Article 5 Ozone Depleting Substances Project Protocol

Destruction of Article 5
Ozone Depleting Substances Banks

Version 1.0

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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 & 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.

The Climate Action Reserve (Reserve) is a voluntary offsets program working to ensure integrity, transparency, and financial value in the North American carbon market. It does this by establishing regulatory-quality standards for the development, quantification, and verification of GHG emission reduction projects in North America; issuing carbon offset credits known as Climate Reserve Tonnes (CRT) generated from such projects; and tracking the transaction of credits over time in a transparent, publicly-accessible system. Adherence to the Reserve's high standards ensures that emission reductions associated with projects are real, permanent and additional, thereby instilling confidence in the environmental benefit, credibility, and efficiency of the North American carbon market.

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 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 depleters, 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. (accessed 9/24/09). *List of Parties categorized as operating under Article 5 paragraph 1 of the Montreal Protocol*: see http://ozone.unep.org/Ratification_status/list_of_article_5_parties.shtml for a list of countries operating under Article 5.
[4] See http://ozone.unep.org/Ratification_status/ for a list of all countries that have ratified the Montreal Protocol.

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

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

- The project developer and owner of emission reductions are the same for all ODS destroyed
- The qualifying destruction facility is the same for all Certificates of Destruction
- The destruction activities span a timeframe of no more than 12 months from commencement of the first ODS destroyed to completion of the last
- 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% or higher. This definition incorporates both destruction and transformation technologies as defined by the EPA and the Clean Air Act (40 CFR 82).

Technology & 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% 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 three eligible sources of ODS refrigerant. These sources are:

1. Stockpiled virgin or used ODS refrigerant, including government stockpiles of seized ODS, that can legally be sold to the market
2. Government stockpiles of seized ODS that cannot be legally sold to the market
3. ODS refrigerant recovered from industrial, commercial, or residential equipment at servicing or end-of-life

The eligibility of privately held virgin ODS is subject to import restrictions as indicated in Section 3.2.

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 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]

[6] TEAP, Volume 3B: Report of the task force on destruction technologies (2002).
[7] Attestation of Title form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

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	→	*Within 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*

* See Section 3.2 for additional information on project start date

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 date on which destruction activities are commenced, as documented on a Certificate of Destruction.

To be eligible, the project must be submitted to the Reserve no more than six months after the project start date, unless the project is submitted during the first 12 months following the date of adoption of this protocol by the Reserve Board (the Effective Date).[8] For a period of 12 months from the Effective Date of this protocol (Version 1.0), projects with start dates no more than 24 months prior to Effective Date of this protocol are eligible. Specifically, projects with start dates on or after February 3, 2008 are eligible to register with the Reserve if submitted by February 3, 2011. Projects with start dates prior to February 3, 2008 are not eligible under this protocol. Projects may always be submitted for listing by the Reserve prior to their start date.

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 submitted to the Reserve to confirm that early production phase-out occurred.

[8] Projects are considered submitted when the project developer has fully completed and filed the appropriate Project Submittal Form, available on the Reserve's website at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

Privately held and saleable virgin ODS refrigerants are eligible under this protocol only if the project developer submits a voluntary pre-import notification to EPA no later than 60 days from the Effective Date of this Protocol and submits the completed Entry Summary[9] to U.S. Customs and Border Protection prior to June 30, 2010. The voluntary pre-import notification must be submitted to the Office of Atmospheric Programs, Stratospheric Protection Division of EPA, and must include the following information:

- ODS country of origin
- ODS manufacturer and exporter
- Quantity and type of ODS to be imported
- Expected ODS arrival date
- ODS port of entry
- ODS chain of custody upon arrival in U.S.

3.3 Project Crediting Period

An ODS project is defined as a discrete series of destruction events over a 12-month period. 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.

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[10] prior to the commencement of verification activities each time the project is verified (see Section 8). In addition, the project's Monitoring and Operations Plan (Section 6) must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test. The Legal Requirement Test must be met as of the date of ODS export from the Article 5 country.

[9] Form 7501, available at: http://www.cbp.gov/xp/cgov/toolbox/forms/.
[10] Attestation of Voluntary Implementation form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

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

Project developers must attest that the project is in material compliance with all applicable laws (e.g., air, water quality, safety, etc.) by signing the Attestation of Regulatory Compliance[12] prior to verification activities commencing for each project. Projects are not eligible to receive CRTs for GHG reductions that occur as the result of production, collection or destruction activities that are not in material compliance with regulatory requirements.[13] Non-compliance solely 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.

