

VCS Methodology

VM0016

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## Recovery and Destruction of Ozone-Depleting Substances

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Sectoral Scope 11

Prepared by:

**Energy Changes Projekt Entwicklung GmbH**

Obere Donaustraße 12/128

1020 Vienna, Austria

[www.energy-changes.com](http://www.energy-changes.com)

and

**USG Umweltservice GmbH**

Franz-Fritsch-Straße 11/Süd/104

4600 Wels, Austria

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## 1 SOURCES

This methodology refers to the latest version of the following approved methodologies:

- Climate Action Reserve (CAR) methodology *U.S. Ozone Depleting Substances Project Protocol, Destruction of U.S. Ozone Depleting Substances Banks*
- Climate Action Reserve (CAR) methodology *Article 5 Ozone Depleting Substances Project Protocol, Destruction of Article 5 Ozone Depleting Substances Banks*
- RAL Deutsches Institut für Gütesicherung: Quality Assurance and Test Specifications for the Demanufacture of Refrigeration Equipment

This methodology refers to the latest version of the following approved tools and modules:

- CDM tool *Tool for the demonstration and assessment of additionality*
- CDM tool *Tool to calculate the emission factor for an electricity system*
- VCS module *VMD0048 Activity method for the determination of additionality for recovered and stockpiled ODS refrigerant projects*

The following have also informed the development of the methodology:

- CDM tool *Tool to calculate project or leakage CO2 emissions from fossil fuel combustion*
- CDM tool *Tool to calculate baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation*

## 2 SUMMARY DESCRIPTION OF THE METHODOLOGY

Additionality and Crediting Method	
Additionality	Project / Activity Method
Crediting Baseline	Project

This methodology quantifies the GHG emission reductions from activities that recover and destroy Ozone-Depleting Substances (ODS) from products where a partial or total atmospheric release of ODS occurs in the baseline scenario. Project activities can be implemented in Montreal Protocol Article 5 and Non-Article 5 countries.

Project activities may recover and destroy ODS refrigerants, ODS blowing agents or both.

## 3 DEFINITIONS

In addition to the definitions set out in VCS document *Program Definitions*, the following definitions and acronyms apply to this methodology:

### **Article 5 Country**

Any party to the Montreal Protocol that is a developing country and whose annual calculated level of consumption of the controlled substances in Annex A (of the Montreal Protocol) is less than 0.3 kilograms per capita

### **Non Article 5 Country**

Any party to the Montreal Protocol which is not an Article 5 country

### **Destruction Facility**

The facility where the destruction of the ODS takes place and which meets the screening criteria for destruction technologies set out in the report, as may be updated from time to time, by the UNEP Technology and Economic Assessment Panel (TEAP) Task Force on Destruction Technologies. *UNEP Technology and Economic Assessment Panel (TEAP) Report of the Task Force on Destruction Technologies*, UNEP, 2002.

### **Ozone-Depleting Substance (ODS)**

A family of man-made compounds that includes, but is not limited to, chlorofluorocarbons (CFCs), bromofluorocarbons (halons), methyl chloroform, carbon tetrachloride, methyl bromide, and hydrochlorofluorocarbons (HCFCs). These compounds have been shown to deplete stratospheric ozone, and therefore are typically referred to as ODS. Many Ozone-Depleting Substances also have a Global Warming Potential (GWP) and are therefore Greenhouse Gases (GHG).

CFC ODS: An ODS listed in Annex A, Group 1 or Annex B, Group 1 of Appendix I of this methodology.

HCFC ODS: An ODS listed in Annex C, Group 1 of Appendix I of this methodology.

### **ODS blowing agent**

A chemical (being an ODS) added to plastics and rubbers that generates inert gases on heating, causing the resin to assume a cellular structure

### **ODS refrigerant**

A chemical (being an ODS) used or intended for use in a cooling mechanism, such as an air conditioner or refrigerator, as the heat carrier which changes from gas to liquid and then back to gas in the refrigeration cycle

### **Product**

Any of the following: refrigeration, air conditioning or fire suppression equipment, systems or appliances, or thermal insulation foams

### **Recovery**

To remove ODS refrigerants and blowing agents in any condition from a system and store it in an external container

### **Recovery Facility**

The facility where the project proponent recovers ODS refrigerants and blowing agents from appliances, or the facility where collected refrigerant is aggregated by the project proponent in preparation for destruction. The location where refrigerant is recovered from stationary equipment, such as a chiller, is not a recovery facility.

### **Recycle**

To extract ODS refrigerants from an appliance and clean it using oil separation and single or multiple passes through filter-driers, which reduce moisture, acidity, and particulate matter

### **Reclaim**

To reprocess used ODS refrigerants or blowing agents, typically by distillation, to specifications similar to that of virgin product specifications

### **Refrigerator appliance**

Any appliance whose main purpose is the cooling of foodstuffs and other temperature-sensitive products and which are further defined as following (*according to RAL Deutsches Institut für Gütesicherung: Quality Assurance and Test Specifications for the Demanufacture of Refrigeration Equipment*):

Domestic fridges: These are refrigerators of a typical domestic design with a storage capacity of up to 180 litres. The appliances may or may not be equipped with a separate deep-freeze compartment. (Type 1 appliances).

Domestic fridge-freezers: These are refrigeration appliances of a typical domestic design with a storage capacity ranging from 180 to 350 litres. Generally, these appliances have a separate deep-freeze compartment. (Type 2 appliances).

Domestic chest freezers and upright freezers: These are deep-freeze appliances of a typical domestic design with a storage capacity up to 500 litres. (Type 3 appliances).

### **Stockpile**

A CFC ODS refrigerant stored in an external container(s) by a single person or entity (including but not limited to private companies, organizations, and/or government agencies), or by multiple people or entities at a single location. A stockpile may be composed of one or more containers of any size. Containers in a stockpile may consist of recovered, reclaimed, recycled, or unused (manufactured for use but never so used) CFC ODS.

## **4 APPLICABILITY CONDITIONS**

This methodology applies to project activities that recover and destroy ODS where the baseline scenario is the partial or total atmospheric release of ODS. This methodology does not apply to ODS refrigerant or ODS blowing agents that are manufactured for the sole purpose of their subsequent destruction.

Project activities can be implemented in Article 5 as well as in Non-Article 5 countries<sup>1</sup>.

Only ODS listed in Appendix I of this methodology, and for which the VCS rules (as may be updated from time to time) apply, are eligible. ODS in a stockpile must be CFC ODS in order to be eligible under this methodology.

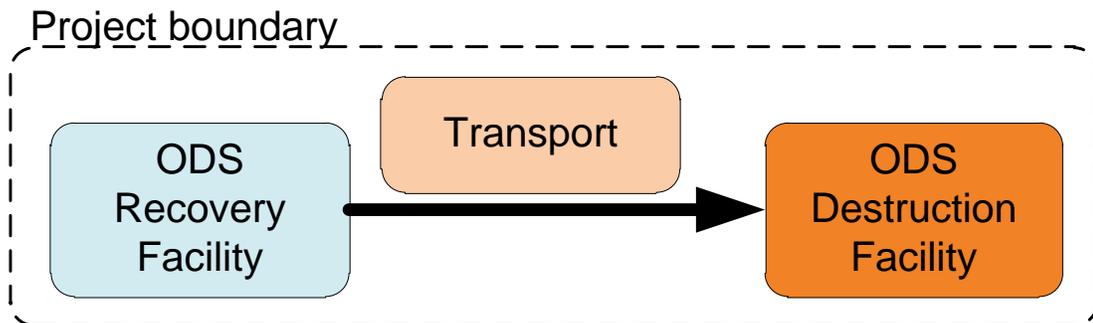
The methodology can be applied to either ODS refrigerants and/or ODS blowing agents. In the case of ODS blowing agents the methodology is only applicable to project activities recovering and destroying ODS blowing agents contained in insulation foam of end-of-life refrigerator appliances. The ODS blowing agent must be extracted from the foam to a concentrated form prior to destruction. This must be done under negative pressure to ensure that fugitive release of ODS cannot occur.

