CLIMATE ACTION RESERVE

Article 5 | Version 2.0 | June 27, 2012

Ozone Depleting Substances

Project Protocol

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Released June 27, 2012

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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
CRT	Climate Reserve Tonne
CPT	Comprehensive Performance Test
DOT	U.S. Department of Transportation
DRE	Destruction and removal efficiency
EPA	United States Environmental Protection Agency
GWP	Global warming potential
HBFC	Hydrobromofluorocarbons
HCFC	Hydrochlorofluorocarbons
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
RCRA	Resource Conservation and Recovery Act
REFPROP	Reference Fluid Thermodynamic and Transport Properties Database
Reserve	Climate Action Reserve
TEAP	Technology and Economic Assessment Panel
UNEP	United Nations Environment Programme

1 Introduction

The Climate Action Reserve Article 5 Ozone Depleting Substances Project Protocol provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with destruction of high global warming potential ozone depleting substances (ODS) in the United States (U.S.) that are sourced from Article 5 countries, and that would have otherwise been released to the atmosphere. This project type includes only ODS used in refrigerant applications. All destroyed ODS must originate in an Article 5 country and be fully documented, chemically analyzed, and destroyed at a qualifying destruction facility within the United States to be eligible for crediting under this protocol. Projects wishing to generate credits from the destruction of ODS originating inside the U.S. must use the Climate Action Reserve's U.S. 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 project reports 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 Verification Program Manual and Section 8 of this protocol.

This 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]

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.
[2] United Nations Environment Programme, Ozone Secretariat. (1987 and subsequent amendments). The Montreal

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 potential (GWP). The GWP of these ODS range from several hundred to several thousand times that of carbon dioxide (see Table 5.2).

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] The current ODS phase-out schedule for Article 5 countries as dictated by the Montreal Protocol is presented in Table 2.1.

Table 2.1. Production Phase-Out Schedule of the Montreal Protocol for Article 5 Countries

Ozone Depleting Substance	Article 5 Countries
CFC (chlorofluorocarbons)	January 1, 2010
Halons	January 1, 2010
Carbon tetrachloride	January 1, 2010
Methyl chloroform	January 1, 2015
Methyl bromide	January 1, 2015
HBFC (Hydrobromofluorocarbons)	January 1, 1996
HCFC (hydrochlorofluorocarbons)	January 1, 2013: freeze at baseline (average 2009/2010)
	January 1, 2015:10% below baseline
	January 1, 2020: 35% below baseline
	January 1, 2025: 67.5% below baseline
	January 1, 2030-December 31, 2039: total of 2.5 % of baseline during the entire period
	January 1, 2040: full phase-out

This protocol is explicitly limited to the destruction of phased-out ODS refrigerants sourced in Article 5 countries and destroyed within the United States. ODS sourced from within the U.S. are covered in the companion U.S. Ozone Depleting Substances Project Protocol.

[2] United Nations Environment Programme, Ozone Secretariat. (1987 and subsequent amendments). The Montreal Protocol on Substances that Deplete the Ozone Layer.
[3] 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.
[4] See http://ozone.unep.org/Ratification_status/ for a list of all countries that have ratified the Montreal Protocol.

As of January 1, 2010, the Montreal Protocol has stopped all production of CFC ODS in Article 5 countries, with the exception of certain critical use exemptions. However, this framework does not require the destruction of extant stocks of ODS. Rather, virgin stockpiles may be sold for use, and installed banks may be recovered, recycled, reclaimed, and reused indefinitely, often in equipment with very high leak rates. Because the Montreal Protocol does not forbid the use of existing or recycled controlled substances beyond the phase-out dates, even properly managed ODS banks will eventually be released to the atmosphere during equipment servicing, use, and end-of-life.

Prior to the production phase-out in Article 5 countries, equipment utilizing CFC refrigerants was preferred in a wide variety of applications. These applications included industrial and commercial refrigeration, cold storage, comfort cooling equipment (i.e. air conditioning), and various consumer applications. While the production of CFC refrigerants has been phased out, use of these ODS is still widespread, and can be found everywhere from vehicle air conditioners to industrial chillers. These substances continue to be released from equipment through operation, servicing, and end-of-life.

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[5] of eligible imported 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 country) 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.

While 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. three months or six 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

[5] Under 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 CFR 82).

Technology and Economic Assessment Panel (TEAP) guidelines provided in the *Report of the Task Force on Destruction Technologies*.[6] Under this protocol, non-RCRA permitted facilities cannot receive and destroy ODS materials that are classified as hazardous waste in the U.S. or that were classified as hazardous waste in the country of origin. Non-RCRA facilities 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). Any ODS deemed hazardous waste either in the U.S. or in the country of origin must be destroyed at a RCRA-permitted facility.

2.3 Eligible ODS

Eligible ODS under this protocol are limited to those listed under Annex A, Group I of the Montreal Protocol and used in refrigerant applications. With the exception of certain critical uses, these CFC have been fully phased out of production as of January 1, 2010. The Annex A, Group I CFC used in refrigeration applications and eligible for crediting under this protocol are:

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

2.4 Eligible ODS Sources

Under this protocol, there are four eligible sources of ODS refrigerant. These sources are:

1. Privately held stockpiles of used ODS refrigerant that can legally be sold to the market
2. Article 5 government stockpiles of seized ODS refrigerant that can legally be sold to the market
3. Article 5 government stockpiles of seized ODS that cannot be legally sold to the market
4. Used ODS refrigerant recovered from industrial, commercial, or residential equipment at servicing or end-of-life

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.

Furthermore, only ODS refrigerants phased out of production in the country of origin before the date of export are eligible for crediting under this protocol. For projects with export dates prior to the Montreal Protocol mandated phase-out of January 1, 2010, a letter from the Ozone Secretariat must be provided to the Reserve at time of project submittal to confirm that early production phase-out occurred.

Privately held and saleable virgin ODS refrigerants are not eligible under this protocol.

2.5 The Project Developer

The “project developer” is an 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

[6] TEAP. (2002). Report of the task force on destruction technologies. *Volume 3B*.

GHG reductions. Ownership of the GHG reductions must be established by clear and explicit title and the project developer must attest to such ownership prior to commencement of verification activities each time a project is verified by signing the Reserve's Attestation of Title form.[7]

[7] 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	→	*ODS source: Article 5 countries* *ODS destruction: 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 an ODS destruction event to be eligible as a project under this protocol, all ODS must be sourced from Article 5 countries, imported into the United States in compliance with U.S Environmental Protection Agency (EPA) rules as defined in 40 CFR 82, and destroyed within the United States or its territories. Project developers seeking to register projects involving the destruction of domestically sourced ODS in the U.S. must use the Reserve's U.S. Ozone Depleting Substances Project Protocol. Projects that destroy ODS outside of the United States and its territories are not eligible for registration with the Reserve.

3.2 Project Start Date

The project start date is defined as the day project ODS departs from its point of entry into the United States. To be eligible, the project must be submitted to the Reserve no more than six months after the project start date.[8] 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, 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 will be issued for all ODS emissions avoided by the 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.

[8] 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/.

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[9] prior to the commencement of verification activities each time the project is verified (see Section 8).[10] In addition, the project's Monitoring and Operations Plan (Section 5.3) must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test. The Legal Requirement Test must be met as of the date of ODS export from the Article 5 country.

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.[11]

For this protocol, the Reserve uses a Performance Standard Test based on an evaluation of Article 5 "common practice" for managing ODS. As detailed in Appendix B, destruction of ODS is not common practice in Article 5 countries. Because the Reserve has determined that destruction of CFC refrigerant from Article 5 countries is not common practice, projects that meet the project definition and other eligibility requirements of this protocol 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.