The regulatory compliance requirement extends to the operation of destruction facilities where the ODS is destroyed. Destruction facilities have the potential to contribute to environmental concerns beyond ozone depletion and climate change. For example, emissions from destruction facilities may contribute to criteria and/or toxic pollutants. However, compliance with existing EPA regulations greatly reduces or eliminates these pollutants. Accordingly, all destruction facilities must meet the full burden of applicable regulatory requirements during the time the ODS destruction occurs. Any upsets or exceedences of permitted emission limits must be managed in keeping with an authorized startup, shutdown, and malfunction plan.[14]

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.

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[11] A summary of the study to establish the Performance Standard Test is provided in Appendix B.
[12] Attestation of Regulatory Compliance form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.
[13] Non-compliance dues solely due to "acts of nature" or minor administrative infractions which have been resolved will be considered non-material.
[14] 40 CFR 63.1206.

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.

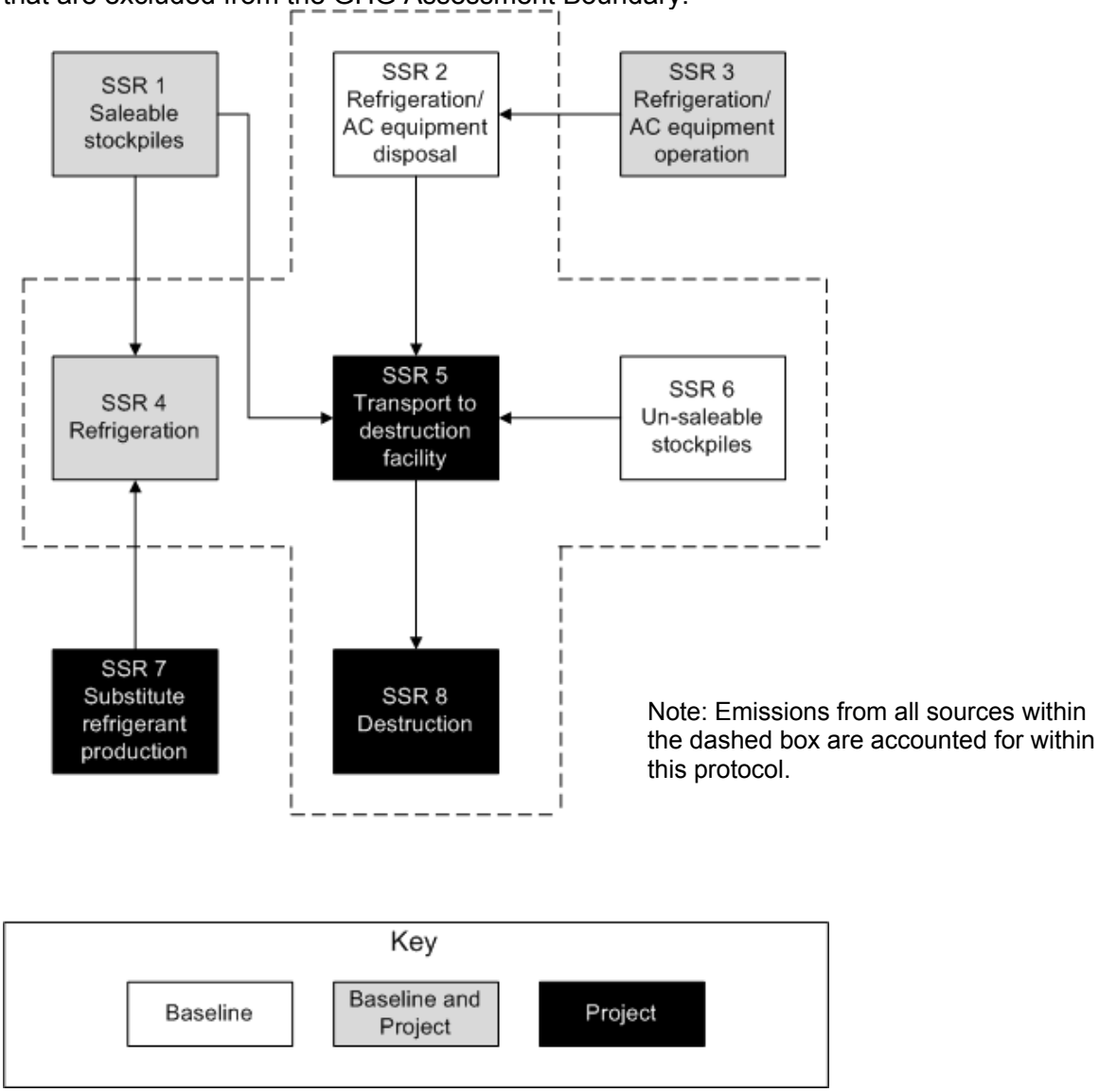

Figure 4.1. Illustration of the GHG Assessment Boundary

[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	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
2	Refrigerant and A/C 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 collection of refrigerant at end-of-life or servicing	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
3	Refrigeration and A/C equipment operation	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
4	Refrigeration	Emissions of ODS from leaks and servicing through continued operation of equipment	ODS	I	**Baseline:** Estimated based on market-weighted emission rates **Project:** N/A	Baseline equipment emissions will be significant
		Emissions of substitute from leaks and servicing through continued operation of equipment	CO_2e	I	**Baseline:** N/A **Project:** Estimated based on market-weighted emissions	Project equipment emissions will be significant