All ODS must be collected, stored, and transported in cylinders or other hermetically sealed containers.

## 5 PROJECT BOUNDARY

The spatial extent of the project boundary encompasses:

- The recovery facility
- Transportation from the recovery facility to the destruction facility
- The destruction facility



The greenhouse gases included in or excluded from the project boundary are shown in Table below.

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<sup>1</sup> For the avoidance of doubt: Recovery and destruction activities can take place in separate countries.

**Table 1:** GHG Sources Included In or Excluded From the Project Boundary

Source		Gas	Included?	Justification/Explanation
Baseline	Emissions through the release of ODS refrigerants into the atmosphere	$\sum_{i=1}^n ODS_i$	Yes	Main emission source in the baseline
	Emissions through the release of ODS blowing agent into the atmosphere	$\sum_{i=1}^n ODS_i$	Yes	Main emission source in the baseline
Project	Emissions through on-site fossil fuel and electricity consumption at the recovery facility	CO <sub>2</sub>	Yes	May be an important emission source
		CH <sub>4</sub>	No	Excluded for simplification. This emission source is assumed to be very small
		N <sub>2</sub> O	No	Excluded for simplification. This emission source is assumed to be very small
	Emissions through transportation of ODS from the recovery facility to the destruction facility	CO <sub>2</sub>	Yes	May be an important emission source
		CH <sub>4</sub>	No	Excluded for simplification. This emission source is assumed to be very small
		N <sub>2</sub> O	No	Excluded for simplification. This emission source is assumed to be very small
	Emissions associated to the destruction process of ODS	CO <sub>2</sub>	Yes	May be an important emission source
		CH <sub>4</sub>	No	Excluded for simplification. This emission source is assumed to be very small
		N <sub>2</sub> O	No	Excluded for simplification. This emission source is assumed to be very small
		$\sum_{i=1}^n ODS_i$	Yes	May be an important emission source

## 6 BASELINE SCENARIO

The project proponent must use Step 1 of the latest version of the CDM *Tool for the demonstration and assessment of additionality*, to identify all realistic and credible baseline alternatives. In doing so, relevant policies and regulations related to the management of ODS banks should be taken into account. Such policies or regulations may include mandatory ODS capture or destruction requirements because of regional or local environmental regulations. In addition, the assessment of alternative scenarios should take into account regional economic and technological circumstances.

### **For ODS refrigerants the realistic and credible alternative(s) may include, *inter alia***

- R1 Project activity not performed as emission reduction project
- R2 Products are disposed of into an incineration facility and thereby ODS refrigerants are destroyed
- R3 Atmospheric release of the ODS refrigerant or partial capture and destruction
- R4 Atmospheric release of the ODS refrigerant or partial capture and reuse in existing products or continued storage in stockpile

### **For ODS blowing agents the realistic and credible alternative(s) may include, *inter alia***

- BAF1 Project activity not performed as emission reduction project
- BAF2 The refrigerators containing foams (blowing agents) are disposed of into an incineration facility and thereby ODS blowing agents are destroyed
- BAF3 The refrigerators containing foams (blowing agents) are disposed of at a landfill/dump
- BAF4 Before final disposal, the refrigerators containing foam are shredded. The foams are subsequently:
  - BAF4.1 disposed of at an incineration facility
  - BAF4.2 disposed of at a landfill/dump
  - BAF4.3 disposed of by open burning
  - BAF4.4 extracted and ODS blowing agents are partly captured and destroyed

The methodology is only applicable for ODS refrigerants if the most plausible baseline scenario for the ODS refrigerant is either R3 or R4 or a combination of both. In respect of ODS blowing agents the methodology is only applicable if the most plausible baseline scenario for ODS blowing agents from foam is either one of BAF4.1, BAF4.2, BAF4.3 or BAF4.4 or any combination of these scenarios.

## 7 ADDITIONALITY

The project proponent should use the two-step process set out in Section 7.1 for the demonstration of additionality for projects that destroy CFC refrigerant and fulfill the applicability conditions of VCS activity method module *Activity method for the determination of additionality for recovered and stockpiled ODS refrigerant projects*. The project proponent must use the project method set out in Section 7.2 for all other projects eligible under this methodology.

### 7.1 Destruction of CFC refrigerant

#### Step 1: Regulatory surplus

The project proponent must demonstrate regulatory surplus in accordance with the rules and requirements regarding regulatory surplus set out in the latest version of the *VCS Standard*.

#### Step 2: Positive list

The applicability conditions of VCS activity method module *Activity method for the determination of additionality for recovered and stockpiled ODS refrigerant projects* represent the positive list. The positive list was established using the revenue streams option (Option C in the *VCS Standard*). Projects that meet all of the applicability conditions of this methodology and the VCS activity method module *Activity method for the determination of additionality for recovered and stockpiled ODS refrigerant projects* are deemed additional.

### 7.2 Destruction of ODS refrigerant and/or ODS blowing agents

This methodology uses a project method for the demonstration of additionality of all project activities that are not eligible to apply the activity method described above. Such projects include the destruction of ODS blowing agents and the destruction of other ODS refrigerants where the activity method is not applicable or preferred, in which case project proponents shall apply the latest version of the CDM *Tool for the demonstration and assessment of additionality*.

## 8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

### 8.1 Baseline Emissions

**Baseline emissions from existing ODS contained in products and/or stockpiles are determined with the following equation:**

$$BE_{ODS,y} = BE_{ODS_{ref},y} + BE_{ODS_{foam},y} \quad (1)$$

Where:

$BE_{ODS,y}$  = Total quantity of baseline emissions from ODS refrigerants and blowing agents (foam) which would be released into the atmosphere in the absence of the project activity in year y [tCO<sub>2</sub>e]

$BE_{ODS\_ref,y}$  = Baseline emissions from ODS refrigerants which would be released into the atmosphere in the absence of the project activity in year y [tCO<sub>2</sub>e]

$BE_{ODS\_foam,y}$  = Baseline emissions from ODS blowing agents contained in insulation foams of refrigeration appliances which would be released into the atmosphere in the absence of the project activity in year y [tCO<sub>2</sub>e]

**Baseline emissions from ODS refrigerants are determined as follows:**

$$BE_{ODS\_ref,y} = \sum_{i=1}^n \left( (M_{DESTR,refr,i,y} \times VR_{refr} \times EF_{VR}) + (M_{DESTR,refr,i,y} \times RR_{refr,i,y} \times EF_{RR,refr,i,y}) + (M_{DESTR,refr,i,y} \times DR_{refr} \times EF_{DR}) \right) \times GWP_{refr,i} \quad (2)$$

$$1 = VR_{refr} + RR_{refr,i,y} + DR_{refr} \quad (3)$$

Where:

$BE_{ODS\_ref,y}$  = Baseline emissions from ODS refrigerants which would be released into the atmosphere in the absence of the project activity in year y [tCO<sub>2</sub>e]

$M_{DESTR,refr,i,y}$  = Quantity of ODS refrigerant i destroyed by the project activity in year y [tODS<sub>i</sub>]

$VR_{refr}$  = Rate of ODS refrigerants (destroyed) which would be vented into the atmosphere in the baseline [%;0-100%]

$EF_{VR}$  = Emission factor for the rate of ODS refrigerants (destroyed) which would be vented into the atmosphere [1]

$DR_{refr}$  = Rate of ODS refrigerants (destroyed) by the project activity which would also be destroyed in the baseline [%;0-100%]

$EF_{DR}$  = Emission factor for the rate of ODS refrigerants (destroyed) by the project activity which would also be destroyed in the baseline [0]