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 operations 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

[9] Attestation of Voluntary Implementation form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.
[10] 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.
[11] A summary of the study to establish the Performance Standard Test is provided in Appendix B.

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.[12]

Project developers must attest that the project has met this requirement by signing the Attestation of Regulatory Compliance[13] prior to verification activities commencing for each project.[14] Projects are not eligible to receive CRTs for GHG reductions that occur as the result of production, 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 significant 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.

All importation activities must be conducted in full compliance with the rules promulgated by the U.S. EPA per the authority granted by Title VI of the Clean Air Act (40 CFR 82), and U.S. Customs. Full documentation of this process, including all petition and record-keeping documents, must be retained and provided for verification. Any ODS that does not have a complete import record is ineligible.

[12] 40 CFR 63.1206.
[13] Attestation of Regulatory Compliance form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.
[14] 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 change in GHG emissions caused by an ODS project.[15]

Figure 4.1 below provides a general illustration of the GHG Assessment Boundary, 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.

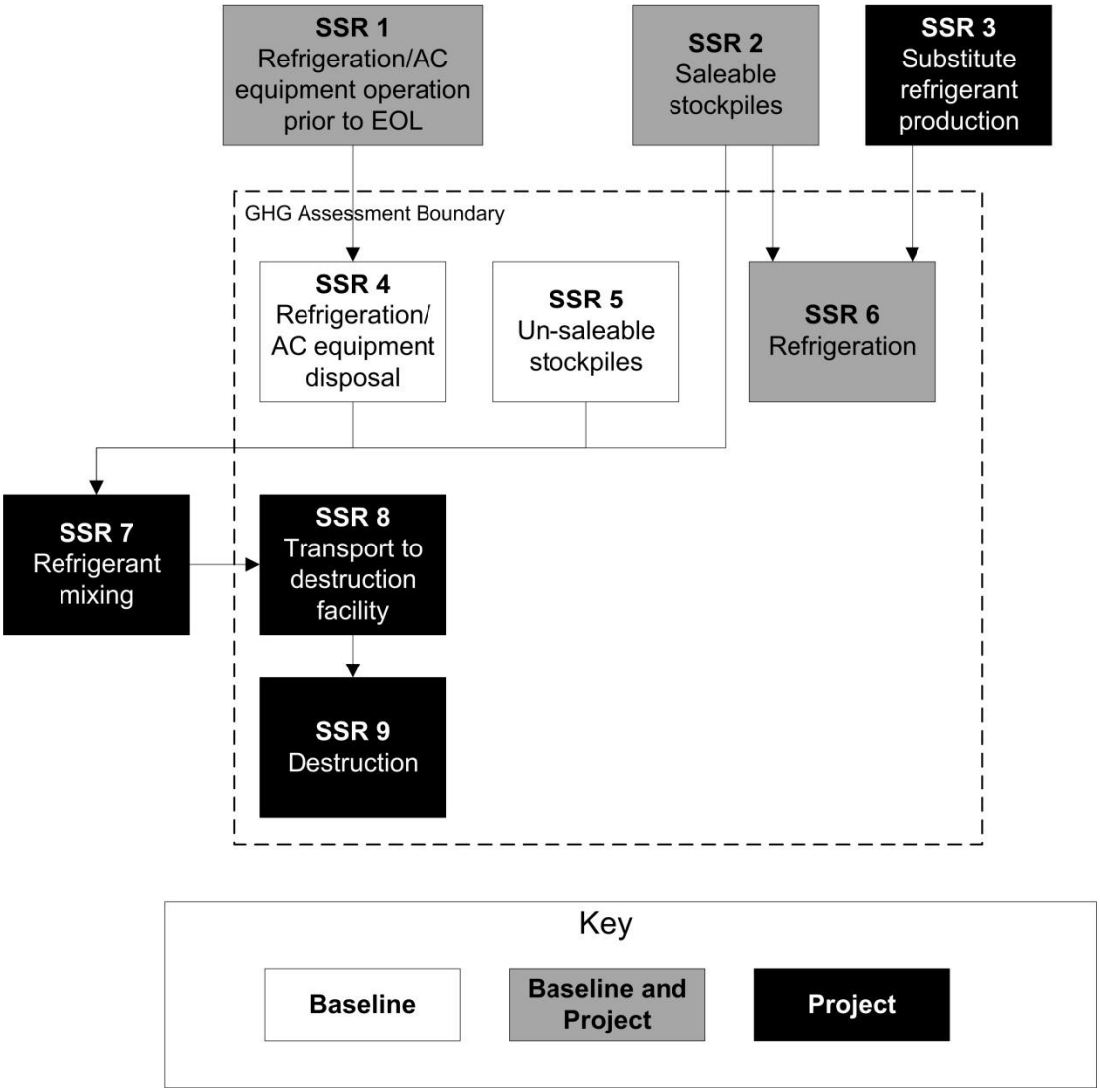

Figure 4.1. Illustration of the GHG Assessment Boundary

[15] 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.

Table 4.1. Illustration of the GHG Assessment Boundary

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
1	Refrigeration and A/C equipment operation prior to end-of-life (EOL)	ODS emissions from leaks and servicing of ODS origin equipment prior to end-of-life	ODS	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
2	Saleable stockpiles	ODS emissions occurring from long-term storage of ODS which can legally be sold to market	ODS	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
3	Substitute refrigerant production	Emissions of substitute refrigerant occurring during production	CO_2e	E	N/A	Excluded, as this emission source is assumed to be very small
		Fossil fuel emissions from the production of substitute refrigerants	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
4	Refrigeration/ AC equipment disposal	Emissions of ODS from the release of refrigerant at end-of-life	ODS	I	**Baseline**: Estimated as 100% immediate release **Project**: N/A	Baseline emissions will be significant
		Fossil fuel emissions from the recovery and aggregation of refrigerant at end-of-life	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

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
5	Un-saleable stockpiles	ODS emissions occurring from long-term storage of ODS which cannot legally be sold to market	ODS	I	**Baseline**: Estimated based on site-specific emission rates **Project**: N/A	Baseline emissions will be significant
6	Refrigeration	Emissions of ODS from leaks and servicing through continued operation of equipment	ODS	I	**Baseline**: Estimated according to appropriate baseline scenario **Project**: N/A	Baseline equipment emissions will be significant
		Emissions of substitute from leaks and servicing through continued operation of equipment	CO_2e	I	**Baseline:** N/A **Project:** Estimated based on default emission rate	Project equipment emissions will be significant
		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
7	Refrigerant mixing	Fossil fuel emissions from ODS mixing activities at mixing facility	CO_2	E	N/A	Excluded, as these emission sources are assumed to be very small
			CH_4			
			N_2O			

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
8	Transport to destruction facility	Fossil fuel emissions from the vehicular and ocean transport of ODS from aggregation point to final destruction facility in the U.S.	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
9	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

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 summing the calculated baseline emissions for all relevant SSRs (as indicated in Table 4.1) using Equation 5.3. This includes emissions from stockpiled refrigerants and end-of-life refrigerants that would have occurred over the ten-year crediting period. Note that emissions shall be quantified in pounds throughout this section and converted into metric tons in Equation 5.3 below.

The Reserve has defined four different baselines for refrigerants in Article 5 countries. Table 5.1 identifies the refrigerant categories, and the associated applicable baseline scenario. The standardized baseline scenarios in Table 5.1 have been selected to provide a conservative estimation of baseline emissions from ODS refrigerants in Article 5 countries.

