources. They were set to be achievable by a variety of available technologies while ensuring adequate protection of human health and the environment.

2.1.4 Technical Capability

As well as meeting the above performance requirements it is necessary that the destruction technologies have been demonstrated to be technically capable at an appropriate scale of operation. In practical terms, this means that the technology should be demonstrated to achieve the required DRE while satisfying the emissions criteria established above. Demonstration of destruction of ODS is preferred but not necessarily required. Destruction of halogenated compounds that are refractory, i.e. resistant to destruction, is acceptable. For example, demonstrated destruction of polychlorinated biphenyls (PCBs) was often accepted as an adequate surrogate for demonstrated ODS destruction.

For this evaluation, an ODS destruction technology is considered technically capable if it meets the following minimum criteria:

- It has been demonstrated to have destroyed ODS to the technical performance standards, on at least a pilot scale or demonstration scale (designated in Table 2-2 as “Yes”).

- It has been demonstrated to have destroyed a refractory chlorinated organic compound other than an ODS, to the technical performance standards, on at least a pilot scale or demonstration scale (designated in Table 2-2 as “P,” which indicates that the technology is considered to have a high potential for application with ODS, but has not actually been demonstrated with ODS).

- The processing capacity of an acceptable pilot plant or demonstration plant must be no less than 1.0 kg/hr of the substance to be destroyed, whether ODS or a suitable surrogate.

These criteria of technical capability will minimize the risk associated with technical performance and ensure that destruction of ODS will be performed in a predictable manner consistent with protecting the environment.

Appendix B presents a detailed discussion of the selection of 1.0 kg/hr as the minimum capacity for a pilot plant in order to demonstrate technical capability, which represents a change from the criterion originally selected in the 1992 UNEP report.

Appendix D Development of Refrigerant Emissions Rates

Under this protocol refrigerant emissions are estimated in reference to the emission loss rates of the equipment into which those refrigerants would have been installed in the baseline. This appendix explains the methodology the Reserve followed to determine the protocol's prescribed emission rates for refrigerant baseline and project emissions.

As described in Appendix A, the CAA and 40 CFR 82 prohibit intentional venting of ODS to the atmosphere. However, due to the disperse nature of servicing and ODS recovery, a significant portion of ODS refrigerants are unintentionally lost during recovery. As a result, every year a significant quantity of ODS is released directly to the atmosphere during equipment servicing and handling, but due to the dispersed nature of these emissions it is difficult to determine the overall share that is being emitted rather than re-used.

The CAA allows the recovery and sale of reclaimed ODS to the refrigeration and air conditioning markets. In fact, because they can no longer be produced or imported, ODS refrigerants still have a high value for recovery and reuse. Whereas destruction of recovered ODS imposes a cost on industry, resale provides positive revenue from recovered ODS.

As previously noted, the share of ODS refrigerant that is recovered and sold to market versus the share that is released during servicing and end-of-life is unknown. To avoid overestimating emissions in the baseline, the conservative approach for estimating GHG reductions is to assume that all ODS is being recovered and recycled into the ODS end use market. The baseline scenario for refrigerants under this protocol is therefore defined as full recovery and recharge for refrigeration and air conditioning applications.

The population of equipment that utilizes ODS refrigerants is rapidly aging and approaching end of life. As such, this equipment exhibits relatively high emission rates and refrigerants are lost to the atmosphere at a rapid rate. For the purposes of this protocol, the baseline emissions of ODS are defined as the amount of ODS that would have been released over the ten-year crediting period had it not been destroyed, but rather been used to recharge existing equipment (see Figure D.1).