$RR_{refr,i,y}$  = Rate of ODS refrigerants i which would be used, reused or remain in storage in the baseline [%;0-100%]

$EF_{RR,refr,i,y}$  = Emission factor for the rate of ODS refrigerant i (destroyed) which would be reused in the baseline [0-1.0]

$GWP_{refr,i}$  = Global warming potential of ODS refrigerant type i that converts 1 ton of ODS i to tons of CO<sub>2</sub> equivalents. [tCO<sub>2</sub>e/tODS<sub>i</sub>]

$$EF_{VR} = 1 \quad (4)$$

$$EF_{DR} = 0 \quad (5)$$

$$EF_{RR,refr,i} = 1 - (1 - LR_{refr,i})^{tcp} \quad (6)$$

Where:

$EF_{RR,refr,i}$  = Emission factor for the rate of ODS refrigerant i (destroyed) which would be reused in the baseline [0-1.0]

$LR_{refr,i}$  = Leak rate of ODS refrigerant i (destroyed), which would be used as refrigerant for existing equipment or remain in storage in the baseline [%;0-100%]

$tcp$  = Project crediting period [10]

When destruction of the ODS refrigerants by the project activity is mandated by law, statute or other regulatory framework applying in the host country, the baseline shall be the gradually increasing compliance with such law, statute or other regulatory framework, and the baseline GHG emissions shall be calculated as follows:

$$BE_{ODS_{ref},y,a} = BE_{ODS_{ref},y} \times (1 - CR_y) \quad (7)$$

Where:

$BE_{ODS_{ref},y}$  = Baseline emissions from ODS refrigerants which would be released into the atmosphere in the absence of the project activity in year y [tCO<sub>2</sub>e]

$BE_{ODS_{ref},y,a}$  = Adjusted baseline emissions to be used for the calculation of emission reductions in year y [tCO<sub>2</sub>e]

$CR_y$  = Host country-level compliance rate of the law, statute or other regulatory framework in the year y. Calculation of the compliance rate shall exclude other projects implemented under GHG programs. If the compliance rate exceeds 50%, the project shall receive no further credit [%; 0-100%]

**Baseline emissions from ODS blowing agents are determined as follows:**

$$BE_{ODS_{foam},y} = \sum_{i=1}^n \left( \left( M_{APPLIANCE,foam,i,y} \times ER_{foam,i} - (M_{APPLIANCE,foam,i,y} - M_{DESTR,foam,i,y}) \right) \times GWP_{foam,i} \right) \quad (8)$$

Where:

- $BE_{ODS\_foam,y}$  = Baseline emissions from ODS blowing agents contained in insulation foams of refrigeration appliances which would be released into the atmosphere in the absence of the project activity in year y [tCO<sub>2</sub>e]
- $M_{DESTR,foam,i,y}$  = Quantity of ODS blowing agent i destroyed by the project activity in year y [tODS<sub>i</sub>]
- $M_{APPLIANCE,foam,i,y}$  = Total quantity of ODS blowing agent i contained in the total number of refrigerator appliances from which ODS is recovered in year y [tODS<sub>i</sub>]
- $ER_{foam,i}$  = Rate by which ODS blowing agent i contained in foam of refrigeration appliances would be released into atmosphere based on the disposal practice (baseline) in the respective host country [%;0-100%]
- $GW_{P_{foam,i}}$  = Global warming potential of ODS blowing agent type i that converts 1 ton of ODS i to tons of CO<sub>2</sub> equivalents. [tCO<sub>2</sub>e/tODS<sub>i</sub>]

$$M_{APPLIANCE,foam,i,y} = M_{APPLIANCE,1,foam,i,y} + M_{APPLIANCE,2,foam,i,y} + M_{APPLIANCE,3,foam,i,y} \quad (9)$$

Where:

- $M_{APPLIANCE,1,foam,i,y}$  = Total quantity of ODS blowing agent i contained in the total number of type 1 refrigerator appliances from which ODS is recovered in year y [tODS<sub>i</sub>]
- $M_{APPLIANCE,2,foam,i,y}$  = Total quantity of ODS blowing agent i contained in the total number of type 2 refrigerator appliances from which ODS is recovered in year y [tODS<sub>i</sub>]
- $M_{APPLIANCE,3,foam,i,y}$  = Total quantity of ODS blowing agent i contained in the total number of type 3 refrigerator appliances from which ODS is recovered in year y [tODS<sub>i</sub>]

$$M_{APPLIANCE,1,foam,i,y} = \sum_1^J M_{app,1,foam,i,y} \quad (10)$$

Where:

- $M_{APPLIANCE,1,foam,i,y}$  = Quantity of ODS blowing agent i contained in one type 1 refrigerator appliance from which ODS is recovered during year y [tODS<sub>i</sub>]
- J = Total number of type 1 refrigerator appliances from which ODS blowing agent i is recovered in year y [Number]

$$M_{APPLIANCE,2,foam,i,y} = \sum_1^K M_{app,2,foam,i,y} \quad (11)$$

Where:

- $M_{app,2,foam,i,y}$  = Quantity of ODS blowing agent i contained in one type 2 refrigerator appliance from which ODS is recovered during year y [tODSi]
- K = Total number of type 2 refrigerator appliances from which ODS blowing agent i is recovered in year y [Number]

$$M_{APPLIANCE,3,foam,i,y} = \sum_1^L M_{app,3,foam,i,y} \quad (12)$$

Where:

- $M_{app,3,foam,i,y}$  = Quantity of ODS blowing agent i contained in one type 3 refrigerator appliance from which ODS is recovered during year y [tODSi]
- L = Total number of type 3 refrigerator appliances of which ODS blowing agent i is recovered in year y [Number]

For baseline scenarios BAF4.1 and BAF4.2 the following default factors shall be used for  $ER_{foam,i}$

**Table 2: Default Factors**

Disposal Practice (Baseline)	Applicable default factor		
	ODSi	$ER_{foam,i}$	Source
BAF4.1: disposed of at an incineration facility	CFC-11	0.24	Same as used in CAR U.S. Ozone Depleting Substances Project Protocol Table 5.3 and 5.4 Based on Scheutz, C. et al. (2007a)
	CFC-12	0.24	
	HCFC-22	0.24	
	HCFC-141b	0.24	
BAF4.2: disposed of at a landfill/dump	CFC-11	0.44	Same as used in CAR U.S. Ozone Depleting Substances Project Protocol Table 5.3 and 5.4 Based on Scheutz, C. et al. (2007a/b) Fredenslund, A. et al. (2005)
	CFC-12	0.55	
	HCFC-22	0.75	
	HCFC-141b	0.5	

For BAF4.3 and BAF4.4,  $ER_{foam,i}$  shall be based on host country officially published data, research studies or industry data.