Table 5.1. Refrigerant Baseline Scenarios

Refrigerant Origin	Baseline Scenario	Applicable Annual Emission Rate	10-year Cumulative Emissions (%)[16] (ER_{refr})
1. Privately held stockpiles of used ODS refrigerant that can legally be sold to the market	Use for recharge of existing refrigeration equipment	25%[17]	94%
2. Article 5 government stockpiles of ODS refrigerant that can legally be sold into the refrigerant market	Use for recharge of existing refrigeration equipment	25%[17]	94%
3. Article 5 government stockpiles of ODS refrigerants that cannot legally be sold into the refrigerant market	Continued storage	Site specific emission rate as documented (see Equation 5.2)	$1-(1-ER_{stock})^{10}$
4. Used ODS refrigerant recovered from end-of-life equipment	End-of-life release to the atmosphere	100%	100%

The site specific emission rate for government stockpiles that cannot legally be sold into the refrigerant market shall be calculated according to Equation 5.2.

Equation 5.2. Calculating Site-Specific Emission Rate

$$ER_{stock,i} = \left(1 - \frac{Q_{end}}{Q_{start}}\right)^{\frac{1}{y}}$$

Where,			Units
$ER_{stock,i}$	=	Average annual emission rate of refrigerant ODS *i*	%
Q_{end}	=	Total quantity of ODS refrigerant *i* in government stockpile at time of destruction	lb ODS
Q_{start}	=	Total quantity of ODS refrigerant *i* in government stockpile at time of seizure	lb ODS
y	=	Time from seizure to destruction of ODS stockpile	years

Equation 5.3 shall be used to calculate the baseline emissions that would have occurred over a ten-year horizon in the absence of the project activity, per the project crediting period limit (see Section 3.3). This equation requires the use of the applicable emission rate provided in Table 5.1 or calculated using Equation 5.2, and the ODS-specific GWP provided in Table 5.2.

[16] 10-year cumulative emissions = 1-(1-emission rate)^{10}, or the percent of a given substance which will be released over ten years at a constant emission rate.
[17] United Nations Environment Programme, Technology and Economic Assessment Panel. (2005). Report of the Task Force on Foam End-of-Life Issues.

Equation 5.3. Baseline Emissions

$$BE = \left[\frac{\sum_i \left(Q_{refr,i} \times ER_{refr,i} \times GWP_{refr,i} \right)}{2204.623} \right] \times (1 - VR)$$

Where,			Units
BE	=	Total quantity of refrigerant baseline emissions	tCO_2e
$Q_{refr,,i}$	=	Total quantity of eligible, pure refrigerant ODS *i* destroyed by the project	lb ODS
$ER_{refr,i}$	=	10-year cumulative emission rate of refrigerant ODS *i* (see Table 5.1)	%
$GWP_{refr,i}$	=	Global warming potential of refrigerant ODS *i* (see Table 5.2)	lb CO_2e/ lb ODS
2204.623	=	Conversion from pounds to metric tons	lb/t
VR	=	Deduction for vapor composition risk (see Section 5.3)	%

Table 5.2. Global Warming Potential of Eligible ODS Refrigerants

ODS Species	Global Warming Potential[18] (CO_2e)
CFC-11	4,750
CFC-12	10,900
CFC-113	6,130
CFC-114	10,000
CFC-115	7,370

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 $Q_{refr,i}$ prior to the calculation of Equation 5.3 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 $Q_{refr,i}$ 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

[18] 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.

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.

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

5.2 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 5.4, project emissions equal:

- Emissions from substitute refrigerants, 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 5.4 below.

Equation 5.4. Total Project Emissions

$$PE_t = \frac{Sub_{ref} + Tr + Dest}{2204.623}$$

Where,			Units
PE_t	=	Total quantity of project emissions during the reporting period	tCO_2e
Sub_{ref}	=	Total emissions from substitute refrigerant	lb CO_2e
Tr	=	Total emissions from transportation of ODS (calculated using either the default value in Equation 5.6, or Equation 5.12)	lb CO_2e
Dest	=	Total emissions from the destruction process associated with destruction of ODS (calculated using either the default value in Equation 5.6, or Equation 5.7 through Equation 5.11)	lb CO_2e
2204.623	=	Conversion from pounds to metric tons	lb/t

5.2.1 Calculating Project Emissions from the Use of CFC 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 from stockpiles that can legally be sold to market must therefore estimate the emissions associated with the non-CFC substitute chemicals that are assumed to be used in their place. Projects that destroy used refrigerant recovered from end-of-life equipment do not need to account for substitutes, as the destruction of this ODS does not increase the demand for substitute refrigerants. Similarly, projects that destroy government stockpiles that cannot legally be sold to the refrigerant market do not need to account for substitutes, as the destruction is not expected to increase use of substitute refrigerants. The point of origin of the ODS must be documented to support the selected baseline per Section 6.2. If the verifier can confirm that the point of origin is either end of life equipment tracked to location of ODS recovery or government stockpiles that cannot be legally sold, then $Sub_{refr} = 0$.

Equation 5.5 accounts for the emissions associated with the substitute refrigerants that will be used in place of destroyed ODS refrigerants. Like the destroyed ODS calculations in the baseline, substitute emissions shall also be estimated based on the projected emissions over the ten-year crediting period.

Destroyed ODS refrigerants are assumed to be replaced by HFC-134a. A review of the literature indicates that HFC-134a and HC-600a are the dominant new refrigerants being used in place of ODS in Article 5 countries.[19] However, no reliable, quantitative data could be identified on the relative market share of these refrigerants. As HFC-134a has a higher GWP, this assumption is therefore conservative.

Project emissions from the use of non-CFC substitute refrigerants shall be calculated, as applicable, according to Equation 5.5.

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

Equation 5.5. Calculating Project Emissions from the Use of Non-ODS Refrigerants

$$Sub_{refr} = \sum_i \left(Q_{refr,i} \times 0.77 \times 1430 \right)$$

Where,			Units
$Sub_{,refr}$	=	Total quantity of project refrigerant substitute emissions	lb CO_2e
$Q_{refr,i}$	=	Total quantity of eligible, pure refrigerant ODS *i* destroyed	lb
0.77	=	Leak rate of HFC-134a (13.7% per year)[20]	% (0-1)
1430	=	Global warming potential of HFC-134a	lb CO_2e/ lb sub

5.2.2 Calculating Default Project Emissions from ODS Destruction and Transportation

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 a default emission factor for ODS projects based on conservative assumptions and the SSRs outlined in Table 4.1.[21] The emission factor shall be equal to 7.5 pounds CO_2e per pound of ODS refrigerant destroyed. This emission factor aggregates both transportation and destruction emissions.

Project developers have the option of using the default emission factor, or using the in Sections 5.2.3 and 5.2.4 to calculate project-specific emissions. Equation 5.6 shall be used to calculate ODS transportation and destruction emissions if default emission factors are used.

Equation 5.6. Project Emissions from Transportation and Destruction Using the Default Emission Factors

$$Tr + Dest = Q_i \times 7.5$$

Where,			Units
Tr + Dest	=	Total emissions from ODS transportation and destruction, as calculated using default emission factors	lb CO_2e
Q_i	=	Total quantity of refrigerant *i* ODS sent for destruction, including eligible and ineligible material	lb ODS
7.5	=	Default emission factor for transportation and destruction of ODS	lb CO_2e/ lb ODS

5.2.3 Calculating Site-Specific Project Emissions from ODS Destruction

Under this protocol, ODS must be destroyed at destruction facilities which demonstrate compliance with the TEAP recommendations.[22] These facilities demonstrate their ability to achieve destruction efficiencies upwards of 99.99 percent for substances with thermal stability ratings higher than the ODS included herein.[23] Associated with the operation of these facilities are emissions of CO_2 from the fuel and electricity used to power the destruction, emissions of un-combusted ODS, and emissions of CO_2 from the oxidation of ODS. Equation 5.7 through

[20] United Nations Environment Programme, Technology and Economic Assessment Panel. (2006). Report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee.
[21] See Appendix D for a summary of how the default emission factor was derived.
[22] TEAP, http://uneptie.org/ozonaction/topics/disposal.htm.
[23] ICF International. (2009). ODS Destruction in the United States of America and Abroad. *U.S. EPA Stratospheric Protection Division*.