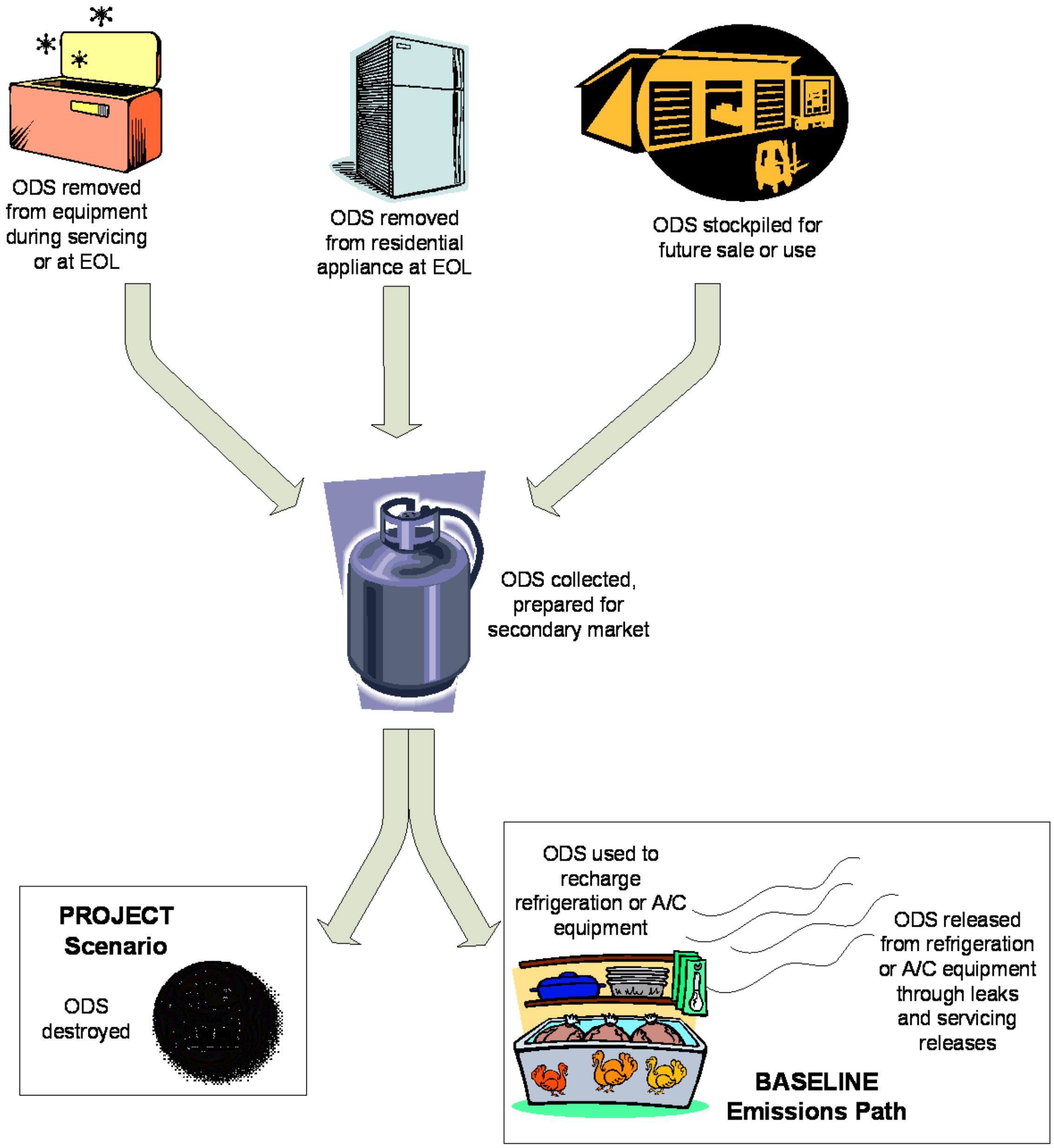

Figure D.1. Illustration of Refrigerant Project Baseline Scenario and Project Scenario

D.1 Baseline Emissions Rates

The refrigerant baseline scenario is defined as recirculation into the refrigerant re-sale market. This market can either be supplied by recovered, or recoverable, ODS refrigerant or refrigerant currently being stockpiled. Determining why refrigerant may have been removed from certain equipment – why a chiller may have been decommissioned or likewise, why excess supplies may exist and why a stockpile was not utilized – is beyond the scope of this protocol because it cannot be assessed in the standardized manner required by the Reserve. Therefore, to enable standardization the baseline is calculated from the time that ODS refrigerant has been recovered, and focuses on what would have happened to a given quantity of ODS refrigerant in the re-sale market. By defining the baseline in this way, the Reserve is able to utilize a single baseline for refrigerant removed from residential appliances (e.g. refrigerators or A/C units) and commercial or industrial equipment.

When ODS enters the re-sale market it could be used in any refrigeration or A/C equipment that needs servicing, regardless of whether it is for large refrigeration, large A/C, or mobile A/C. Since it is impossible to know the exact equipment that the destroyed ODS would have been used in, and the associated emission rate, the ODS baseline is defined as the weighted average of all end-use emission rates of ODS refrigerant in the market under the assumption that it would be absorbed into the overall market. The emission rate for refrigerants is defined as the total annual emissions resulting from both leaks and servicing events of the equipment that would have been recharged by the ODS refrigerant had it not been destroyed.

To determine the applicable weighted emission rate for each ODS refrigerant, the Reserve used data provided by the U.S. EPA from the Vintaging Model. This model compiles estimates of the type, age, refrigerant, leak rates, servicing emission rates, and other information for equipment and ODS applications within the U.S. market. The EPA has tracked this data through years of cooperation with industry, and as a result the EPA Vintaging Model is able to approximate when stocks of ODS will reach end-of-life, and the rates at which installed banks of ODS will be emitted from various equipment categories.

The Vintaging Model is based on industry surveys, engineering estimates, stakeholder feedback, and approximations of industry trends and technologies and is used primarily as a predictive tool rather than a tool for regulating industry. As a result, estimates of emission rates for individual equipment categories may be uncertain and may either over- or under-estimate actual emissions. However, at an aggregate level the model provides a reasonably accurate representation of ongoing emissions for the ODS market as a whole. Despite its limitations, the Vintaging Model represents a comprehensive data source on the U.S. ODS industry, and is therefore the best source for developing emission estimates for each source of ODS in the protocol.

The accuracy of the Vintaging Model increases with greater levels of data aggregation. That is, it likely more accurately estimates CFC emissions from the U.S. economy as a whole than it does CFC emissions from a specific end use like centrifugal chillers. In this protocol, the Reserve has aggregated data to an intermediate level. The categories provided in this protocol were selected because they were determined to be an appropriate balance of specificity and aggregation by the Reserve in consultation with the working group and stakeholders. While finer resolution data is presented in this appendix to illustrate the way in which the Reserve calculated these aggregated values, it should be stressed that each individual value is an approximation and not an exact value.