When destruction of the ODS blowing agents by the project activity is mandated by law, statute or other regulatory framework applying in the host country, the baseline shall be the gradually increasing compliance with such law, statute or other regulatory framework, and the baseline GHG emissions shall be calculated as follows:

$$BE_{ODS\_foam,y,a} = BE_{ODS\_foam,y} \times (1 - CR_y) \quad (13)$$

Where:

- $BE_{ODS\_foam,y,a}$  = Adjusted baseline emissions to be used for the calculation of emission reductions in year y [tCO<sub>2</sub>e]
- $BE_{ODS\_foam,y}$  = Baseline emissions from ODS blowing agents contained in insulation foams of refrigeration appliances which would be released into the atmosphere in the absence of the project activity in year y [tCO<sub>2</sub>e]
- $CR_y$  = Host country-level compliance rate of the law, statute or other regulatory framework in the year y. Calculation of the compliance rate shall exclude other projects implemented under GHG programs. If the compliance rate exceeds 50%, the project shall receive no further credit [%;0-100%]

## 8.2 Project Emissions

Project emissions in year y are:

- Emissions that are caused by the project activity due to energy consumption at the ODS recovery facility
- Emissions that are caused by the project activity due to ODS transportation
- Emissions that are caused by the project activity due to ODS destruction

$$PE_y = PE_{Energy\_Consump,y} + PE_{ODS\_Transport,y} + PE_{ODS\_Destruction,y} \quad (14)$$

- $PE_y$  = Project emissions during year y [tCO<sub>2</sub>e]
- $PE_{Energy\_Consump,y}$  = Project emissions from energy consumption at the ODS recovery facility during year y [tCO<sub>2</sub>e]
- $PE_{ODS\_Transport,y}$  = Project emission from ODS transportation during year y [tCO<sub>2</sub>e]
- $PE_{ODS\_Destruction,y}$  = Project emission from ODS destruction during year y [tCO<sub>2</sub>e]

Determination of  $PE_{Energy\_Consump,y}$ :

$$PE_{Energy\_Consump,y} = PE_{EC,y} + PE_{FC,j,y} \quad (15)$$

Where:

- $PE_{Energy\_Consump,y}$  = Project emissions from energy consumption attributable to the ODS recovery facility during year y [tCO<sub>2</sub>e]
- $PE_{EC,y}$  = Project emissions from electricity consumption from the grid at the ODS recovery facility during year y [tCO<sub>2</sub>e]
- $PE_{FC,j,y}$  = Project emissions from fossil fuel consumption attributable to the ODS recovery facility including third party used fossil fuel to generate energy for the ODS recovery facility during year y [tCO<sub>2</sub>e]

Determination of  $PE_{EC,y}$ :

$$PE_{EC,y} = EC_{PJ,y} \times EF_{grid,y} \times (1 + TDL_y) \quad (16)$$

Where:

- $PE_{EC,y}$  = Project emissions from electricity consumption from the grid at the ODS recovery facility during year y [tCO<sub>2</sub>e]
- $EC_{PJ,y}$  = Amount of electricity consumed at the ODS recovery facility from the grid during year y [MWh]
- $EF_{grid,y}$  = Grid emission factor during monitoring period y [tCO<sub>2</sub>e /MWh]
- $TDL_y$  = Average technical transmission and distribution losses in the grid for the voltage level at which electricity is obtained from the grid at the project site during year y [%;0-100%]

For determination of  $EF_{grid,y}$  the project proponent shall choose one of the following options:

- Calculate the combined margin emission factor, using the procedures in the latest approved version of the CDM “Tool to calculate the emission factor for an electricity system”; or
- Use a conservative default value of 1.3 tCO<sub>2</sub>/MWh

For determination of  $TDL_y$

- Use recent, accurate and reliable data available within the country; or
- Use a conservative default value of 20%

Determination of  $PE_{FC,j,y}$ :

$$PE_{FC,j,y} = \sum_i FC_{i,j,y} \times COEF_{i,y} \quad (17)$$

Where:

- $PE_{FC,j,y}$  = Project emissions from fossil fuel consumption attributable to the ODS recovery facility including third party used fossil fuel to generate energy for the ODS recovery facility during year y [tCO<sub>2</sub>e]
- $FC_{i,j,y}$  = Amount of fuel type i combusted in process j at the ODS recovery facility or at any third party generating energy for the ODS recovery facility during year y [mass or volume unit]
- $COEF_{i,y}$  = CO<sub>2</sub> emission coefficient of fuel type i in year y [tCO<sub>2</sub>e / mass or volume unit] i are the fuel types combusted in process j

The CO<sub>2</sub> emission coefficient  $COEF_{i,y}$  can be calculated according to two different procedures, depending on the available data about the fossil fuel type  $i$ :

- **Option A:** The CO<sub>2</sub> emission coefficient  $COEF_{i,y}$  is calculated based on the chemical composition of the fossil fuel type  $i$ , using the following approach:

If  $FC_{i,j,y}$  is measured in a mass unit:  $COEF_{i,y} = w_{C,i,y} \times 44/12$

If  $FC_{i,j,y}$  is measured in a volume unit:  $COEF_{i,y} = w_{C,i,y} \times \rho_{i,y} \times 44/12$

Where:

- $COEF_{i,y}$  = CO<sub>2</sub> emission coefficient of fuel type i during year y [tCO<sub>2</sub>e / mass or volume unit]
- $w_{C,i,y}$  = Weighted average mass fraction of carbon in fuel type i during year y [tC / mass unit of the fuel]
- $\rho_{i,y}$  = Weighted average density of fuel type i during year y [mass unit / volume unit of the fuel]

- **Option B:** The CO<sub>2</sub> emission coefficient  $COEF_{i,y}$  is calculated based on net calorific value and CO<sub>2</sub> emission factor of the fuel type  $i$ , as follows:

$$COEF_{i,y} = NCV_{i,y} \times EF_{CO_2,i,y} \quad (18)$$

Where:

- $COEF_{i,y}$  = CO<sub>2</sub> emission coefficient of fuel type i during year y [tCO<sub>2</sub>e / mass or volume unit]
- $NCV_{i,y}$  = Weighted average net calorific value of the fuel type i during year y [GJ/mass or volume unit]

$$EF_{CO_2,i,y} = \text{Weighted average CO}_2 \text{ emission factor of fuel type } i \text{ during year } y \text{ [tCO}_2\text{e /GJ]}$$

Where necessary data is available option A should be used.

Determination of  $PE_{ODS\_Transport,y}$  and  $PE_{ODS\_Destruction,y}$ :

For project emissions due to ODS transportation and destruction, the project proponent shall apply the default factors provided by the latest version of the *CAR Article 5 Ozone Depleting Substances Project Protocol: (Calculating Default Project Emissions from ODS Destruction and Transportation)*

$$PE_{ODS\_Transport,y} + PE_{ODS\_Destruction,y} = (M_{DESTR,refr,i,y} + M_{DESTR,foam,i,y}) \times EF_{ODS\_Transport+Destruction,y} \quad (19)$$

Where:

$PE_{ODS\_Transport,y}$	=	Project emission from ODS transportation during year y [tCO <sub>2</sub> e]
$PE_{ODS\_Destruction,y}$	=	Project emission from ODS destruction during year y [tCO <sub>2</sub> e]
$M_{DESTR,refr,i,y}$	=	Quantity of ODS refrigerant i sent for destruction by the project activity, including eligible and ineligible material, during year y [tODSi]
$M_{DESTR,foam,i,y}$	=	Quantity of ODS blowing agent i sent for destruction by the project activity, including eligible and ineligible material, during year y [tODSi]
$EF_{ODS\_Transport+Destruction,y}$	=	Default emission factor aggregating both transportation and destruction emissions [tCO <sub>2</sub> ] (sourced from CAR, as above)

### 8.3 Leakage

Leakage emissions occur where in the baseline ODS refrigerant would have been re-used and in the project scenario must be substituted by other chemicals. Reuse may result in a gradual release of ODS over the project crediting period. 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.

$$LE_{ODS\_Substitute,y} = \sum_i^n M_{Destr,refr,i,y} \times TLR_{substitute,i} \times GWP_{substitute,i} \quad (20)$$

Where:

$$LE_{ODS\_Substitute,y} = \text{Leakage emissions through ODS substitute } i \text{ during year } y \text{ [tCO}_2\text{e]}$$

- $M_{Destr,refr,i,y}$  = Quantity of ODS refrigerant i which is sent to destruction by the project activity in year y [tODSi]
- $TLR_{substitute,i}$  = Total leakage of substitute chemical i over the project crediting period [0-1]
- $GWP_{substitute,i}$  = Global warming potential of substitute chemical i [tonsCO<sub>2</sub>e/substitute,i]

$$TLR_{substitute,i} = 1 - (1 - LR_{substitute,i;y})^{tcp} \quad (21)$$

Where:

- $TLR_{substitute,i}$  = Total leakage of substitute chemical i over the project crediting period [0-1]
- $LR_{substitute,i;y}$  = Leak rate of substitute chemical i in year y [0-1]
- $tcp$  = Project crediting period

For project activities taking place in Article 5 countries, the project proponent shall apply a substitute chemical derived from either official published data, research, industry studies, or default values provided in the latest version of the *CAR Article 5 Ozone Depleting Substances Project Protocol*. The leak rate  $LR_{substitute,i;y}$  shall be obtained from either official published data, research, industry studies, or default values provided in the latest version of the *CAR Article 5 Ozone Depleting Substances Project Protocol*.