Equation 5.9 provide guidance on calculating emissions from ODS destruction in cases where project developers opt not to use the default factors outlined in Section 5.2.3.

Equation 5.7. 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 5.8)	lb CO_2
EL_{dest}	=	Total indirect emissions from grid electricity used at the destruction facility (Equation 5.9)	lb CO_2
$ODS_{emissions}$	=	Total emissions of un-destroyed ODS (Equation 5.10)	lb CO_2e
ODS_{CO2}	=	Total emissions of CO_2 from ODS oxidation (Equation 5.11)	lb CO_2

Equation 5.8. 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 D)	kg CO_2/ volume fossil fuel
0.454	=	Conversion from kg to lb of CO_2	kg CO_2/ lb CO_2

Equation 5.9. Electricity Emissions from the Destruction of ODS

$$EL_{dest} = EL_{PR} \times EF_{EL}$$

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}	=	Carbon emission factor for electricity used[24]	lb CO_2/ MWh

[24] 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 5.10. Calculating Project Emissions from ODS Not Destroyed

$$ODS_{emissions} = \sum_i Q_{refr,i} \times 0.0001 \times GWP_i$$

Where,			Units
$ODS_{emissions}$	=	Total emissions of un-destroyed ODS	lb CO_2e
$Q_{refr,i}$	=	Total quantity of refrigerant ODS *i* sent for destruction	lb ODS
0.0001	=	Maximum allowable portion of ODS fed to destruction that is not destroyed (0.01%)	
GWP_i	=	Global warming potential of ODS *i* (see Table 5.2)	lb CO_2e/ lb ODS

Equation 5.11. Calculating Project Emissions of CO_2 from the Oxidation of ODS

$$ODS_{CO2} = \sum_i Q_{refr,i} \times 0.9999 \times CR_i \times \frac{44}{12}$$

Where,			Units
ODS_{CO2}	=	Total emissions of CO_2 from ODS oxidation	lb CO_2
$Q_{refr,i}$	=	Total quantity of refrigerant ODS *i* sent for destruction	lb ODS
0.9999	=	Minimum destruction efficiency of destruction facility (99.99%)	
CR_i	=	Carbon ratio of ODS *i* CFC-11: 12/137 CFC-12: 12/121 CFC-113: 24/187 CFC-114: 24/171 CFC-115: 24/154	MW C/ MW ODS
44/12	=	Ratio of molecular weight of CO_2 to C	MW CO_2/ MW C

5.2.4 Calculating Site-Specific Project Emissions from ODS Transportation

As part of any ODS destruction project, ODS must be transported from the Article 5 origin country to the U.S. Further, upon arrival in the U.S., ODS must be transported from aggregators to destruction facilities. Emissions from both of these activities must be accounted for under this protocol using either Equation 5.6 or Equation 5.12. Equation 5.12 provides guidance on calculating site-specific CO_2 emissions associated with the transport of ODS. Emissions shall be calculated for each leg of the transportation process separately, and then summed according to Equation 5.12 below.

Equation 5.12. Calculating Project Emissions from the Transportation of ODS[25]

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

Where,			Units
Tr	=	Total emissions from transportation of ODS	lb CO_2e
PMT_i	=	Pound-miles traveled[26] for ODS *i* destroyed (to be calculated including the eligible ODS, any accompanying material, and containers from point of aggregation to destruction)	pound-miles
EF_{TMT}	=	CO_2 emissions per pound-mile traveled On-road truck transport = 0.000297 Rail transport = 0.0000252 Waterborne craft = 0.000048 Aircraft = 0.0015279	lb CO_2/ pound-mile

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 5.4 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 5.3 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 at the time of sampling (internal temperature if available, otherwise ambient temperature), 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 shall be determined using Equation 5.13.

Table 5.3. 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

[25]Derived from: U.S. Environmental Protection Agency, Climate Leaders. (2008). Greenhouse Gas Inventory Protocol Core Module Guidance: Optional emissions from business travel, commuting, and product transport.
[26] A pound-mile is defined as the product of the distance travelled in miles and the mass transported in pounds. Therefore, 500 lbs transported four miles is equal to 2,000 pound-miles.

Table 5.4. 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 5.4:

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 5.13. Determining Liquid Fill Level in Project Container

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

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 Operations

The Reserve requires a Monitoring and Operations Plan to be established for all monitoring, operations, 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, operations, 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 and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.2 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 7.2 for minimum record keeping requirements); and the role of individuals performing each specific monitoring and operational activity. The Monitoring and Operations Plan shall 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 F 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. In addition, the Monitoring and Operations Plan must stipulate data management systems and coordination of data between ODS aggregators, project developers, and destruction facilities.

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 (see 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 relating to confirming that reductions have not been claimed by other parties for the destruction activity in question.[27]

All projects are required to have one or more Certificate(s) of Destruction accounting for all eligible ODS destroyed as part of the 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

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

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

6.2 Point of Origin and Import Documentation Requirements

Project developers are responsible for collecting data on the point of origin for each quantity of ODS, as defined in Table 6.1. The project developer must maintain detailed acquisition records of all quantities of ODS destroyed by the project.

Table 6.1. Identification of Point of Origin

ODS	Point of Origin	10-year Cumulative Emissions (%)[1]
1. Virgin ODS stockpiles	Location of stockpile	94% or site-specific emission rate (see Section 5.1)
2. Used ODS stockpiled prior to February 3, 2010	Location of stockpile	94% or site specific emission rate (see Section 5.1)
3. Used ODS in quantities less than 500 lbs	Location where ODS is first aggregated to greater than 500 lbs	94%
4. Used ODS in quantities greater than 500 lbs	Site of installation from which ODS is removed	94%
5. Used ODS of any quantity recovered from end-of-life equipment	Location where ODS is recovered from end-of-life equipment	100%

[1] This information is provided to illustrate the connection between point of origin and the cumulative emission rate used to calculate baseline emissions. See Table 5.1 for more details on these emission rates and related baseline scenarios.

Project developers must be able to document the point of origin for all ODS that will be included in the project as defined in the table above. For destroyed ODS where the point of origin is a reservoir-style stockpile (i.e. it was not sealed), 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 elements 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 virgin stockpiles, documentation of the point of origin must be generated at the time material is placed at the stockpile location and every time material is added to the stockpile. For used 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 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 ODS recovered from end-of-life equipment, the project developer must provide documentation to confirm that the ODS was recovered at the point of origin and that the equipment was disposed of/decommissioned after the ODS was recovered. It may not be possible to document the exact time the ODS was recovered from all equipment (e.g. at a reclamation facility processing large numbers of appliances), but the verifier must confirm that the inventory and activity logs support the quantity of ODS being destroyed for that reporting period.

All data must be generated at the point of origin. Documentation of the point of origin of ODS shall include the following:

- Facility name and physical address
- 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

In addition to establishing the point of origin, for destroyed virgin ODS project developers must also provide government documentation that the virgin ODS was produced prior to the production phase-out in that country, and that it has not been produced illegally. This may be in the form of an audit conducted by or for the government that identifies the stockpile and entity holding it, or correspondence regarding the stockpile from, or submitted to, a government agency. Verifiers may request independent confirmation of the asserted documentation from government officials or their representatives.