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
		Indirect emissions from grid-delivered electricity	CO_2	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			CH_4	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
			N_2O	E	N/A	Excluded, as project activity is unlikely to affect emissions relative to baseline activity
5	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
6	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
7	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

SSR		Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
8	Destruction	Emissions of ODS from incomplete destruction at destruction facility	ODS	I	**Baseline:** N/A **Project:** Estimated based on ODS destroyed, or included in default deduction	Project emissions will be small, and can be calculated using the default factor provided
		Emissions from the oxidation of carbon contained in destroyed ODS	CO_2	I	**Baseline:** N/A **Project:** Estimated based on ODS destroyed, or included in default deduction	Project emissions will be small, and can be calculated using the default factor provided
		Fossil fuel emissions from the destruction of ODS at destruction facility	CO_2	I	**Baseline:** N/A **Project:** Estimated based on ODS destroyed, or included in default deduction	Project emissions will be small, and can be calculated using the default factor provided
			CH_4	E	N/A	Excluded, as this emission source is assumed to be very small
			N_2O	E	N/A	Excluded, as this emission source is assumed to be very small
		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. Project developers may choose a project time length shorter than 12 months if desired. GHG emission reductions must be quantified and verified at least once for the entire project time length. If desired, project developers may choose to undergo multiple verifications to quantify GHG reductions over shorter reporting sub-periods. 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.

The Reserve has defined three 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. ODS obtained from private stockpiles or government stockpiles that can legally be sold into the refrigerant market	Use for recharge of existing refrigeration equipment	25%[17]	94%
2. ODS refrigerants obtained from government stockpiles that cannot legally be sold into the refrigerant market	Continued storage	Site specific emission rate as documented (see Equation 5.2)	$1-(1-ER_{stock})^{10}$
3. Used ODS refrigerant recovered from end-of-life equipment within the past 12 months	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	tODS
Q_{start}	=	Total quantity of ODS refrigerant *i* in government stockpile at time of seizure	tODS
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

$$BE = \sum_i \left(Q_i \times ER_{refr,i} \times GWP_{refr,i} \right)$$

Where,			Units
BE	=	Total quantity of refrigerant baseline emissions	tCO_2e
$Q_{,i}$	=	Total quantity of refrigerant ODS *i* destroyed	tODS
$ER_{refr,i}$	=	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)	tCO_2e/ tODS

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

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

Equation 5.4. Total Project Emissions

$$PE_t = Sub_{ref} + Tr + Dest$$

Where,			Units
PE_t	=	Total quantity of project emissions during the reporting period	tCO_2e
Sub_{ref}	=	Total emissions from substitute refrigerant	tCO_2e
Tr	=	Total emissions from transportation of ODS (calculated using either the default value in Equation 5.6, or Equation 5.12)	tCO_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)	tCO_2e

[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*.

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. For those projects, Sub_{refr} = 0. The point of origin of the ODS must be documented to support the selected baseline per Section 6.2.

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.

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

$$Sub_{refr} = \sum_i \left(Q_i \times 0.77 \times 1430\right)$$

Where,			Units
$Sub_{,refr}$	=	Total quantity of project refrigerant substitute emissions	tCO_2e
Q_i	=	Total quantity of refrigerant ODS *i* destroyed	t
0.77	=	Leak rate of HFC-134a (13.7% per year)[20]	% (0-1)
1430	=	Global warming potential of HFC-134a	tCO_2e/ tsub

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

[19] United Nations Environment Programme, Technology and Economic Assessment Panel. (2006). *Progress Report*.
[20] United Nations Environment Programme, Technology and Economic Assessment Panel. (2006). *Report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee*

and the SSRs outlined in Table 4.1.[21] The emission factor shall be equal to 7.5 tonnes CO_2e per tonne 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	tCO_2e
Q_i	=	Total quantity of refrigerant *i* ODS sent for destruction	tODS
7.5	=	Default emission factor for transportation and destruction of ODS	tCO_2e/ tODS

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% 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 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	tCO_2e
FF_{dest}	=	Total emissions from fossil fuel used in the destruction facility (Equation 5.8)	tCO_2
EL_{dest}	=	Total indirect emissions from grid electricity used at the destruction facility (Equation 5.9)	tCO_2
$ODS_{emissions}$	=	Total emissions of un-destroyed ODS (Equation 5.10)	tCO_2e
ODS_{CO2}	=	Total emissions of CO_2 from ODS oxidation (Equation 5.11)	tCO_2

[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] EPA, Destruction of ODS in the United States (2008), prepared by ICF International.