For project activities taking place in Non-Article 5 countries, the project proponent shall apply substitute chemicals derived from either official published data, research, industry studies, or default values provided in the latest version of the *CAR U.S. Ozone Depleting Substances Project Protocol*. The leak rate  $LR_{substitute,i;y}$  shall be obtained from either official published data, research, industry studies, or default values provided in the latest version of the *CAR U.S. Ozone Depleting Substances Project Protocol*.

#### 8.4 Net GHG Emission Reduction and Removals

Emission reductions are calculated as follows:

$$ER_{ODS,y} = BE_{ODS,refr,y} + BE_{ODS,foam,y} - PE_y - LE_y \quad (22)$$

Where:

- $ER_{ODS,y}$  = means total emission reductions during year y [tCO<sub>2</sub>e]

- $BE_{ODS\_refr,y}$  = means the baseline emissions from ODS refrigerants banks which would be released into the atmosphere in the absence of the project activity during year y [tCO<sub>2</sub>e]
- $BE_{ODS\_foam,y}$  = means baseline emissions from ODS blowing agents contained in insulation foams of refrigeration appliances which would be released into the atmosphere in the absence of the project activity during year y [tCO<sub>2</sub>e]
- $PE_y$  = means the project emissions by the project activity during year y [tCO<sub>2</sub>e]
- $LE_y$  = means the leakage emissions by the project activity during year y [tCO<sub>2</sub>e]

## 9 MONITORING

### 9.1 Data and Parameters Available at Validation

Data / Parameter:	$GWP_{ODSi}$ (refrigerants, blowing agents and substitute chemical)
Data unit:	tCO <sub>2</sub> e/tODS <sub>i</sub>
Description:	Global Warming Potential of ODS <sub>i</sub>
Source of data:	IPCC
Description of measurement methods and procedures to be applied:	See value Appendix I of this methodology for the first commitment period. Shall be updated according to any future COP/MOP decisions.
Comments:	

Data / Parameter:	$VR_{refr}$
Data unit:	% expressed as number [0-100%]
Description:	Rate of ODS refrigerants (destroyed) which would be vented into the atmosphere in the baseline
Source of data:	Default value(s) given below or project-specific rate(s) sourced from officially published country data, research studies, industry data, etc.  In non-Article 5 countries, it is conservatively assumed that no intentional venting occurs and all ODS refrigerant is either used, reused or stored as a stockpile. As such, the default rate is 0%.

	In Article 5 countries, the default rate is similarly 0% unless the project proponent demonstrates that all or a portion of the ODS refrigerant destroyed as part of the project was recovered from products at end-of-life. In the absence of any regulatory prohibition on venting, all ODS refrigerant recovered from products at end-of-life is assumed to be vented directly to the atmosphere (100%) in the baseline.
Description of measurement methods and procedures to be applied:	In Article 5 countries, maintain point of origin documentation to demonstrate the portion of ODS refrigerant sourced from products at end-of-life.
Comments:	Calculated as a cumulative rate over the 10-year period following ODS destruction.

Data / Parameter:	$DR_{refr}$
Data unit:	% expressed as number [0-100%]
Description:	Rate of ODS refrigerants (destroyed) which would be destroyed in the baseline
Source of data:	Default value given below or project-specific rate(s) sourced from officially published data, research studies, industry data, etc. In the absence of a government mandate, product stewardship scheme, or other program that creates an incentive or mechanism for ODS refrigerant destruction in the country(ies) where the project activity occurs, the default rate is 0%.
Description of measurement methods and procedures to be applied:	
Comments:	Calculated as a cumulative rate over the 10-year period following ODS destruction.

Data / Parameter:	$RR_{refr,i}$
Data unit:	% expressed as number [0-100%]
Description:	Rate of ODS refrigerant i (destroyed) which would be used, reused or remain in storage in the baseline

Source of data:	<p>Default value(s) given below or project-specific rate(s) sourced from officially published data, research studies, industry data, etc.</p> <p>In non-Article 5 countries, it is conservatively assumed that all ODS refrigerant recovered from products is recycled or reclaimed for reuse. If in a stockpile, it is assumed that the ODS refrigerant is used to recharge existing equipment, or in the case of a government stockpile of ODS refrigerant that cannot legally be sold into the commercial refrigerant market, remains in storage. As such, the default rate is 100%.</p> <p>In Article 5 countries, the default rate is similarly 100% unless the project proponent demonstrates that all or a portion of the ODS refrigerant destroyed as part of the project was recovered from products at end-of-life. The portion of ODS refrigerant not recovered from products at end-of-life is assumed to be recycled or reclaimed, used in existing equipment and/or remain in storage (as in the case of a government stockpile of ODS refrigerant that cannot legally be sold into the commercial refrigerant market).</p>
Description of measurement methods and procedures to be applied:	<p>Maintain point of origin documentation to demonstrate the quantity of ODS refrigerant sourced from a government stockpile that cannot legally be sold into the commercial refrigerant market.</p> <p>In Article 5 countries, maintain point of origin documentation to demonstrate the quantity of ODS refrigerant not sourced from products at end-of-life.</p>
Comments:	<p>Calculated as a cumulative rate over the 10-year period following ODS destruction.</p>

Data / Parameter:	$LR_{refr,i}$
Data unit:	% expressed as number [0-100%]
Description:	<p>Leak rate of ODS refrigerant <i>i</i> (destroyed), which would be used as refrigerant for existing equipment or remain in storage in the baseline</p>
Source of data:	<p>Default value(s) given below or project-specific rate(s) sourced from officially published data, research studies, industry data, etc.</p> <p>In non-Article 5 countries, default values for ODS refrigerant used or reused in existing equipment are the annual weighted average emission rates given in the latest version of the Climate Action Reserve's <i>U.S. ODS Project Protocol</i>.</p>

	<p>In Article 5 countries, default values for ODS refrigerant used or reused in existing equipment are the applicable annual emission rates given in the latest version of the Climate Action Reserve's <i>Article 5 ODS Project Protocol</i>.</p> <p>In the case of government stockpiles of ODS refrigerant that cannot legally be sold into the commercial refrigerant market and therefore remain in storage in either non-Article 5 or Article 5 countries, the default rate is 10%<sup>2</sup>.</p>
Description of measurement methods and procedures to be applied:	
Comments:	

Data / Parameter:	$ER_{foam,i}$
Data unit:	% expressed as number [0-100%]
Description:	Rate by which ODS blowing agents contained in foam of refrigeration appliances would be released into atmosphere based on the disposal practice (baseline) in the respective host country
Source of data:	<p>Depending on baseline scenario (BAF1-4). For BAF4.1-4.2 see scientific sources Appendix II to this methodology and/or default values provided by the latest version of the <i>Climate Action Reserve (CAR): U.S. Ozone Depleting Substances Project Protocol</i>.</p> <p>For baseline scenarios BAF4.3 and BAF4.4 officially published data, research studies or industry data shall be used.</p>
Description of measurement methods and procedures to be applied:	
Comments:	