At the Reserve’s request, the EPA ran the Vintaging Model and provided data on the weighted average emission rates for CFC-11, CFC-12, CFC-114, and CFC-115 as indicated in Table D.1. These outputs are composites of emission rates associated with dozens of separate subcategories within the refrigeration market that are reflected in the Vintaging Model.

As illustrated in Table D.1, the resulting weighted average emission rates derived from the Vintaging Model are based on emissions from the Mobile A/C, Large Refrigeration, and Large A/C sub-sectors, as these were identified as the sub-sectors of the market where refrigerant recharge predominantly will occur in 2012.

The EPA Vintaging Model assumptions rely on the expected life of various types of equipment that utilize ODS. Because vehicles with CFC-12 systems are older than the assumed 12-year lifespan of a vehicle, the Vintaging Model indicated that no CFC-12 will be used in the automotive sector in 2012. Consultation with members of the refrigerant reclaim and wholesale industry indicated that CFC-12 is still being sold in large quantities for mobile A/C applications. In fact, upwards of 50 percent of the U.S. CFC-12 demand may be in the mobile market. The Reserve confirmed this finding through review of confidential sales records that indicated a majority of CFC-12 sales were intended for the automotive market. Accordingly, a 50 percent mobile market share has been assumed to be conservative, and the Vintaging Model data has been adjusted accordingly. For the mobile market the Reserve further assumed an emission rate of 40.7 percent (leak and servicing emissions) per year for CFC-12, and 18 percent emission rate for the replacement, HFC-134a.

As the EPA Vintaging Model does not track CFC-13 and CFC-113 as refrigerants, the Reserve used conservative assumptions to derive appropriate emission rates. Our understanding is that CFC-13 is used as a very low temperature refrigerant. Since the system size it is utilized in is uncertain, the Reserve assumed a large refrigeration system to be conservative. The California Air Resources Board (ARB) Compliance Offset Protocol for ODS projects utilizes a nine percent annual leak rate for large refrigeration systems, in accordance with the impact of California's Refrigerant Management Program. To be conservative and consistent with the ARB compliance protocol, the Reserve has used this same nine percent annual leak rate. CFC-113 is used primarily in chillers, much like CFC-11. The Reserve conservatively assumed that all CFC-113 went into large A/C applications. The same emission rate and substitution rate as CFC-11 were used, as the chemicals' application and use are similar. This is also consistent with the ARB compliance protocol.

The results, incorporating both industry and Vintaging Model data, are presented in Table D.1.

Table D.1. Weighted Average Annual Loss Rate Percent and Market Share for Class I ODS [68]

	2010 Weighted Average Annual Loss Rate Percent and Market Share for Class I ODS											
	CFC-11		**CFC-12**		**CFC-13**		**CFC-113**		**CFC-114**		**CFC-115**	
Refrigeration and A/C Sector	Market Share	Loss Rate	Market Share	Loss Rate	Market Share	Loss Rate	Market Share	Loss Rate	Market Share	Loss Rate	Market Share	Loss Rate
Mobile[69]	-	-	50%	41%	-	-	-	-	-	-	-	-
Large Refrigeration	3%	19%	33%	10%	100%	9%	-	-	-	-	100%	25%
Large AC	97%	20%	17%	14%	-	-	100%	20%	100%	14%	-	-
Market-Weighted Annual Loss Rate	**20%**		**26%**		**9%**		**20%**		**14%**		**25%**	
10-year Total Loss	**89%**		**95%**		**61%**		**89%**		**77%**		**94%**	

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[68] EPA. (2011). EPA Vintaging Model. *Version VM IO file_v4.4_3.23.11.*

[69] The market share for mobile refrigeration was derived from industry surveys conducted by Reserve staff.

The categories identified in Table D.1 are weighted aggregates of the subsectors presented in Table D.2.

Table D.2. Characterization of Categories from the EPA Vintaging Model

Category	End Use
Large AC	Centrifugal Chillers
	Positive Displacement Chillers
Large Refrigeration	Large Retail Food
	Cold Storage
	Refrigerated Transport
	Industrial Process Refrigeration
Mobile	Mobile AC
	School & Tour Buses AC
	Transit Buses AC
	Trains AC
Small AC	Dehumidifiers
	Window Units
	Unitary A/C
	Water & Ground Source HP
	Packaged Terminal AC/HP
Small Refrigeration	Small and Medium Retail Food
	Household Refrigerated Appliances
	Ice Makers

Interviews with industry experts indicated that a large share of recoverable refrigerant is vented to the atmosphere directly rather than re-introduced as recycled or reclaimed material into the market. As this would result in 100 percent immediate release, calculating all refrigerant ODS baseline emissions according to a market emission rate as described above is conservative.

The weighted annual emission rates calculated in Table D.1 are used in the protocol to calculate baseline emissions from the release of ODS refrigerant in Equation 5.3.

D.2 Project Emissions Rates

By removing ODS refrigerant from the re-sale market through destruction projects, substitute refrigerants will be required to fulfill the U.S. refrigeration need. Much as predicting the baseline use of destroyed ODS is difficult and inappropriate, so too is predicting the specific refrigerant that will fill the void when the ODS is destroyed and the baseline does not come to pass because of the project. Therefore, the Reserve employed the same technique used for establishing the emissions rate of the baseline when developing a generic, weighted substitute GWP and emission rate for the project.