Equation 5.8. Fossil Fuel Emissions from the Destruction of ODS

$$FF_{dest} = \frac{\sum_k \left(FF_{PR,k} \times EF_{FF,k} \right)}{1000}$$

Where,			Units
FF_{dest}	=	Total carbon dioxide emissions from the destruction of fossil fuel used to destroy ODS	tCO_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
1000	=	kg/t of CO_2	$kgCO_2$/ tCO_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	tCO_2
EL_{PR}	=	Total electricity consumed to destroy ODS	MWh
EF_{EL}	=	Carbon emission factor for electricity used; see Appendix D	tCO_2/ MWh

Equation 5.10. Calculating Project Emissions from ODS Not Destroyed

$$ODS_{emissions} = \sum_i Q_i \times 0.0001 \times GWP_i$$

Where,			Units
$ODS_{emissions}$	=	Total emissions of un-destroyed ODS	tCO_2e
Q_i	=	Total quantity of refrigerant ODS *i* sent for destruction	tODS
0.0001	=	Maximum allowable portion of ODS fed to destruction that is not destroyed	% (0-1)
GWP_i	=	Global warming potential of ODS *i* (see Table 5.2)	tCO_2e/ tODS

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

$$ODS_{CO2} = \sum_i Q_i \times CR_i \times \frac{44}{12}$$

Where,			Units
ODS_{CO2}	=	Total emissions of CO_2 from ODS oxidation	tCO_2
Q_i	=	Total quantity of refrigerant ODS *i* sent for destruction	tODS
CR_i	=	Carbon ratio of ODS *i* CFC-11: 12/137 CFC-12: 12/121 CFC-114: 24/187 HCFC-22: 12/87 HCFC-141b: 24/117	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[24]

$$Tr = \frac{\sum_i \left(TMT_i \times EF_{TMT}\right)}{1000}$$

Where,			Units
Tr	=	Total emissions from transportation of ODS	tCO_2e
TMT_i	=	Tonne-miles-traveled[25] for ODS *i* destroyed (to be calculated including the ODS, any accompanying material, and containers from point of aggregation to destruction)	tonne-miles
EF_{TMT}	=	CO_2 emissions per tonne-mile-traveled On-road truck transport = 0.297 Rail transport = 0.0252 Waterborne craft = 0.048 Aircraft = 1.5279	$kgCO_2$
1000	=	Conversion from kg to tonnes	kg/tonne

[24]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*.

[25] A tonne-mile is defined as the product of the distance travelled in miles and the mass transported in tonnes. Therefore, half a tonne transported four miles is equal to two tonne-miles.

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 should 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 to confirm that reductions have not been claimed by other parties for the destruction activity in question.

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
- Destruction Facility
- Generator name (party requesting destruction)
- Certificate of Destruction ID number
- Start destruction date
- Ending destruction date

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
1. Virgin stockpiles	Location of stockpile
2. Used ODS stockpiled greater than 12 months	Location of stockpile
3. Used ODS quantities less than 500 lbs, and collected in the last 12 months	Location where ODS is first aggregated to greater than 500 lbs[a]
4. Used ODS quantities greater than 500 lbs, and collected in the last 12 months	Site of installation from which ODS is removed

[a] The point of origin for ODS collected by service technicians in individual quantities less than 500 pounds is defined as the holding facility at which several small quantities were combined and exceeded 500 pounds in aggregate. That is, those handling quantities less than 500 pounds need not provide documentation. However, once smaller quantities are aggregated and exceed 500 pounds collectively, tracking will be required from that location and point in time forward.