The project developer shall also document the process by which the ODS was obtained and imported. Project developers must maintain a full record of the U.S. EPA and/or U.S. Customs import process[28] for verification purposes. The record must include the following:

- Commercial invoice showing transfer of ownership of the ODS from the owner in the source country to the project developer
- Shipping manifests or ocean bills of lading (where appropriate) showing the country of export
- U.S. Customs import declaration showing the product being imported into the U.S
- Copy of Class 1 ODS import report showing that product has been imported for destruction

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

- For imports of used ODS, copy of EPA non-objection notice that corresponds to the import of used ODS (this non-objection notice is not required for imports of virgin Class 1 substance for destruction)
- Source of ODS: stockpile or end-of-life
- Serial or ID numbers of containers used for storage and transport
- Mode of transport, distance travelled prior to arriving at a U.S. port of entry, and net weight of ODS and containers transported

6.3 Custody and Ownership Documentation Requirements

In conjunction with establishing the point of origin and importation process for each quantity of ODS, project developers must also document the custody and ownership of ODS. These records shall include names, addresses, and contact information of persons buying/selling the 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 to the project developer. The verification body will review these records and will perform other tests necessary to authenticate the previous owners of the material and 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. No GHG credits may be issued under this protocol for ODS where ownership cannot be established.

The transfer of custody may be established using the following documentation, as appropriate:

- Tax ID, or other applicable identifier, of transferor and transferee
- Bill of lading (where appropriate)
- Date of transfer of custody
- Serial or ID numbers of all containers containing ODS (received and delivered)
- Weight of all containers containing ODS (received and delivered)
- Distance and mode of transportation used to move ODS (truck, rail or air)

6.4 ODS Composition and Quantity Analysis Requirements

The requirements of this section must be followed to determine the quantities of ODS refrigerants. 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 for the measurement of each container:

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 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
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 and contaminants 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[29] standard, 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[30]
3. Samples must be taken with a clean, fully evacuated sample bottle that meets applicable U.S. Department of Transportation (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[31]
8. Chain of custody from point of sampling to AHRI laboratory for each sample must be documented by paper bills of lading or electronic, third-party tracking that includes proof of delivery (e.g. FedEx, UPS)

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 taking into account the temperature

[29] AHRI. (2006). Standard 700-2006: Standard for Specifications for Fluorocarbon Refrigerants.
[30] For instances where the project developer is the destruction facility itself, an outside technician must be employed for sample taking.
[31] Projects that destroy ODS prior to the adoption date of this protocol may use proxy data from NOAA recording stations in the area.

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 the ODS from 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 6.4.1.

6.4.1 Analysis of Mixed ODS

If a container holds mixed ODS, its contents must be processed and measured for composition and concentration according to the requirements of this section (in addition to the requirements of Section 6.4). 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 6.4. 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 of each container shall be determined using the results of the analysis of this section. The results of the composition analysis in Section 6.4 shall be used by verifiers to confirm that the destroyed ODS was in fact the same ODS that is sampled under these requirements.

The ODS mixture must be circulated in a container that meets all of the following criteria:

1. The container has no solid interior obstructions[32]
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 the ODS (see 40 CFR 82.156).[33]

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 six 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 6.4. Both samples shall be analyzed at an AHRI-approved laboratory per the requirements of Section 6.4. The mass composition and concentration of the mixed ODS shall be equal to the lesser of the two GWP-weighted concentrations.

If a temporary holding tank is used, after drawing the sample, the holding tank shall be emptied back into the original container for transport to the destruction location.

6.5 Destruction Facility Requirements

Destruction of ODS must occur at a facility that meets all of the guidelines provided in Appendix C and in the TEAP Task Force on Destruction Technologies.[34] 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

[32] Mesh baffles or other interior structures that do not impede the flow of ODS are acceptable.
[33] U.S. EPA. Required Levels of Evacuation. Retrieved December 21, 2009, from http://www.epa.gov/Ozone/title6/608/608evtab.html.
[34] Available at http://www.uneptie.org/ozonaction/topics/disposal.htm.

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 personnel training. Any upsets or exceedances of emission limits must be managed in keeping with an authorized startup, shutdown, and malfunction plan. Non-RCRA facilities must document operation consistent with the TEAP requirements, as defined in this section and Appendix C.

Operating parameters of the destruction unit while destroying ODS material shall be monitored and recorded as described in the Code of Good Housekeeping[35] approved by the Montreal Protocol. This data shall 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[36] was calculated. The DRE is determined by using the Comprehensive Performance Test (CPT)[37] 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

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

Destruction facilities shall provide a valid Certificate of Destruction for all ODS destroyed. The Certificate of Destruction shall include:

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

[35] TEAP. (2006). Code of Good Housekeeping. *Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer - 7th Edition*.
[36] DRE disclosed in Title V operating permit.
[37] CPT must have been conducted with a less combustible chemical than the ODS in question.

- Serial, tracking or ID Number of all containers for which ODS destruction occurred
- Owner of destroyed ODS
- 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

6.6 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 5.3 through 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		For each reporting period		Must be monitored and determined for each reporting period
		Mass of ODS (or ODS mixture) in each container		Per container	M	Must be determined for each container destroyed
		Concentration of ODS (or ODS mixture) in each container		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 5.3	BE_t	Total quantity of baseline emissions during the reporting period	tCO_2e	For each reporting period	C	
Equation 5.1, Equation 5.4	PE_t	Total quantity of project emissions during the reporting period	tCO_2e	For each reporting period	C	
Equation 5.2	$ER_{stock,i}$	Average annual emission rate of refrigerant ODS *i*	%	For each reporting period	C	
Equation 5.2	Q_{end}	Total quantity of ODS refrigerant *i* in government stockpile at time of destruction	lb ODS	For each reporting period	M	
Equation 5.2	Q_{start}	Total quantity of ODS refrigerant *i* in government stockpile at time of seizure	lb ODS	For each reporting period	M	
Equation 5.3, Equation 5.5, Equation 5.10, Equation 5.11	$Q_{refr,i}$	Total quantity of eligible refrigerant ODS *i* destroyed	lb ODS	For each reporting period	M	
Equation 5.3	$ER_{refr,i}$	10-year cumulative emission rate of refrigerant ODS *i*	%	N/A	R	See Table 5.1
Equation 5.3, Equation 5.10	$GWP_{refr,i}$	Global warming potential of refrigerant ODS *i*	lb CO_2e/ lb ODS	N/A	R	See Table 5.2
Equation 5.3	VR	Vapor risk deduction factor	% (0-1)	For each reporting period	R	See Table 5.4
Equation 5.4, Equation 5.5	$Sub_{,ref}$	Total emissions from substitute refrigerant	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 5.4, Equation 5.6, Equation 5.12	Tr	Total emissions from transportation of ODS	lb CO_2e	For each reporting period	C	May be calculated using default or using project specific inputs
Equation 5.4, Equation 5.6, Equation 5.7	Dest	Total emissions from the destruction process associated with destruction of ODS	lb CO_2e	For each reporting period	C	May be calculated using default or using project specific inputs
Equation 5.6	Q_i	Total quantity of refrigerant *i* sent for destruction, including eligible and ineligible material	lb ODS	For each reporting period	M	
Equation 5.7, Equation 5.8	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 5.7, Equation 5.9	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 5.7, Equation 5.10	$ODS_{emissions}$	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 5.7, Equation 5.11	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 5.8	$FF_{PR,k}$	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 5.8	$EF_{FF,k}$	Fuel specific emission factor	kg CO_2/ volume fuel	N/A	R	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.9	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 5.9	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
Equation 5.11	CR_i	Carbon ratio of ODS *i*	MW C/ MW ODS	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 5.12	PMT_i	Pound-miles-traveled for ODS *i* destroyed	tonne-miles	For each reporting period	M	Including weight of all storage containers Use only if calculating site-specific project emissions from ODS destruction
Equation 5.12	EFPMT	Mode-specific emission factor	kg CO_2/ pound-mile	N/A	R	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.13	$Fill_{liquid}$	Liquid fill level in project container	% (0-1)	For each reporting period	C	
Equation 5.13	$V_{container}$	Volumetric capacity of project container	gallons	For each reporting period	O	
Equation 5.13	$M_{destroyed}$	Total mass of material destroyed in the project container	lbs	For each reporting period	M	
Equation 5.13	ρ_{liquid}	Density of the liquid phase material in the project container	lb/gal	For each reporting period	C	
Equation 5.13	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 F (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 F (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 Project 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 details).