Substitute emissions for CFC-11, CFC-12, CFC-114, and CFC-115 are based on the weighted average of new market entrants for their respective refrigeration purposes as modeled by the EPA Vintaging Model for 2012. Pulling from industry expertise and internal EPA research, the Vintaging Model predicts that the ODS substitutes in Table D.3 through Table D.8 will be the dominant refrigerant substitutes. The model further provides the emission rates associated with each substitute, the relative charge size of the substitute required to meet the same refrigerant need as the replaced ODS,[70] and data on the market share attributable to each substitute. Using this information, the Reserve calculated the weighted average substitute emissions per pound of ODS destroyed.

The parameters of substitute emissions are used in the protocol to estimate the project scenario emissions associated with the use of substitute refrigerants in Equation 5.6.

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[70] In many cases, more or less of a substitute refrigerant is needed to perform the same function as the replaced ODS.

Table D.3. Calculation of Substitute Emissions for CFC-11

Application	CFC-11 Recharge Market Share	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-11 Market Share	GWP (CO$_2$e)	Relative Charge Size (lb Sub/lb ODS)	Sub Used to Replace One lb CFC-11 (lbs)	Loss Rate of Sub (%/yr)	10-year lbCO$_2$e/ODS Destroyed
Large Refrigeration	3%	HCFC-123	65%	2%	90	0.88	0.017	5%	1
		HFC-134a	35%	1%	1300	1.4	0.019	5%	8
Large AC	97%	HCFC-123	41%	33%	90	0.88	0.289	2%	7
		HFC-134a	59%	64%	1300	1.4	0.894	2%	186
					CFC-Sub Emissions (lbCO$_2$e/lbODS destroyed)				**202**

Table D.4. Calculation of Substitute Emissions for CFC-12

Application	CFC-12 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-12 Market Share	GWP (CO$_2$e)	Relative Charge Size (lb Sub/lb ODS)	Sub Used to Replace One lb CFC-12 (lbs)	Loss Rate of Sub (%/yr)	10-year lbCO$_2$e/ODS Destroyed
Mobile	50%	HFC-134a	100%	50%	1300	.74	0.370	18%	415
Large Refrigeration	33%	HCFC-123	14%	8%	90	0.88	0.068	4%	1
		HFC-134a	34%	20%	1300	1.4	0.278	4%	73
		R-404A	36%	3%	2028	0.78	0.026	11%	130
		R-410A	1%	1%	1725	0.88	0.005	5%	2
		R-507A	16%	1%	3300	0.78	0.008	12%	95
Large AC	17%	HCFC-123	19%	2%	90	0.88	0.014	1%	0
		HFC-134a	78%	14%	1300	1.4	0.196	3%	59
		R-407C	3%	2%	1526	0.76	0.012	2%	1
		R-410A	1%	0%	1725	0.76	0.003	1%	0
					CFC-Sub Emissions (lbCO$_2$e/lbODS destroyed)				**777**

Table D.5. Calculation of Substitute Emissions for CFC-13

Application	CFC-13 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-13 market share	GWP (CO_2e)	Relative Charge Size (lb Sub/lb ODS)	Sub Used to Replace One lb CFC-13 (lbs)	Loss Rate of Sub (%/yr)	10-year lbCO_2e/ODS Destroyed
Large Refrigeration	100%	HFC-23	100%	100%	11700	1	1.000	9%	7144
					CFC-Sub Emissions (lbCO_2e/lbODS destroyed)				**7144**

Table D.6. Calculation of Substitute Emissions for CFC-113

Application	CFC-113 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-113 Market Share	GWP (CO_2e)	Relative Charge Size (lb Sub/lb ODS)	Sub used to Replace One lb CFC-113 (lbs)	Loss Rate of Sub (%/yr)	10-year lbCO_2e/ODS Destroyed
Large AC	100%	HCFC-123	34%	34%	77	0.88	0.299	2%	5
		HFC-134a	66%	66%	1300	1.4	0.925	2%	215
					CFC-Sub Emissions (lbCO_2e/lbODS destroyed)				**220**

Table D.7. Calculation of Substitute Emissions for CFC-114

Application	CFC-114 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-114 Market Share	GWP (CO_2e)	Relative Charge Size (lb Sub/lb ODS)	Sub Used to Replace One lb CFC-114 (lbs)	Loss Rate of Sub (%/yr)	10-year lbCO_2e/ODS Destroyed
Large AC	100%	HFC-134a	100%	100%	1300	1.4	1.400	4%	659
					CFC-Sub Emissions (lbCO_2e/lbODS destroyed)				**659**

Table D.8. Calculation of Substitute Emissions for CFC-115

Application	CFC-115 Market Share of Recharge	ODS Substitute	Market Share Relative to Subsector (by weight)	Overall CFC-115 Market Share	GWP (CO_2e)	Relative Charge Size (lb Sub/lb ODS)	Sub used to Replace One lb CFC-115 (lbs)	Loss Rate of Sub (%/yr)	10-year lbCO_2e/ODS Destroyed
Large Refrigeration	100%	R-404A	68%	53%	2028	0.85	0.448	17%	999
		R-507A	31%	12%	3300	0.85	0.101	15%	691
		Non-ODP/GWP	1%	36%	0	1	0.355	15%	0
					CFC-Sub Emissions (lbCO_2e/lbODS destroyed)				**1689**

Appendix E Foam Recovery Efficiency and Calculations

The following methodology calculates the site- or process-specific recovery efficiency for blowing agent recovery projects, and uses this value for calculation of emission reductions in Section 5. Determination of accurate recovery efficiency allows baseline emissions and project emissions to be calculated in reference to the initial quantity of foam blowing agent diverted from baseline treatment.