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

- Address of point of origin
- Identification of the system by serial number, if available, or description, location, and function, if serial number is unavailable (for quantities greater than 500 pounds)
- 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[26] for verification purposes. For projects involving the import of privately held virgin ODS, these records must demonstrate that the voluntary pre-import notification was submitted to U.S. EPA within 60 days of the Effective Date of this protocol, and that the Entry Summary was submitted to U.S. Customs by June 30, 2010. 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

[26] 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 to the project developer. 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 be properly calibrated per the facility's RCRA permit, or for non-RCRA facilities, calibrated at least quarterly to an accuracy of within 5% of reading
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[27] standard, or its successor. The laboratory performing the composition analysis must not be affiliated with the project developer.
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[28]
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. Each sample must be taken in liquid state
5. A minimum sample size of one pound must be drawn for each sample
6. 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[29]
7. Chain of custody from point of sampling to ARI 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 ARI 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% of the saturation point for the ODS taking into account the temperature recorded at the time the sample was taken
4. Analysis of high boiling residue, which must be less than 10% 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 the container holds non-mixed ODS (defined as greater than 90% composition of a single ODS species) no further information or sampling is required to determine the mass and composition of the ODS.

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

If the container holds mixed ODS, which is defined as less than 90% 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.

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[30]
2. The container was fully evacuated prior to filling
3. The container must have sampling ports to sample liquid and gas phase ODS
4. The sampling ports must be located in the middle third of the container (i.e., not at one end or the other)
5. The container and associated equipment can circulate the mixture via a closed loop system from the bottom to the top

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).[31]

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
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

[30] Mesh baffles or other interior structures that do not impede the flow of ODS are acceptable.
[31] EPA, Required Levels of Evacuation, available at: http://www.epa.gov/Ozone/title6/608/608evtab.html, accessed 12/21/09

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[32] (see Appendix C for a summary of destruction facility requirements and reproduction of applicable TEAP guidelines). This may include any RCRA-permitted HWC, as well as any other destruction or transformation facility which meets the requirements of Appendix C. Facilities permitted as RCRA HWCs are considered to meet the guidelines by default; no further testing for TEAP compliance is required.

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 exceedences 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[33] 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[34] was calculated. The DRE is determined by using the Comprehensive Performance Test (CPT)[35] 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

[32] http://www.uneptie.org/ozonaction/topics/disposal.htm.
[33] TEAP, Code of Good Housekeeping in *Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer - 7th Edition* (2006).
[34] DRE disclosed in Title V operating permit.
[35] CPT must have been conducted with a less combustible chemical than the ODS in question.

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
- Destruction facility
- Generator name
- Certificate of Destruction ID number
- Serial, tracking, or ID Number of all containers for which ODS destruction occurred
- Owner of destroyed ODS
- Weight of material destroyed from each container
- Start destruction date
- Ending 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 6 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 project		Must be monitored and determined for each project
		Mass of ODS (or ODS mixture) in each container		Per container	M	
		Concentration of ODS (or ODS mixture) in each container		Per container	M	
Equation 5.1	ER_t	Total quantity of emission reductions during the reporting period	tCO_2e	For each project	C	
Equation 5.1, Equation 5.3	BE_t	Total quantity of baseline emissions during the reporting period	tCO_2e	For each project	C	
Equation 5.1, Equation 5.4	PE_t	Total quantity of project emissions during the reporting period	tCO_2e	For each project	C	
Equation 5.2	$ER_{stock,i}$	Average annual emission rate of refrigerant ODS *i*	%	For each project	C	
Equation 5.2	Q_{end}	Total quantity of ODS refrigerant *i* in government stockpile at time of destruction	tODS	For each project	M	
Equation 5.2	Q_{start}	Total quantity of ODS refrigerant *i* in government stockpile at time of seizure	tODS	For each project	M	
Equation 5.3, Equation 5.5, Equation 5.6, Equation 5.10, Equation 5.11	Q_i	Total quantity of refrigerant ODS *i* destroyed	tODS	For each project	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*	tCO_2e/ tODS	N/A	R	See Table 5.2
Equation 5.4, Equation 5.5	$Sub_{,ref}$	Total emissions from substitute refrigerant	tCO_2e	For each project	C	
Equation 5.4, Equation 5.6, Equation 5.12	Tr	Total emissions from transportation of ODS	tCO_2e	For each project	C	May be calculated using default or using project specific inputs

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.4, Equation 5.6, Equation 5.7	Dest	Total emissions from the destruction process associated with destruction of ODS	tCO_2e	For each project	C	May be calculated using default or using project specific inputs
Equation 5.7, Equation 5.8	FF_{dest}	Total emissions from fossil fuel used in the destruction facility	tCO_2e	For each project	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	tCO_2e	For each project	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	tCO_2e	For each project	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	tCO_2	For each project	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	tCO_2e	For each project	M	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.8	$EF_{FF,k}$	Fuel specific emission factor	$kgCO_2$/ volume fuel	N/A	R	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.9	EL_{PR}	Total electricity consumed to destroy ODS	MWh	For each project	M	Use only if calculating site-specific project emissions from ODS destruction
Equation 5.9	EF_{EL}	Carbon emission factor for electricity used	tCO_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
Equation 5.12	TMT_i	Tonne-miles-traveled for ODS *i* destroyed	tonne-miles	For each project	M	Including weight of all storage containers Use only if calculating site-specific project emissions from ODS destruction
Equation 5.12	EF_{TMT}	Mode-specific emission factor	$kgCO_2$/ tonne-mile	N/A	R	Use only if calculating site-specific project emissions from ODS destruction

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
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form
- Verification Report
- Verification Opinion

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 Opinion
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form

At a minimum, 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 jointly verified. This may provide economies of scale for the project verifications and improve the efficiency of the verification process.