Under joint project verification, each project, as defined by the project developer in accordance with the relevant protocol, is submitted, listed and registered separately in the Reserve system. Furthermore, each project requires its own separate verification process and Verification Statement (i.e. each project is assessed by the verification body separately as if it were the only project using 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.

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.

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
- Copies of all import documentation from U.S. Customs
- Executed Attestation of Title forms, Attestation of Regulatory Compliance forms, and Attestation of Voluntary Implementation forms
- Destruction facility monitoring 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 5, 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 a 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 import destruction projects.

Verification bodies trained to verify ODS Article 5 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 Article 5 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 Article 5 Ozone Depleting Substances Project Protocol (this document), the Reserve Program Manual, and Verification Program Manual. To verify an ODS destruction project developer's project report, 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	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	Frequency
Point of Origin of ODS	Article 5 countries	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 ▪ CFC refrigerant ODS have been phased-out of production in the country of origin ▪ Eligible ODS include CFC-11, CFC-12, CFC-113, CFC-114, and CFC-115	Each verification
Performance Standard	Project destroys ODS refrigerant that meets 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 verification body; project must be in material compliance with all applicable laws	Each verification
Exclusions	▪ ODS sourced from the U.S. and its territories ▪ ODS sourced from non-Article 5 countries ▪ ODS destroyed outside of the U.S. and its territories ▪ ODS produced for or used in any application other than refrigeration	Each verification

8.5 Core Verification Activities

The Article 5 Ozone Depleting Substances Project Protocol provides explicit requirements and guidance for quantifying GHG reductions associated with the destruction of ODS sourced from Article 5 countries. 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 reduction 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 recovered, aggregated 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 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 performance 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 facilities 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 required site visits must have occurred no more than 12 months prior to the end date of the reporting period.

Table 8.2. Verification Site Visit Requirements

ODS Source	Site Visit(s) Required
ODS obtained from private stockpiles or government stockpiles that can legally be sold to the refrigerant market	▪ Site of stockpile ▪ Destruction facility ▪ ODS mixing & sampling facility (if applicable) ▪ One additional project facility[a]
ODS refrigerants obtained from government stockpiles that cannot legally be sold into the refrigerant market	▪ Site of stockpile ▪ Destruction facility ▪ ODS mixing & sampling facility (if applicable) ▪ One additional project facility[a]
Used ODS refrigerant recovered from end-of-life equipment	▪ Destruction facility ▪ ODS mixing & sampling facility (if applicable) ▪ 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 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.

8.7 ODS Verification Items

The following tables provide lists of items that a verification body must 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 or where interpretation of project documentation is required. 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 reporting period. If any one requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or sub-set of the reporting period) may be ineligible for issuance of CRTs.

Table 8.3. Eligibility Verification Items

Protocol Section	Project Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that the project meets the definition of an ODS Article 5 project	No
2.2	Verify that the project activities involve a single project developer and a single qualifying destruction facility	No
2.2	Verify that the destroyed ODS is sourced from Article 5 countries	No
2.2	Verify that the destroyed ODS has been phased out in the country of origin	No
2.2	Verify that the ODS was used as or produced for use as solvents, medical aerosols, or other non-refrigeration applications	Yes
2.2	Verify that project activities span no more than 12 months	No
2.5	Verify ownership of the reductions by reviewing Attestation of Title and chain of custody documentation	No
2.5	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
3.2	Verify eligibility of project start date	No
3.2	Verify accuracy of project start date based on records	No
3.4.1	Confirm execution of the Attestation of Regulatory Compliance form to demonstrate eligibility under the Legal Requirement Test	No
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
5.3	Verify that the project Monitoring and Operations Plan contains	Yes

Protocol Section	Project Eligibility Qualification Item	Apply Professional Judgment?
	procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times	
5.3	Verify that monitoring meets the requirements of the protocol; if it does 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
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 within the three years prior to the end date of destruction activities	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 discreet 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 items in Table 8.4 cannot be verified, 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?
5.3	Verify that the destruction facility monitored the parameters identified in Section 6	No
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, 6.4	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	Verify that the scales used for measuring mass of ODS destroyed are properly maintained and tested for calibration quarterly	No
6.4	Verify that the weight of full and empty ODS containers was measured two days prior to destruction commencing and two days following completion, respectively	No
6.4	Verify that all ODS samples were taken by a third-party technician while in the possession of the destruction company	No
6.4	Verify the chain of custody by which ODS sample was transferred from the destruction facility to the lab	No

Protocol Section	Operational Requirement and ODS Eligibility Items	Apply Professional Judgment?
6.4	Verify that all ODS was analyzed for composition and concentration at a lab approved under the AHRI 700-2006 standard, or its successor	No
6.4	Verify that the calculation of ODS composition and mass concentration correctly accounted for moisture, mixing, and high boiling residue	No
6.4.1	For mixed refrigerants, verify that credits are only claimed for refrigerants eligible under this protocol	No
6.4.1	For mixed refrigerants, verify that credits are only claimed for refrigerants eligible under this protocol	No
6.4.1	For mixed refrigerants, verify that proper re-circulation occurred	No
6.4.1	For mixed refrigerants, verify that recirculation and sampling were performed by properly trained technicians	Yes
6.5	Verify that the Certificate of Destruction contains all required information	No
Appendix C	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* and of this protocol	No
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
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

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?
2.2	Verify that all destroyed ODS for which CRTs are claimed appear on a valid Certificate of Destruction	No
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
5.1	Verify that the project was correctly characterized as end-of-life, saleable stockpile, or un-saleable stockpile	Yes
5.1	Verify that the appropriate baseline scenario was applied for each quantity of ODS destroyed	Yes
5.2.1	Verify that the substitute emissions have been properly characterized, calculated, and aggregated correctly	No
5.2.2, 5.2.3	Verify that the project developer correctly quantified and aggregated electricity use, or that the default factor was applied	Yes
5.2.2, 5.2.3	Verify that the project developer correctly quantified and aggregated	Yes

Protocol Section	Quantification Item	Apply Professional Judgment?
	fossil fuel use, or that the default factor was applied	
5.2.2, 5.2.3	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity, or that the default factor was applied	Yes
5.2.2, 5.2.3	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
5.2.2, 5.2.4	Verify that the project developer correctly quantified and aggregated transportation emissions, 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?
5.3	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
5.3	Verify that appropriate monitoring equipment is in place at destruction facility to meet the requirements of the protocol	Yes
5.3	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform these functions	Yes
5.3	Verify that appropriate training was provided to personnel assigned to operations, record-keeping, sample-taking, and other project activities	Yes
5.3	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. Verify 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 require 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. 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.[38]
Emissions rate	The annual rate at which ODS 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). [39]
Recharge	Replenishment of refrigerant agent (using reclaimed or virgin

[38] United Nations Environment Programme. (November 11, 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*.
[39] IPCC. Available at http://www.mnp.nl/ipcc/pages_media/SROC-final/SROC_A2.pdf.

	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 chemicals used to replace the ODS destroyed by a project.
Transportation system	A term used to encompass the entirety of the system that moves the ODS from the country of origin to the destruction facility.