The methodology prescribed in this appendix uses a mass balance approach similar to that utilized by the Waste Electrical and Electronic Equipment Directive (WEEE),[71] RAL Quality Assurance Association (RAL),[72] and other internationally recognized standards. However, applying these standards directly to projects using this protocol was deemed inappropriate for several reasons.

First, these standards are based on assumptions about the size of appliances, quantity of foam, and concentration of CFC foam blowing agent in the polyurethane (PU) foam found in Europe. The empirical work underlying these assumptions was conducted in Europe, and it is unclear whether these values are similar in the U.S. The Reserve's research indicates that U.S. appliances are larger, have a greater quantity of foam per appliance, and a higher concentration of CFC foam blowing agent in the PU foam.

Second, the existing international standards are intended to benchmark best practices in appliance recycling and ODS recovery. Accordingly, uncertainty in the assumptions of these standards (e.g. kg foam per appliance, concentration of ODS blowing agent) is acceptable provided that the standard is consistently applied from one project to the next. As such, these standards provide a means of comparison between processes or practices, but do not provide a mechanism by which to calculate losses of ODS that may occur during the project activity. As a GHG accounting methodology, this protocol must provide a mechanism for estimating project emissions that occur during recycling.

The methodology provided in this appendix differs in one significant way from the internationally accepted standards that precede it. The other standards dictate a minimum recover efficiency of 90 percent that must be demonstrated. This protocol does not specify a minimum recovery efficiency, but instead builds in an incentive to optimize ODS blowing agent recovery. For application in the U.S., where blowing agent recovery to a concentrated form is rare, this approach has several advantages.

While the Reserve fully endorses a 90 percent or higher recovery efficiency as the end goal, this method will allow gap or bridge technologies and processes with lower than 90 percent recovery to be eligible provided that emissions accounting is properly conducted and credited.

Additionally, higher recovery efficiencies – including those above 90 percent – are incentivized by minimizing project emissions (deducted at 100 percent) in the calculations, in addition to increasing the quantity of ODS recovered and destroyed (calculated only as released portion, per Equation 5.7).

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[71] WEEE Forum. (2007). Requirements for the Collection, Transportation, Storage, Handling and Treatment of Household Cooling and Freezing Appliances containing CFC, HCFC, or HFC.

[72] RAL Deutsches Institut für Gütesicherung und Kennzeichnung e.V. (2007). Quality Assurance and Test Specifications for the Demanufacture of Refrigeration Equipment.

E.1 Calculating Recovery Efficiency

All appliance foam projects must calculate a recovery efficiency once per project based on a run of a minimum ten appliances. Basing this analysis on a number of appliances greater than ten will likely result in a higher calculated recovery efficiency due to the 90 percent upper confidence limit used for calculating the concentration of ODS blowing agent in the foam. A larger sample size will decrease uncertainty and thus lower the estimated blowing agent concentration and increase recovery efficiency; however, sampling of additional appliances will also increase testing costs.

The procedures below shall be used to calculate recovery efficiency.

Estimate initial blowing agent concentration

The concentration of ODS blowing agent in the PU foam prior to any appliance treatment shall either be assumed to equal to 14.9 percent (a conservative value identified by Fredenslund et al. (2005) for U.S. appliances[73]) or calculated according to the steps below. Calculating a sample-specific value allows project developers to document a lower ODS blowing agent concentration, which will result in a higher estimated recovery efficiency.

The following steps shall be followed to document a sample-specific ODS blowing agent concentration:

1. Cut four PU foam samples from each appliance (left side, right side, top, bottom) using a reciprocating saw. Samples must be at least four inches square and the full thickness of the insulation
2. Seal the cut edges of each foam sample using aluminum tape or similar product that prevents off-gassing
3. Individually label each sample to record appliance model, and site of sample (left, right, top, or bottom)
4. Analyze samples according to the procedures dictated for building foam in Section 6.4. Samples may be analyzed individually (four analyses per appliance), or a single analysis may be done using equal masses of foam from each sample (one analysis per appliance)
5. Based on the average of the samples for each appliance, calculate the 90 percent upper confidence limit of the concentration. The 90 percent upper confidence limit shall be used as the parameter BA_{conc} in the equations below

Extract the ODS blowing agent and separate foam residual

The ODS blowing agent from the sampled appliances must be collected and quantified according to the steps below.

1. Begin processing with all equipment shut down and emptied of all materials.
2. Process all sample appliances
3. Extract and collect concentrated BA. The mass of the recovered blowing agent shall be determined by comparison of the mass of the fully evacuated receiving containers to their mass when filled. This value shall be used as the parameter BA_{post} in the equations below

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[73] Fredenslund, A. et al. (2005). Disposal of Refrigerators-Freezers in the U.S.: State of the Practice. *Technical University of Denmark.*

Separate foam residual

The quantity of foam in the processed appliances must be established either through use of a default value of 12.9 pounds per appliance,[74] or according to step the following steps. If the value of 12.9 pounds per appliance is used, it shall be multiplied by the number of appliances processed to determine $Foam_{res}$ in the calculation of recovery efficiency.