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 Opinion (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 3 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 monitor information (CEMS data, DRE documentation, scale readings, calibration procedures, and permits)
- Verification records and results
- Chain of custody and point of origin documentation
- ODS composition and quantity lab reports

7.4 Reporting Period & Verification Cycle

ODS destruction projects may be no greater than 12 months in duration, measured from commencement (as defined by the project start date) to completion of ODS destruction. As stated in Section 3, project developers may choose a shorter time horizon for their project (e.g., 3 months or 6 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. Project verification for a reporting period must commence no more than six months after the end of the reporting period.

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.

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 Opinion (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	For 12 months following the Effective Date of this protocol, a project with a start date on or after February 3, 2008 may be submitted for listing; after this 12-month period, projects must be submitted for listing within 6 months of the project start date	Each verification
Location of Destruction	United States and its territories	Each verification
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 destruction spans no more than 12 months from the commencement of destruction activities to the conclusion of destruction activities ▪ CFC refrigerant ODS have been phased-out of production in the country of origin	Each verification

Eligibility Rule	Eligibility Criteria	Frequency
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	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 collected and destroyed and to calculate baseline and project emissions.

Verifying emission reduction estimates
The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the 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 Visit

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 per project by the project verifier.

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 refrigerants obtained from government stockpiles that cannot legally be sold into the refrigerant market	▪ Site of stockpile ▪ Destruction facility
Used ODS refrigerant recovered from end-of-life equipment within the past 12 months	▪ Destruction facility

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?
2.5	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
2.2	Verify that the project meets the definition of an ODS Article 5 project	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
6.2	For privately-held virgin stockpiles, verify that the voluntary pre-import notification paperwork was submitted to EPA within 60 days of Effective Date of protocol and that the Entry Summary was submitted to Customs by June 30, 2010	No
2.5	Verify ownership of the reductions by reviewing Attestation of Title and chain of custody documentation	No
2.2	Verify that the project activities involve a single project developer and a single qualifying destruction facility	No
Appendix C	Verify that the destruction facility meets the requirements of this protocol	No
3.2	Verify eligibility of project start date	No
3.2	Verify accuracy of project start date based on records	No
2.2	Verify that project activities span no more than 12 months	No
3.4.1	Confirm execution of the Attestation of Regulatory Compliance form to demonstrate eligibility under the Legal Requirement Test	No
6	Verify that the project Monitoring and Operations Plan contains procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times	Yes
3.4.2	Verify that the project meets the Performance Standard Test	No
3.5	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
6	Verify that monitoring meets the requirements of the protocol; if it does not, verify that a variance has been approved for monitoring variations.	Yes
	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?
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
6.3	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 per EPA permit requirements, or calibrated quarterly	No
6.4	Verify that the weight of full and empty ODS containers was measured 2 days prior to destruction commencing and 2 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
6.4	Verify that all ODS was analyzed for composition and concentration at a lab approved under the ARI-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
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%, 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% or greater destruction and removal efficiency	No
6	Verify that the destruction facility monitored the parameters identified in Section 6	No
6.5	Verify that the Certificate of Destruction identifies all ODS for which credits are being claimed	No

8.7.3 Quantification of GHG Emission Reductions

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

Table 8.5. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that SSRs included in the GHG Assessment Boundary correspond to those required by the protocol and those represented in the project documentation	No
2.2	Verify that all destroyed ODS for which CRTS are claimed appear on a valid Certificate of Destruction	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 fossil fuel use, or that the default factor was applied	Yes
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, 5.2.4	Verify that the project developer correctly quantified and aggregated transportation emissions, 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

8.7.4 Risk Assessment

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

Table 8.6. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project Monitoring and Operations Plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that appropriate monitoring equipment is in place at destruction facility to meet the requirements of the protocol	Yes
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform these functions	Yes
6	Verify that appropriate training was provided to personnel assigned to operations, record-keeping, sample-taking, and other project activities	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. 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 Opinion, 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% 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.[36]
Emissions rate	The annual rate at which ODS is lost to the atmosphere, including emissions from leaks during operation and servicing events.
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). [37]
Recharge	Replenishment of refrigerant agent (using reclaimed or virgin material) into equipment that is below its full capacity because of leakage or because it has been evacuated for servicing or other maintenance.
Reclaim	Reprocessing and upgrading of a recovered ozone depleting substance through mechanisms such as filtering, drying,

[36] Report of the Fifteenth Meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer. United Nations Environment Programme. OzL.Pro.15/9. Nairobi, November 11, 2003.
[37] Source IPCC - http://www.mnp.nl/ipcc/pages_media/SROC-final/SROC_A2.pdf.