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Appendix A Summary of Legal Requirement Test Development

Management activities for ozone depleting substances are dictated in Article 5 countries by both the Montreal Protocol and domestic law. This appendix provides background information on the Montreal Protocol. Further, this section demonstrates that this framework does not require the destruction of ODS. Provided that there are no domestic rules requiring destruction of ODS in the source country, destruction of imported ODS from Article 5 countries meets the Legal Requirement Test under the Climate Action Reserve Article 5 Ozone Depleting Substances Project Protocol.

A.1 Montreal Protocol

The original Montreal Protocol, signed in 1987, was the first step in international efforts 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 (defined as production plus imports minus exports), but 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 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 a 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 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 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), and is restricted to the servicing of existing refrigeration and air-conditioning equipment, subject to review in 2015.

The result of 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. Therefore, this protocol is limited to CFC used in refrigerant applications in Article 5 countries.

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 one of the criterion of "additionality."[40]

Appendix A described the regulatory framework surrounding the end-of-life treatment of refrigerant ODS and established that there is no international requirement to destroy ODS. However, the Reserve looks not only at what the regulatory requirements are, but also at the prevailing practice. Therefore, with the project defined as the destruction of ODS, the Reserve sought to establish whether destruction of ODS sourced in Article 5 countries is standard practice or whether it exceeds standard practice.

146 countries operate as parties under Article 5 of the Montreal Protocol.[41] For this analysis, the Reserve assessed common practice for all ODS as well as the CFC phased out of production in these Article 5 countries by the Montreal Protocol and domestic law. Based on data collected by the United Nations Environment Programme (UNEP), the Reserve determined that destruction of CFC is not standard practice in any Article 5 country.

B.1 Methodology

The primary data source for this analysis was the records maintained by the UNEP Ozone Secretariat.[42] In a 2009 report, UNEP reported on ODS destruction from Article 5 countries between 1990 and 2008. This dataset indicated that, during this timeframe, only the following countries have reported destruction of ODS:

Table B.1. Reported Destruction of ODS in Article 5 Countries[43]

Country	Destruction 1990-2008 (tonnes)
Brazil	23.6
China	867.3
India	21
Mexico	0.7
Republic of Korea	3,078.7
South Africa	1
The former Yugoslav Republic of Macedonia	0.4

[40] See the Climate Action Reserve's Program Manual for further discussion of the Reserve's general approach to determining additionality.
[41] United Nations Environment Programme, Ozone Secretariat. List of Parties categorized as operating under Article 5 paragraph 1 of the Montreal Protocol. Retrieved on September 24, 2009, from http://ozone.unep.org/Ratification_status/list_of_article_5_parties.shtml.
[42] United Nations Environment Programme, Ozone Secretariat. Data Access Center. Retrieved on September 22, 2009, from http://ozone.unep.org/Data_Reporting/Data_Access/.
[43] UNEP. (2009) Addendum to Information provided by Parties in accordance with Article 7 of the Montreal Protocol on Substances that Deplete the Ozone Layer. Available at http://ozone.unep.org/Meeting_Documents/mop/21mop/MOP-21-5-Add-1E.pdf.

For these same countries, the Reserve also queried the Ozone Secretariat's Data Access Center to obtain data on the reported consumption of ODS in these seven countries over the same period to determine the commonality of ODS destruction. Because the data in Table B.1 do not differentiate ODS by type, and the Reserve prefers to use publicly available data whenever possible, the Reserve conducted two analyses to arrive at a lower and upper bound of the relative quantity of ODS being destroyed. The lower bound is defined under the assumption that the ODS destroyed included all classes of ODS for which consumption occurred, including all Annexes and all Groups. The upper bound is defined under the assumption that only Annex A, Group I CFC were destroyed. As shown in Table B.2, the Reserve did receive confirmation that very little of the destroyed ODS was CFC. Nonetheless, the results of this sensitivity analysis are provided in Table B.2 below.

Table B.2. Destruction of ODS in Article 5 Countries (1990 to 2008)

Country	Destruction 1990-2008 (tonnes)	Consumption of All ODS 1990-2008 (tonnes)	Consumption Annex A, Class I 1990-2008 (tonnes)	Lower Bound (destruction/ all ODS cons.)	Upper Bound (destruction/ CFC cons.)
Brazil	23.6	209,849	124,959	0.01%	0.02%
China	867.3	1,392,647	734,064	0.06%	0.12%
India	21	206,793	71,268	0.01%	0.03%
Mexico	0.7	139,590	82,860	0.00%	0.00%
Republic of Korea	3,078.7	232,376	117,692	1.32%	2.62%
South Africa	1	58,528	24,481	0.00%	0.00%
The former Yugoslav Republic of Macedonia	0.4	2,549	2,227	0.02%	0.02%

The analysis above indicates that even using conservative assumptions, since 1990 destruction of ODS has not been common practice even in the few Article 5 countries in which destruction did occur.

The Reserve further assessed the destruction and consumption that took place in these countries more recently (2005 to 2008) to determine if there have been shifts in ODS treatment in these countries. Table B.3 below indicates that destruction of ODS remained uncommon in all Article 5 countries except for the Republic of Korea during 2005 to 2008.

Table B.3. Destruction of ODS in Article 5 Countries (2005 to 2008)

Country	Destruction 2005-2008 (tonnes)	Consumption of All ODS 2005-2008 (tonnes)	Consumption Annex A, Class I 2005-2008 (tonnes)	Lower Bound (destruction/ all ODS cons.)	Upper Bound (destruction/ CFC cons.)
Brazil	23.6	10,662	3,924	0.22%	0.60%
China	867.3	49,536	139,278	1.75%	0.62%
India	0	25,632	8,974	0.00%	0.00%
Mexico	0.7	14,964	3,760	0.00%	0.02%
Republic of Korea	3,078.7	27,875	13,092	11.04%	23.51%
South Africa	0	2,991	92	0.00%	0.00%
The former Yugoslav Republic of Macedonia	0.4	40	28	1.01%	1.45%

To corroborate the results above, the Reserve contacted representatives at the Ozone Secretariat and representatives of the Republic of Korea. The Republic of Korea representative confirmed that of the ODS destroyed between 2005 and 2008, none of it was CFC. All of the destroyed material was carbon tetrachloride that was produced as a byproduct.[44]

Additionally, the Ozone Secretariat provided the Reserve with a summary of all reported CFC destruction in Article 5 countries from 1990 to 2008. The data represented in Table B.4 corroborates the Reserve's finding that destruction of CFC is not common practice in the Republic of Korea, nor in any other Article 5 country.

Table B.4. Destruction of CFC in Article 5 countries 1990 to 2008[45]

Country	Substance	2003	2005	2008
South Africa	CFC-12	0.98		
Brazil	CFC-12		0.135	
Mexico	CFC-12			0.732

B.2 Conclusion

Based on the analysis described above, the Reserve concludes that destruction of ODS is not common practice in any Article 5 country except for the Republic of Korea. Further, the Reserve concludes that destruction of sources of CFC – the sub-set of ODS relevant to this protocol – is not common practice in any Article 5 country. Therefore, all phased-out CFC refrigerants imported from Article 5 countries and destroyed in the U.S. meets the performance standard.

[44] Lim, Sung Yong. (2010). Personal correspondence.
[45] Ozone Secretariat. (2010). CFC Destruction in A5 Parties, personal communication.

Appendix C EPA 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*[46] and Code of Good Housekeeping, as well as the requirements of domestic U.S. law. This appendix provides a brief summary of the rules dictated by domestic law 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 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 destruction technologies approved by the Montreal Protocol Parties which are:

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 (TEAP) destruction recommendations which include 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. This protocol requires DRE of 99.99 percent for any destruction facility used under this protocol.