1. Separate and collect all foam residual, which may be in a fluff, powder, or pelletized form. Processes must be documented to demonstrate that no significant quantity of foam residual is lost in the air or other waste streams
2. If desired, manually separate non-foam components in the residual (e.g. plastic) to determine a percent of foam in residual. If performed, this analysis must be conducted on at least one kilogram of residual, and results may be no lower than 90 percent
3. Weigh the total recovered foam residual, and, if performed, multiply by the percent foam in residual, to calculate total mass of foam recovered. This value shall be used as the parameter $Foam_{res}$

Calculate recovery efficiency

To calculate the recovery efficiency, apply the calculated values to the equations below. The recovery efficiency (RE) calculated below shall be used in the calculations of Section 5.

$$BA_{init} = \frac{Foam_{res}}{(1 - BA_{conc})} \times BA_{conc}$$

Where,

			Units
$Foam_{res}$	=	Mass of foam recovered	lbs foam
BA_{conc}	=	Initial concentration of blowing agent in PU foam	lbs BA / lbs PU
BA_{init}	=	Initial quantity of blowing agent in appliances prior to treatment	lbs BA

$$RE = \frac{BA_{post}}{BA_{init}}$$

Where,

			Units
RE	=	Recovery efficiency	%
BA_{post}	=	Quantity of recovered blowing agent in concentrated form	lbs BA
BA_{init}	=	Initial quantity of blowing agent in appliances prior to treatment	lbs BA

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[74] EcoSolutions Recycling. (2010). Foam content and CFC recovery in residential appliances. *EcoSolutions Recycling, Inc., Quebec*.

Appendix F Default Emission Factors for Calculating ODS Transportation and Destruction Emissions

F.1 Summary

The GHG Assessment Boundary for ODS destruction projects under the Reserve includes emissions in both the baseline and project scenario. These emission sources include the following:

Baseline	Project
▪ Emissions of ODS from foam shredding ▪ Emissions of ODS from foam landfilling ▪ Emissions of ODS from refrigerant applications	▪ Extraction of ODS blowing agent ▪ Emissions of substitute refrigerant applications ▪ CO_2 emissions from fossil fuel and electricity used in destruction facility ▪ CO_2 emissions from fossil fuel used in transport to destruction facility ▪ ODS emissions from incomplete destruction of ODS ▪ CO_2 emissions from ODS oxidation during destruction

All of these emission sources must be accounted for to ensure complete, accurate, and conservative calculations of project emission reductions. However, some of these emission sources are of a significantly greater magnitude than others, and some of the smaller sources are costly to track and verify, and difficult to assess. In order to lessen the burden on project developers and verifiers, the Reserve has calculated a standard deduction that can be applied to all projects to account for the following project scenario emissions:

1. CO_2 emissions from fossil fuel and electricity used by the destruction facility
2. CO_2 emissions from fossil fuel used for transporting the ODS to the destruction facility
3. ODS emissions from incomplete destruction of ODS
4. CO_2 emissions from ODS oxidation during destruction

The aggregate of these emission sources amounts to less than 0.5 percent of total emission reductions under even the most conservative assumptions. As a result, a conservative emission factor can be applied. This appendix provides background on the development of these default emission factors.

F.2 Methodology and Analysis

The Reserve created a model to conservatively calculate all emissions in the baseline and project scenario for ODS projects. The model incorporated all equations from Section 5. The equations that have been rolled up into this emission factor are Equation 5.9 through Equation 5.14.

In many cases, the equations used for estimating emissions required additional input and emissions factors. Where calculations required such inputs (e.g. electricity grid emission factors), the most conservative factors available were used. Fossil fuel emissions from the destruction process were calculated based on confidential industry records made available to the Reserve that describe the energy requirements associated with ODS destruction projects. The assumptions used in this analysis are as follows:

Parameter	Assumption
ODS_i =	1 tonne ODS
$FF_{PR,k}$ =	0.0009 MMBtu natural gas/lb ODS destroyed (for foams and refrigerants)
$EF_{FF,k}$ =	54.01 kg CO_2/MMBtu[75]
EL_{PR} =	0.0002 MWh/lb ODS destroyed for foam, 0.0018 MWh/lb ODS destroyed for refrigerants and extracted ODS blowing agent
EF_{EL} =	0.889 tCO_2/MWh[76]
TMTi =	2,000 miles
EF_{TMT} =	0.000297 $kgCO_2$/PMT[77]
CRi =	Actual per ODS
Foam weight =	8.5% ODS blowing agent by weight (foam weight used for transport and energy use)

Under these assumptions, and the equations provided in Section 5, the calculations provided the following results for different ODS project categories:

Table F.1. Project Emissions (Excluding Substitutes)
All quantities in tonnes CO_2/tonne ODS destroyed.