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

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

Appendix A Summary of Legal Requirement Test Development

Management activities for ozone depleting substances are dictated in 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% 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% by 2010, 99.5% by 2020, and 100% by 2030. The 0.5% 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% in 2015, 35% by 2020, 67.5% by 2025, 97.5% by 2030 and 100% by 2040. The 2.5% during the period 2030-2039 is the average over that time frame (e.g., it can be 5% for 5 years and 0% for the other 5 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".[38]

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.[39] 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.[40] 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[41]

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

[38] See the Climate Action Reserve's Program Manual for further discussion of the Reserve's general approach to determining additionality.
[39] United Nations Environment Programme, Ozone Secretariat. (accessed 9/24/09).*List of Parties categorized as operating under Article 5 paragraph 1 of the Montreal Protocol*, available at: http://ozone.unep.org/Ratification_status/list_of_article_5_parties.shtml
[40] United Nations Environment Programme, Ozone Secretariat. (accessed 9/22/09). *Data Access Center*, available at: http://ozone.unep.org/Data_Reporting/Data_Access/
[41] UNEP, Addendum to: *Information provided by Parties in accordance with Article 7 of the Montreal Protocol on Substances that Deplete the Ozone Layer* (2009), 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 (1990-2008)

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 (2005-2008) 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 2005-2008.

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

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.[42]

Additionally, the Ozone Secretariat provided the Reserve with a summary of all reported CFC destruction in Article 5 countries from 1990-2008. 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 1990-2008[43]

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.

[42] Lim, Sung Yong, Senior Manager, Fund Administration Dept., Korea Specialty Chemical Industry Association (2010) Personal correspondence.
[43] 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*[44] 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 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% 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 Technologies*, and reproduced below. By inclusion here, the recommendations of the excerpted

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

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 3 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, & 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[45]			
Performance Qualification	Units	Diluted Sources	Concentrated Sources
DRE	%	95	99.99
PCDDs/PCDFs	ng-ITEQ/Nm^3	0.5	0.2
HCl/Cl_2	mg/Nm^3	100	100
HF	mg/Nm^3	5	5
HBr/Br_2	mg/Nm^3	5	5
Particulates (TSP)	mg/Nm^3	50	50
CO	mg/Nm^3	100	100

2.1.1 Destruction and Removal Efficiency

Destruction Efficiency (DE) [46] 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) .[47] 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% for foams; and,
- 99.99% 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%, but this was accompanied by a conversion of 25% of the input CFC-12 to CFC-13 ($CClF_3$), which has the same ozone-depleting potential. The interconversion is less severe when

[45] 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.
[46] 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.
[47] 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.

hydrogen is present in the process, but can nonetheless be significant.[48] For this reason, it is important to take into account all types of ODS in the stack gas in defining the DRE.
For the reasons described in the previous paragraph, the Task Force recommends that future calculations of DRE use the approach described below.[49]

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

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

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

2.1.2 Emissions of Dioxins and Furans

Any high temperature process used to destroy ODS has associated with it the potential formation (as by-products) of polychlorinated dibenzo-paradioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). These substances are among the products of incomplete combustion (or PICs) of greatest concern for potential adverse effects on public health and the environment. The internationally recognized measure of the toxicity of these compounds is the toxic equivalency factor (ITEQ), [50] 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.

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

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

[50] 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. [*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*. North Atlantic Treaty Organization/Committee on the Challenge of Modern Society. Report No. 176, Washington, D.C. 1988.]

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

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

These criteria were determined to represent a reasonable compromise between more stringent standards already in place in some industrialized countries [for example, the Canada-Wide Standard of 0.08 ng/m^3 (ITEQ)], and the situation in developing countries where standards may be less stringent or non-existent. Although a previous standard of 1.0 ng/m^3 (ITEQ) had been 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% 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[51]
EL_{PR} =	0.0018 MWh/lb ODS destroyed
EF_{EL} =	0.889 tCO_2/MWh[52]
TMTi =	2,000 miles by truck, 3,000 miles by ocean freighter
EF_{TMT} =	0.297 $kgCO_2$/TMT[53]
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 transportation 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 5 to 6 tonnes CO_2e per tonne ODS destroyed are relatively small. These emissions amount to less than 0.15% 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.