<sup>2</sup> United Nations Environment Programme. (2013). Report on Progress and Experiences gained in Demonstration Projects for the Disposal of Unwanted ODS, Annex III. Executive Committee of the Multilateral Fund. Document No. 7054, Bangkok. Available at: <http://www.multilateralfund.org/70/English/1/7054.pdf>

Data / Parameter:	$LR_{substitute,i}$
Data unit:	% expressed as number [0-100%]
Description:	Leak rate of substitute chemical I in year y [0-1]
Source of data:	<p><u>For project activities taking place in Article 5 countries</u>, the leak rate shall be obtained from either official published data, research, industry studies, or default values provided in the latest version of the <i>CAR Article 5 Ozone Depleting Substances Project Protocol</i>.</p> <p><u>For project activities taking place in Non Article 5 countries</u>, officially published data, research studies, industry data, or default values from the latest version of the <i>CAR U.S. Ozone Depleting Substances Project Protocol</i> shall be used.</p>
Description of measurement methods and procedures to be applied:	
Comments:	

Data / Parameter:	Substitute chemical i
Data unit:	
Description:	Chemical i substituting ODS refrigerant i where in the baseline refrigerant ODS would have been re-used and in the project scenario must be substituted by other chemicals
Source of data:	<p><u>For project activities taking place in Article 5 countries</u>, the project proponent shall apply a substitute chemical derived from either official published data, research, industry studies, or default values provided in the latest version of the <i>CAR Article 5 Ozone Depleting Substances Project Protocol</i>.</p> <p><u>For project activities taking place in Non-Article 5 countries</u>, officially published data, research studies, industry data, or the latest version of the <i>CAR U.S. Ozone Depleting Substances Project Protocol</i> shall be used.</p>
Description of measurement methods and procedures to be applied:	
Comments:	

Data / Parameter:	$M_{app,1,foam,i,y}, M_{app,2,foam,i,y}, M_{app,3,foam,i,y}$
Data unit:	t ODSi/appliance type 1, 2 and 2
Description:	<p>Amount of blowing agent ODSi contained in foam of refrigeration appliance types 1-3 in host country</p> <ul style="list-style-type: none"> <li>• Type 1 appliances, <u>Domestic fridges</u>: These are refrigerators of a typical domestic design with a storage capacity of up to 180 litres. The appliances may or may not be equipped with a separate deep-freeze compartment.</li> <li>• Type 2 appliances, <u>Domestic fridge-freezers</u>: These are refrigeration appliances of a typical domestic design with a storage capacity ranging from 180 to 350 litres. Generally, these appliances have a separate deep-freeze compartment.</li> <li>• Type 3 appliances, <u>Domestic chest freezers and upright freezers</u>: These are deep-freeze appliances of a typical domestic design with a storage capacity up to 500 litres.</li> </ul>
Source of data:	If official national values are available those national values shall be used. In cases where no such official values are available it shall be determined by RAL <i>RAL Quality Assurance and Test Specifications for the Demanufacture of Refrigeration Equipment</i>
Description of measurement methods and procedures to be applied:	
Comments:	

Data / Parameter:	$EF_{ODS\_Transport+Destruction,y}$
Data unit:	tCO <sub>2</sub>
Description:	Default emission factor aggregating both transportation and destruction emissions
Source of data:	Provided by the latest version of the <i>CAR Article 5 Ozone Depleting Substances Project Protocol: (Calculating Default Project Emissions from ODS Destruction and Transportation)</i>
Description of measurement methods	

and procedures to be applied:	
Comments:	

## 9.2 Data and Parameters Monitored

Data / Parameter:	$M_{DESTR,refr,i,y}$
Data unit:	tODSi
Description:	Quantity of ODS refrigerant i destroyed by the project activity in year y
Source of data:	<ul style="list-style-type: none"> <li>• Operation logbook of recovery facility</li> <li>• Identification note for each individual ODS container by a bill of lading</li> <li>• Certificate of Destruction for each individual ODS container (refer to Section 9.3 of this methodology "Monitoring Methodology")</li> </ul>
Description of measurement methods and procedures to be applied:	Refer to Section 9.3 of this methodology "Monitoring Methodology"
Frequency of monitoring/recording:	Each container with ODS sent to destruction
QA/QC procedures to be applied:	All measurements should be conducted with calibrated measurement equipment according to relevant industry standards (refer to Section 9.3 of this methodology "Monitoring Methodology")
Comments:	

Data / Parameter:	$M_{DESTR,foam,i,y}$
Data unit:	tODSi
Description:	Quantity of ODS blowing agent i contained in insulation foams of refrigeration appliances destroyed by the project activity in year y
Source of data:	<ul style="list-style-type: none"> <li>• Operation logbook of recovery facility</li> <li>• Identification note for each individual ODS container by a bill of lading</li> </ul>

	<ul style="list-style-type: none"> <li>• Certificate of Destruction for each individual ODS container (refer to Section 9.3 of this methodology “Monitoring Methodology”)</li> </ul>
Description of measurement methods and procedures to be applied:	Refer to Section 9.3 of this methodology “Monitoring Methodology”
Frequency of monitoring/recording:	Each container with ODS sent to destruction
QA/QC procedures to be applied:	All measurements should be conducted with calibrated measurement equipment according to relevant industry standards (refer to section 9.3 of this methodology “Monitoring Methodology”)
Comments:	

Data / Parameter:	Input flow of appliances (and types) J, K, L into the section of the recovery facility where removal of foams and extraction of ODS blowing agents from foams takes place
Data unit:	Number of refrigeration appliances [Number] and mass unit [e.g. kg]
Description:	Documentation of all input flows into the section of the recovery facility where removal of foams and extraction of ODS from foams takes place according to appliance types (type 1 domestic fridges; type 2 domestic fridge-freezers; type 3 domestic chest freezers and upright freezers;) and by weight.
Source of data:	Operation logbook of recovery facility
Description of measurement methods and procedures to be applied:	Weight measured by calibrated weighing scales.
Frequency of monitoring/recording:	Continuous monitoring, recording monthly, once annually: Test of 1000 appliances
QA/QC procedures to be applied:	All measurements should be conducted with calibrated measurement equipment according to relevant industry standards
Comments:	

Data / Parameter:	Total weight of output fractions from the section of the recovery facility where removal of foams and extraction of ODS blowing agents from foams takes place (test procedure)
Data unit:	Mass unit [e.g. kg]
Description:	Documentation of output flows (type and weight) The following fractions shall be documented: <ul style="list-style-type: none"> <li>• Polyurethane</li> <li>• Ferrous metals</li> <li>• Non-ferrous metals</li> <li>• Plastics</li> <li>• Non-ferrous/plastic fraction</li> <li>• Residual waste</li> <li>• Process water</li> <li>• ODS blowing agents</li> <li>• Other components</li> </ul>
Source of data:	Operation logbook of the recovery facility
Description of measurement methods and procedures to be applied:	Weight measured by calibrated weighing scales.
Frequency of monitoring/recording:	Continuous monitoring, recording monthly, once annually: Test of 1000 appliances
QA/QC procedures to be applied:	All measurements should be conducted with calibrated measurement equipment according to relevant industry standards
Comments:	

Data / Parameter:	$CR_{ODSi,y}$
Data unit:	Number
Description:	Host country-level compliance rate of the law, statute or other regulatory framework in the year y in relation to ODSi. Calculation of the compliance rate shall exclude other projects implemented under GHG programs. If the compliance rate exceeds 50%, the project shall receive no further credit.
Source of data:	Officially published data, research studies, industry data etc...

Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Annually
QA/QC procedures to be applied:	
Comments:	

Data / Parameter:	$FC_{i,j,y}$
Data unit:	Mass or volume unit per year (e.g. ton/y or m <sup>3</sup> /y)
Description:	Quantity of fuel type i combusted in process j
Source of data:	Onsite measurements
Description of measurement methods and procedures to be applied:	<p>Use utility bills or invoices for purchased fuel, or alternatively, either mass or volume meters onsite. In cases where fuel is supplied from small daily tanks, rulers can be used to determine mass or volume of the fuel consumed, with the following conditions: The ruler gauge must be part of the daily tank and calibrated at least once a year and have a book of control for recording the measurements (on a daily basis or per shift);</p> <p>Accessories such as transducers, sonar and piezoelectronic devices are accepted if they are properly calibrated with the ruler gauge and receiving a reasonable maintenance;</p> <p>In case of daily tanks with pre-heaters for heavy oil, the calibration will be made with the system at typical operational conditions.</p>
Frequency of monitoring/recording:	Continuously
QA/QC procedures to be applied:	If onsite measurements are used, the consistency of metered fuel consumption quantities should be cross-checked by an annual energy balance that is based on purchased quantities and stock changes. Where the purchased fuel invoices can be identified specifically for the project activity, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial records.
Comments:	

Data / Parameter:	$W_{c,i,y}$						
Data unit:	ton C/mass unit of the fuel						
Description:	Weighted average mass fraction of carbon in fuel type i in year y						
Source of data:	<p>The following data sources may be used if the relevant conditions apply:</p> <table border="1"> <thead> <tr> <th>Data source</th> <th>Conditions for using the data source</th> </tr> </thead> <tbody> <tr> <td>a) Values provided by the fuel supplier in invoices</td> <td>Where relevant information is available use option a)</td> </tr> <tr> <td>b) Measurements by the project proponent</td> <td>If a) is not available</td> </tr> </tbody> </table>	Data source	Conditions for using the data source	a) Values provided by the fuel supplier in invoices	Where relevant information is available use option a)	b) Measurements by the project proponent	If a) is not available
Data source	Conditions for using the data source						
a) Values provided by the fuel supplier in invoices	Where relevant information is available use option a)						
b) Measurements by the project proponent	If a) is not available						
Description of measurement methods and procedures to be applied:	Measurements should be undertaken in line with national or international fuel standards.						
Frequency of monitoring/recording:	The mass fraction of carbon should be obtained for each fuel delivery, from which weighted average annual values should be calculated.						
QA/QC procedures to be applied:	Verify if the values under a) and b) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in b) should have ISO17025 accreditation or justify that they can comply with similar quality standards.						
Comments:	Applicable where option A is used						

Data / Parameter:	$\rho_{i,y}$				
Data unit:	Mass unit/volume unit				
Description:	Weighted average density of fuel type i in year y				
Source of data:	<p>The following data sources may be used if the relevant conditions apply:</p> <table border="1"> <thead> <tr> <th>Data source</th> <th>Conditions for using the data source</th> </tr> </thead> <tbody> <tr> <td>a) Values provided by the fuel supplier in invoices</td> <td>Where relevant information is available use option a)</td> </tr> </tbody> </table>	Data source	Conditions for using the data source	a) Values provided by the fuel supplier in invoices	Where relevant information is available use option a)
Data source	Conditions for using the data source				
a) Values provided by the fuel supplier in invoices	Where relevant information is available use option a)				

	b) Measurements by the project proponent	If a) is not available
	c) Regional or national default values	If a) is not available These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances).
Description of measurement methods and procedures to be applied:	Measurements should be undertaken in line with national or international fuel standards.	
Frequency of monitoring/recording:	The density of the fuel should be obtained for each fuel delivery, from which weighted average annual values should be calculated.	
QA/QC procedures to be applied:		
Comments:	Applicable where option A is used and where $FC_{i,j,y}$ is measured in a volume unit. Preferably the same data source should be used for $W_{C,i,y}$ and $\rho_{i,y}$ .	

Data / Parameter:	$NCV_{i,y}$	
Data unit:	GJ per mass or volume unit (e.g. GJ/m <sup>3</sup> , GJ/ton)	
Description:	Weighted average net calorific value of fuel type i in year y	
Source of data:	The following data sources may be used if the relevant conditions apply:	
	<b>Data source</b>	<b>Conditions for using the data source</b>
	a) Values provided by the fuel supplier in invoices	Where relevant information is available use option a)
	b) Measurements by the project proponent	If a) is not available
	c) Regional or national default values	If a) is not available. These sources can only be used for liquid fuels and should be based on well documented,

		reliable sources (such as national energy balances).
	d) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If a) is not available
Description of measurement methods and procedures to be applied:	For a) and b): Measurements should be undertaken in line with national or international fuel standards	
Frequency of monitoring/recording:	For a) and b): The NCV should be obtained for each fuel delivery, from which weighted average annual values should be calculated For c): Review appropriateness of the values annually For d): Any future revision of the IPCC Guidelines should be taken into account	
QA/QC procedures to be applied:	Verify if the values under a), b) and c) are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in a), b) or c) should have ISO17025 accreditation or justify that they can comply with similar quality standards.	
Comments:	Applicable where option B of this methodology is used	

Data / Parameter:	$EF_{CO_2,i,y}$	
Data unit:	tCO <sub>2</sub> /GJ	
Description:	Weighted average CO <sub>2</sub> emission factor of fuel type i in year y	
Source of data:	The following data sources may be used if the relevant conditions apply:	
	<b>Data source</b>	<b>Conditions for using the data source</b>
	a) Values provided by the fuel supplier in invoices	Where relevant information is available use option a).

	b) Measurements by the project proponents	If a) is not available
	c) Regional or national default values	If a) is not available These sources can only be used for liquid fuels and should be based on well documented, reliable sources (such as national energy balances).
	d) IPCC default values at the upper limit of the uncertainty at a 95% confidence interval as provided in table 1.4 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories	If a) is not available
Description of measurement methods and procedures to be applied:	For a) and b): Measurements should be undertaken in line with national or international fuel standards.	
Frequency of monitoring/recording:	For a) and b): The CO <sub>2</sub> emission factor should be obtained for each fuel delivery, from which weighted average annual values should be calculated For c): Review appropriateness of the values per monitoring interval y For d): Any future revision of the IPCC Guidelines should be taken into account	
QA/QC procedures to be applied:		
Comments:	Applicable where option B is used. For a): If the fuel supplier does provide the NCV value and the CO <sub>2</sub> emission factor on the invoice and these two values are based on measurements for this specific fuel, this CO <sub>2</sub> factor should be used. If another source for the CO <sub>2</sub> emission factor is used or no CO <sub>2</sub> emission factor is provided, options b), c) or d) should be used	

Data / Parameter:	$EC_{PJ,y}$
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Data unit:	MWh
Description:	Amount of electricity consumed at the ODS recovery facility from the grid during year y
Source of data:	Onsite measurements and recorded by a computer system and/or by printed journals; or, alternatively, utility bills or invoices for purchased electricity
Description of measurement methods and procedures to be applied:	Directly measured by calibrated electricity meter installed at the project site.
Frequency of monitoring/recording:	Continuously, aggregated at least annually
QA/QC procedures to be applied:	If onsite measurements are used, cross check measurement results with invoices for purchased electricity if relevant
Comments:	

Data / Parameter:	$EF_{grid,y}$
Data unit:	tons CO <sub>2</sub> /MWh
Description:	Grid emission factor during the monitoring period y
Source of data:	Choose one of the following options: <ul style="list-style-type: none"> <li>Calculate the combined margin emission factor, using the procedures in the latest approved version of the CDM “Tool to calculate the emission factor for an electricity system”;</li> </ul> Use a conservative default value of 1.3 tCO <sub>2</sub> /MWh.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	
QA/QC procedures to be applied:	If the “Tool to calculate the emission factor for an electricity system” will be used the source and/or the calculation shall be available by printed journals.
Comments:	