	Fossil Fuel Emissions from the Destruction	Electricity Emissions from the Destruction	Emissions from ODS Not Destroyed	Emissions from CO_2	Emissions from the Transportation of ODS	Total
CFC-11 refrigerant or extracted BA	0.04	3.53	0.47	0.32	0.59	4.95
CFC-12 refrigerant or extracted BA	0.04	3.53	1.07	0.36	0.59	5.59
CFC-114 refrigerant	0.04	3.53	1.00	0.47	0.59	5.63
CFC-115 refrigerant	0.04	3.53	0.74	0.47	0.59	5.36
CFC-11 building foam	0.42	41.50	0.47	0.32	6.99	49.70
CFC-12 building foam	0.42	41.50	1.07	0.36	6.99	50.35
HCFC-141b building foam	0.42	41.50	0.07	0.75	6.99	49.74

Because the ODS covered in this protocol have such high GWPs (750 to 10,900) even emissions of 50 tonnes CO_2e per tonne of ODS destroyed are relatively small compared to emissions of the overall baseline and project scenarios. For refrigerant projects, the emissions

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[75] U.S. EPA Climate Leaders. (2007). Stationary Combustion Guidance. Note: The highest emission factor was selected to be conservative.

[76] U.S. EPA eGRID2007, Version 1.1 Year 2005 GHG Annual Output Emission Rates (December 2008). Note: the highest emission factor in the nation was selected to be conservative.

[77] U.S. EPA Climate Leaders. (2008). Optional emissions from business travel, commuting, and product transport. Note: the highest emitting mode of transportation was selected to be conservative.

amount to less than 0.15 percent of baseline emissions. For building foams, emissions from the four emission sources can be as high as five percent of baseline emissions.

F.3 Conclusion

To account for the emission sources analyzed above, project developers may apply a 7.5 tonne CO_2e/tonne ODS emission factor to all ODS refrigerant projects and to appliance ODS blowing agent projects. A 75 tonne CO_2e/tonne ODS emission factor must be applied to building ODS blowing agent projects that destroy intact foam. These default emission factors represent a conservative estimate of the potential emissions from the four selected sources and were derived using worst-case emission factors and empirical data.

Appendix G Emission Factor Tables

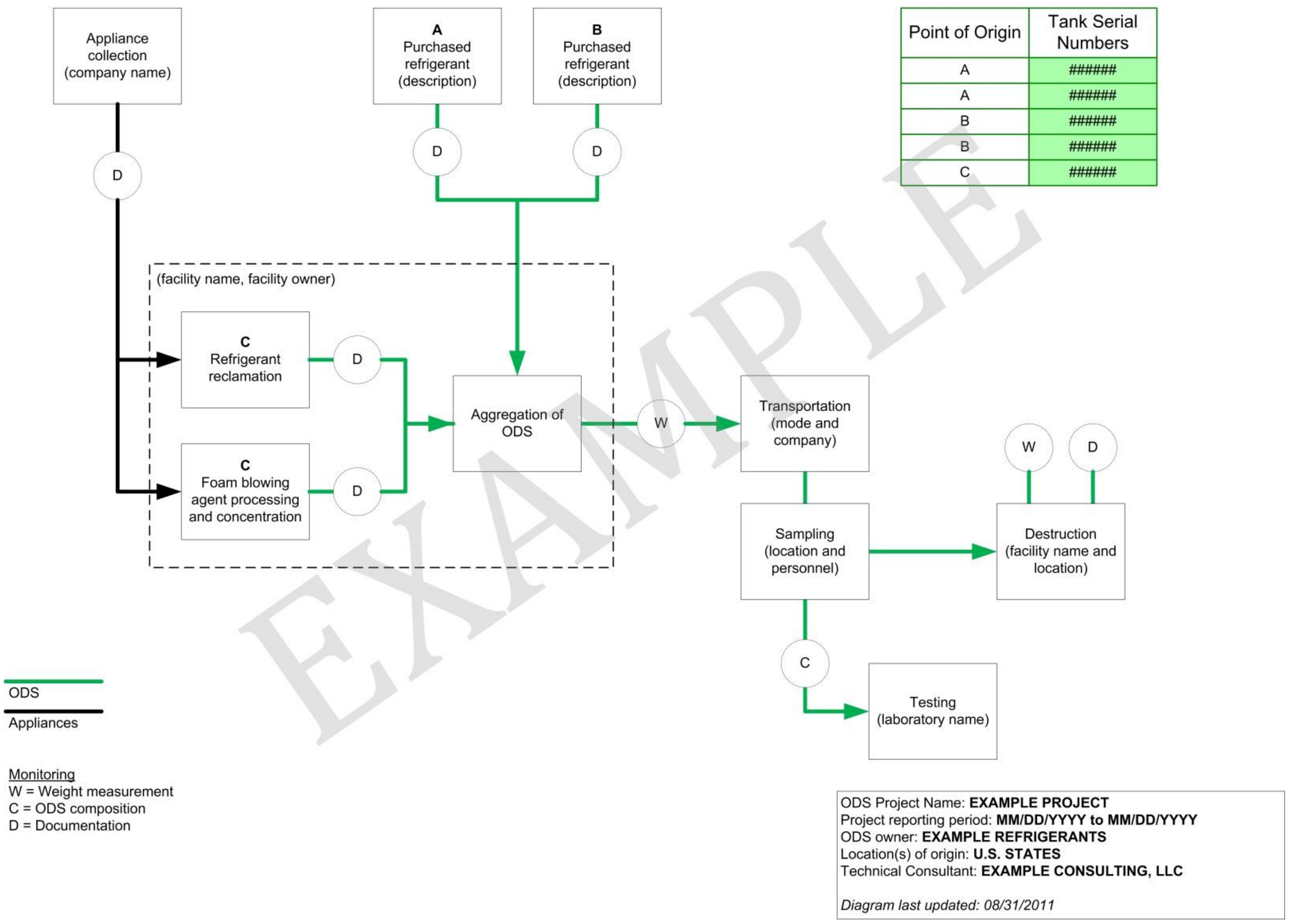
Table G.1. CO_2 Emission Factors for Fossil Fuel Use