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

Table E.2. CO_2 Electricity Emission Factors

eGRID subregion acronym	eGRID subregion name	Annual output emission rates	
		(lb CO_2/MWh)	(metric ton CO_2/MWh)*
AKGD	ASCC Alaska Grid	1,232.36	0.559
AKMS	ASCC Miscellaneous	498.86	0.226
AZNM	WECC Southwest	1,311.05	0.595
CAMX	WECC California	724.12	0.328
ERCT	ERCOT All	1,324.35	0.601
FRCC	FRCC All	1,318.57	0.598
HIMS	HICC Miscellaneous	1,514.92	0.687
HIOA	HICC Oahu	1,811.98	0.822
MROE	MRO East	1,834.72	0.832
MROW	MRO West	1,821.84	0.826
NEWE	NPCC New England	927.68	0.421
NWPP	WECC Northwest	902.24	0.409
NYCW	NPCC NYC/Westchester	815.45	0.370
NYLI	NPCC Long Island	1,536.80	0.697
NYUP	NPCC Upstate NY	720.80	0.327
RFCE	RFC East	1,139.07	0.517
RFCM	RFC Michigan	1,563.28	0.709
RFCW	RFC West	1,537.82	0.698
RMPA	WECC Rockies	1,883.08	0.854
SPNO	SPP North	1,960.94	0.889
SPSO	SPP South	1,658.14	0.752
SRMV	SERC Mississippi Valley	1,019.74	0.463
SRMW	SERC Midwest	1,830.51	0.830
SRSO	SERC South	1,489.54	0.676
SRTV	SERC Tennessee Valley	1,510.44	0.685
SRVC	SERC Virginia/Carolina	1,134.88	0.515

Source: UE EPA eGRID2007, Version 1.1 Year 2005 GHG Annual Output Emission Rates (December 2008).
* Converted from lbs CO_2/ MWh to metric tons CO_2/MWH using conversion factor 1 metric ton = 2,204.62 lbs.

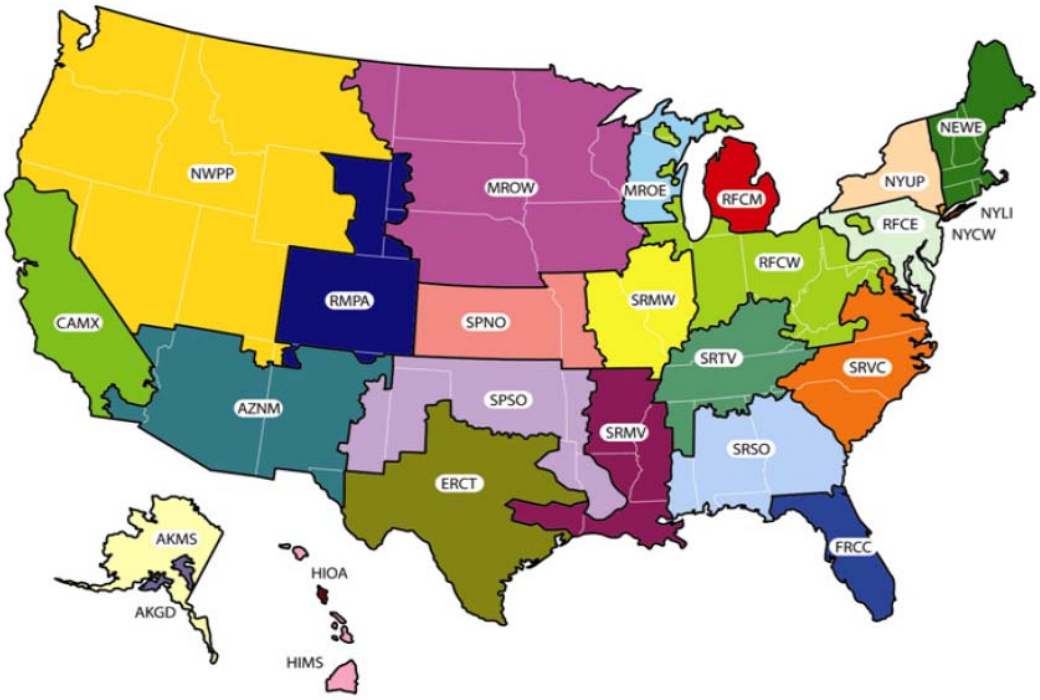

Figure E.1. Map of eGRID2007 Subregions