Any destruction facility that is regulated by EPA as a RCRA-permitted HWC is 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*

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

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 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. No ODS destruction credits shall be issued for destruction that occurs at a facility that has not passed the criteria below within three years of commencement of destruction activities.

(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[47]

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

[47] 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% O_2.

HBr/Br_2	mg/Nm^3	5	5
Particulates (TSP)	mg/Nm^3	50	50
CO	mg/Nm^3	100	100

2.1.1 Destruction and Removal Efficiency

Destruction Efficiency (DE) [48] 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) .[49] 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.[50] For this reason, it is important to take into account all types of ODS in the stack gas in defining the DRE.

[48] 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.

[49] 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.

[50] 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. *Journal of the Chemical Society, Chemical Communications, No.3*, 347-348; Murphy, A.B., Farmer, A.J.D., Horrigan, E.C., & McAllister, T. (2002). Plasma destruction of ozone depleting substances. *Plasma Chemistry and Plasma Processing, 22*, 371-385.

For the reasons described in the previous paragraph, the Task Force recommends that future calculations of DRE use the approach described below.[51]

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, $\mathrm{DRE} = \dfrac{N_1^{\mathrm{in}} - \sum_i N_i^{\mathrm{out}}}{N_1^{\mathrm{in}}}$

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),[52] 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.

[51] Since different ODS have different ozone depletion potentials (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 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.*

[52] 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.]

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 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 D Default Emissions Factors for Calculating ODS Transportation and Destruction Emissions

D.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 refrigerant applications	▪ 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.

D.2 Methodology and Analysis

The Reserve created a model that incorporated all of the relevant equations from Section 5 to conservatively calculate emissions resulting from the four project sources mentioned above. The equations that have been rolled up into this emission factor are Equation 5.7 through Equation 5.12.

In many cases, the equations used for estimating emissions required additional input and emission 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
$EF_{FF,k}$ =	54.01 kg CO_2/MMBtu[53]
EL_{PR} =	0.0018 MWh/lb ODS destroyed
EF_{EL} =	0.889 tCO_2/MWh[54]
TMTi =	2,000 miles by truck, 3,000 miles by ocean freighter
EF_{TMT} =	0.297 $kgCO_2$/TMT[55]
CR^I =	Actual per ODS

Under these assumptions, and use of Equation 5.7 through Equation 5.12, the calculations provided the following results for the different project categories:

Table D.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 Transporta-tion of ODS	Total
CFC-11 refrigerant	0.11	3.53	0.47	0.32	0.59	5.02
CFC-12 refrigerant	0.11	3.53	1.07	0.36	0.59	5.66
CFC-114 refrigerant	0.11	3.53	1.00	0.47	0.59	5.70
CFC-115 refrigerant	0.11	3.53	0.74	0.47	0.59	5.43

Because the ODS covered in this protocol have such high GWPs (750 to 10,900) even emissions of five to six tonnes CO_2e per tonne ODS destroyed are relatively small. These emissions amount to less than 0.15 percent baseline emissions.

D.3 Conclusion

To account for the emission sources above, project developers may apply a 7.5 tonne CO_2e/tonne ODS emission factor for all ODS Article 5 projects. This default emission factor represents a very conservative estimate of these emission sources derived using worst-case emission factors and empirical data.

[53] U.S. EPA, Climate Leaders. (2007). Stationary Combustion Guidance. Note that the highest emission factor was selected to be conservative.
[54] U.S. EPA. (December 2008). eGRID2007, Version 1.1 Year 2005 GHG Annual Output Emission Rates. Note that the highest emission factor in the nation was selected to be conservative.
[55] U.S. EPA, Climate Leaders. (2008). Optional emissions from business travel, commuting, and product transport. Note that the highest emitting mode of transportation was selected to be conservative.

Appendix E Emission Factor Tables

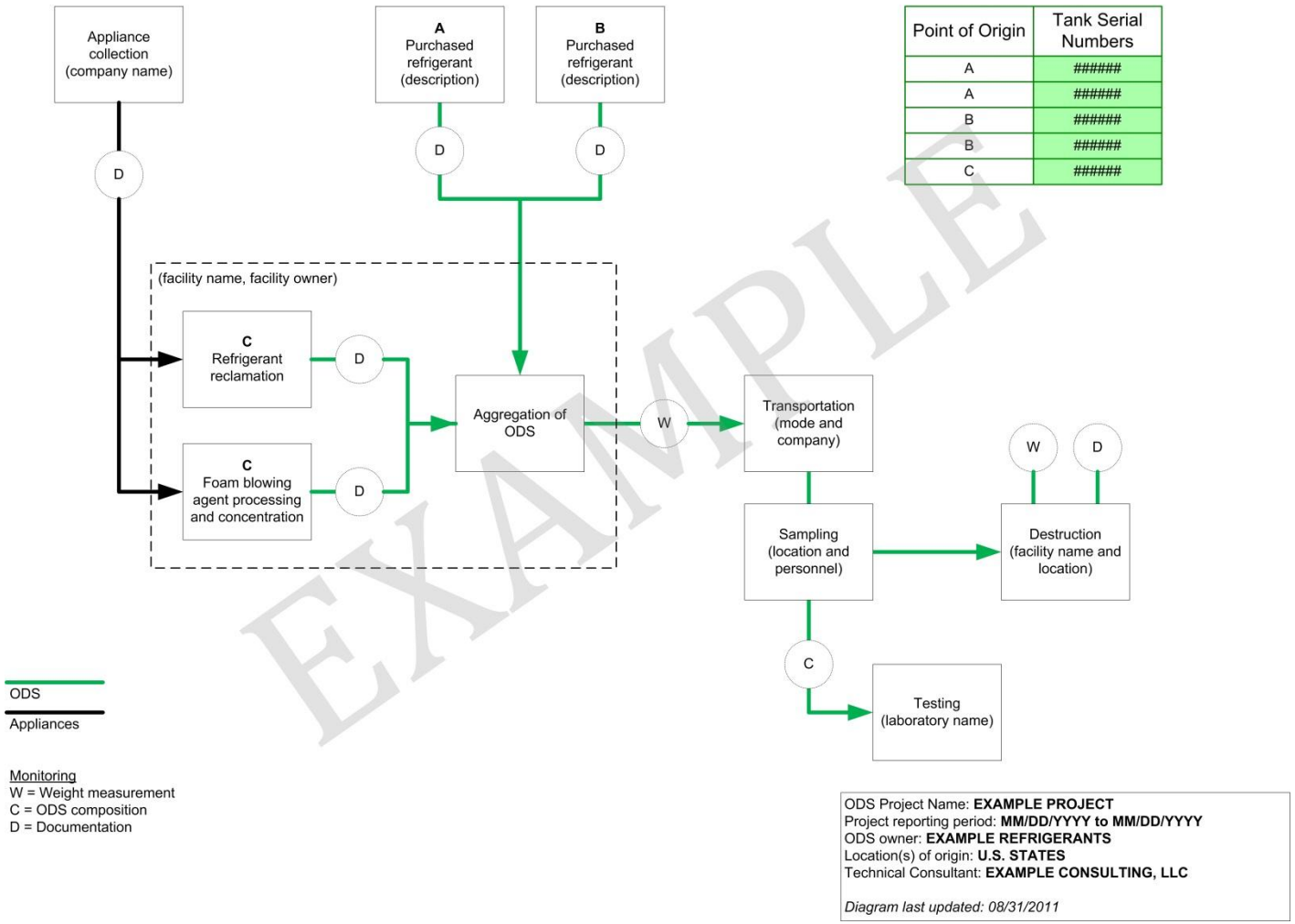
Table E.1. CO_2 Emission Factors for Fossil Fuel Use

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: U.S. 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 F ODS Project Diagram Sample

Generalized ODS Project System Diagram



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

EXAMPLE