Fuel Type	**Heat Content**	**Carbon Content** (Per Unit Energy)	**Fraction Oxidized**	**CO_2 Emission Factor** (Per Unit Energy)	**CO_2 Emission Factor** (Per Unit Mass or Volume)
Coal and Coke	**MMBtu / Short ton**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / Short ton**
Anthracite Coal	25.09	28.26	1.00	103.62	2,599.83
Bituminous Coal	24.93	25.49	1.00	93.46	2,330.04
Sub-bituminous Coal	17.25	26.48	1.00	97.09	1,674.86
Lignite	14.21	26.30	1.00	96.43	1,370.32
Unspecified (Residential/ Commercial)	22.05	26.00	1.00	95.33	2,102.29
Unspecified (Industrial Coking)	26.27	25.56	1.00	93.72	2,462.12
Unspecified (Other Industrial)	22.05	25.63	1.00	93.98	2,072.19
Unspecified (Electric Utility)	19.95	25.76	1.00	94.45	1,884.53
Coke	24.80	31.00	1.00	113.67	2,818.93
Natural Gas (By Heat Content)	**Btu / Standard cubic foot**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / Standard cub. ft.**
975 to 1,000 Btu / Std cubic foot	975 – 1,000	14.73	1.00	54.01	Varies
1,000 to 1,025 Btu / Std cubic foot	1,000 – 1,025	14.43	1.00	52.91	Varies
1,025 to 1,050 Btu / Std cubic foot	1,025 – 1,050	14.47	1.00	53.06	Varies
1,050 to 1,075 Btu / Std cubic foot	1,050 – 1,075	14.58	1.00	53.46	Varies
1,075 to 1,100 Btu / Std cubic foot	1,075 – 1,100	14.65	1.00	53.72	Varies
Greater than 1,100 Btu / Std cubic foot	> 1,100	14.92	1.00	54.71	Varies
Weighted U.S. Average	1,029	14.47	1.00	53.06	0.0546
Petroleum Products	**MMBtu / Barrel**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / gallon**
Asphalt & Road Oil	6.636	20.62	1.00	75.61	11.95
Aviation Gasoline	5.048	18.87	1.00	69.19	8.32
Distillate Fuel Oil (#1, 2 & 4)	5.825	19.95	1.00	73.15	10.15
Jet Fuel	5.670	19.33	1.00	70.88	9.57
Kerosene	5.670	19.72	1.00	72.31	9.76
LPG (average for fuel use)	3.849	17.23	1.00	63.16	5.79
Propane	3.824	17.20	1.00	63.07	5.74
Ethane	2.916	16.25	1.00	59.58	4.14
Isobutene	4.162	17.75	1.00	65.08	6.45
n-Butane	4.328	17.72	1.00	64.97	6.70
Lubricants	6.065	20.24	1.00	74.21	10.72
Motor Gasoline	5.218	19.33	1.00	70.88	8.81
Residual Fuel Oil (#5 & 6)	6.287	21.49	1.00	78.80	11.80
Crude Oil	5.800	20.33	1.00	74.54	10.29
Naphtha (<401 deg. F)	5.248	18.14	1.00	66.51	8.31
Natural Gasoline	4.620	18.24	1.00	66.88	7.36
Other Oil (>401 deg. F)	5.825	19.95	1.00	73.15	10.15
Pentanes Plus	4.620	18.24	1.00	66.88	7.36
Petrochemical Feedstocks	5.428	19.37	1.00	71.02	9.18
Petroleum Coke	6.024	27.85	1.00	102.12	14.65
Still Gas	6.000	17.51	1.00	64.20	9.17
Special Naphtha	5.248	19.86	1.00	72.82	9.10
Unfinished Oils	5.825	20.33	1.00	74.54	10.34
Waxes	5.537	19.81	1.00	72.64	9.58

Source: EPA Climate Leaders. (2007). Stationary Combustion Guidance. Table B-2 except:
Default CO_2 emission factors (per unit energy) are calculated as: Carbon Content × Fraction Oxidized × 44/12.
Default CO_2 emission factors (per unit mass or volume) are calculated as: Heat Content x Carbon Content × Fraction Oxidized × 44/12× Conversion Factor (if applicable).
Heat content factors are based on higher heating values (HHV).

Appendix H ODS Project Diagram Sample

Generalized ODS Project System Diagram



Point of Origin	Tank Serial Numbers
A	######
A	######
B	######
B	######
C	######

ODS Project Name: **EXAMPLE PROJECT**
Project reporting period: **MM/DD/YYYY to MM/DD/YYYY**
ODS owner: **EXAMPLE REFRIGERANTS**
Location(s) of origin: **U.S. STATES**
Technical Consultant: **EXAMPLE CONSULTING, LLC**

Diagram last updated: 08/31/2011