Data / Parameter:	$TDL_y$
Data unit:	
Description:	Average technical transmission and distribution losses in the grid for the voltage level at which electricity is obtained from the grid at the project site during year y
Source of data:	Choose one of the following options: a) Use recent, accurate and reliable data available within the country; b) Use a default value of 20%
Description of measurement methods and procedures to be applied:	For a) $TDL_y$ should be estimated for the distribution and transmission networks of the electricity grid of the same voltage as the connection where the proposed project activity is connected to. The technical distribution losses should not contain other types of grid losses (e.g. commercial losses/theft). The distribution losses can either be calculated by the project proponent or be based on references from utilities, network operators or other official documentation.
Frequency of monitoring/recording:	
QA/QC procedures to be applied:	In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years.
Comments:	

### 9.3 Description of the Monitoring Plan<sup>3</sup>

#### Composition and Quantity Analysis Requirements

The requirements of this section must be followed to determine the quantities of both ODS refrigerants and ODS blowing agents. 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

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<sup>3</sup> This section is mainly based on Climate Action Reserve (CAR): U.S. Ozone Depleting Substances Project Protocol Version 2 February 27 2012 and on RAL Quality Assurance and Test Specifications for the Demanufacture of Refrigeration Equipment version: 2007/09

2. After it has been emptied and the contents have been fully purged and destroyed. The mass of ODS and any contaminants is equal to the difference between the full and empty weight, as measured

The following requirements must be met when weighing the containers of ODS:

1. A single scale must be used for generating both the full and empty weight tickets at the destruction facility
2. Weighing instruments must comply with the relevant national requirements and/or international standards – such as EC Directive 2009/23/EC or International Organization for Legal Metrology OIML R 76-1 – and be subject to regular calibration, as set out in the relevant national requirements and/or international standards to accuracy appropriate to its accuracy class. These instruments shall have a measuring range corresponding to the capacity of containers and tanks weighed. If a scale is found to be out of tolerance, it must be recalibrated.
3. The full weight must be measured no more than two days prior to commencement of destruction per the Certificate of Destruction
4. The empty weight must be measured no more than two days after the conclusion of destruction per the Certificate of Destruction

Composition and concentration of ODS shall be established for each individual container by taking a sample from each container of ODS and having it analyzed for composition and concentration at a lab accredited to perform analyses in compliance with the applicable International Organization for Standardization (ISO) standard or equivalent standards. Further, where national standards exist they may be used in lieu of ISO standards provided that they have been the subject of a verification or validation process addressing their accuracy and representativeness. In the case where no such standards exist, the US Air-Conditioning, Heating and Refrigeration Institute 700-2006 standard shall be applied.

The laboratory performing the composition analysis must not be affiliated with the project proponent or the project activities beyond performing these services.

The following requirements must be met for each sample:

1. The sample must be taken while ODS is in the possession of the company that will destroy the ODS
2. Samples must be taken by a technician unaffiliated with the project developer
3. Samples must be taken with a clean, fully evacuated sample bottle that meets applicable U.S. DOT requirements or an equivalent national (host country) or ISO standard
4. The technician must ensure that the sample is representative of the contents of the container

5. Each sample must be taken in liquid state
6. A minimum sample size of 0.453592 kg (1 pound) must be drawn for each sample
7. Each sample must be individually labeled and tracked according to the container from which it was taken, and the following information recorded:
  - Time and date of sample
  - Name of project developer
  - Name of technician taking sample
  - Employer of technician taking sample
  - Volume of container from which sample was extracted
  - Ambient air temperature at time of sampling
8. Chain of custody for each sample from the point of sampling lab must be documented by paper bills of lading or electronic, third-party tracking that includes proof of delivery

All project samples shall be analyzed using the International Organization for Standardization (ISO) standard applicable. Further, where national standards exist they may be used in lieu of ISO standards provided that they have been the subject of a verification or validation process addressing their accuracy and representativeness. In the case where no such standards exist, the US Air-Conditioning, Heating and Refrigeration Institute 700-2006 standard shall be applied. 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 based on the temperature recorded at the time the sample was taken. For containers that hold mixed ODS, the sample's saturation point shall be assumed to be that of the ODS species in the mixture with the lowest saturation point that is at least 10 percent of the mixture by mass.
4. Analysis of high boiling residue, which must be less than 10% by mass
5. Analysis of other ODS in the case of mixtures of ODS, and their percentage by mass

If any of the requirements above are not met, no GHG reductions may be verified for ODS destruction associated with that container. If a sample is tested and does not meet one of the requirements as defined above, the project proponent may elect to have the material re-sampled and re-analyzed. The project proponent may sample for moisture content and perform any necessary de-watering prior to the required sampling and laboratory analysis.

If the container holds non-mixed ODS (defined as greater than 90% composition of a single ODS species) no further information or sampling is required to determine the mass and composition of the ODS. If the container holds mixed ODS, which is defined as less than 90% composition of a single ODS species, the project proponent must meet additional requirements as provided below.

### **Composition and Quantity Analysis Requirements for Mixed ODS**

If a container holds mixed ODS, its contents must also be processed and measured for composition and concentration according to the requirements of this section. 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 proponent), and by individuals who have been properly trained for the functions they perform. Circulation and sampling may be conducted at the project proponent's facility, but all activities must be directed by a properly trained and contracted third-party. The project description must specify the procedures by which mixed ODS are analyzed.

The composition and concentration of ODS on a mass basis must be determined using the results of the analysis of this section for each container. The results of the composition analysis in the section above shall be used by verifiers to confirm that the destroyed ODS is in fact the same ODS that is sampled under these requirements. Prior to sampling, the ODS mixture must be circulated in a container that meets all of the following criteria:

1. The container has no solid interior obstructions<sup>4</sup>
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 liquid port intake must be at the bottom of the container, and the vapor port intake must be at the top of the container. For horizontally-oriented mixing containers, the intakes must be located in the middle third of the container
5. The container and associated equipment can circulate the mixture via a closed loop system from the bottom to 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 that ODS (see 40 CFR 82.156) or any national (host country) or ISO standard.

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<sup>4</sup> Mesh baffles or other interior structures that do not impede the flow of ODS are acceptable.

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 113.6l/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 and analyzed according to the procedures above. The mass composition and concentration of the mixed ODS shall be equal to the lesser of the two GWP-weighted concentrations.

### **Determination of Recovery Efficiency of Blowing Agents Contained in Foam of Refrigeration Appliances**

An annual test shall be conducted in which at least 1000 refrigeration appliances with ODS containing insulation materials are processed at the recovery facility of the project proponent.

Every appliance used in the test shall be intact, i.e. there shall be no damage to the appliance carcass and the doors typical of that appliance type shall still be attached. No other doors, appliance components or other products containing foam insulation shall be processed during the test. Systematically sorting out refrigeration appliances from the mass flow of incoming devices for the purpose of manipulating the quantity of recovered ODS is strictly forbidden.

To compile a mass balance analysis, the total weight of all the appliances used in the test shall be determined and recorded. In addition, the weight of all material fractions recovered from the processing plant during the test shall be determined.

- Polyurethane
- Ferrous metals
- Non-ferrous metals
- Plastics
- Non-ferrous/plastic fraction
- Residual waste
- Process water
- ODS
- Other components

The gas cylinders used to store the recovered ODS are weighed when empty (i.e. before processing commences) and again when filled (i.e. after processing has been completed). The dry weight in kilograms of ODS recovered is divided by the number of appliances processed. The result is recorded as the quantity of ODS recovered in grams per appliance.

The quantities of ODS blowing agents to be recovered for each appliance type (domestic fridge, domestic fridge-freezers, domestic chest freezers and upright freezers) as specified in Section 3, "Definitions" shall be sourced from official national values. In cases where no such official values are available it shall be determined by RAL *RAL Quality Assurance and Test Specifications for the Demanufacture of Refrigeration Equipment*. The recovery facility must achieve a recovery efficiency of at least 90% otherwise no credits can be generated for the respective monitoring period.

The RAL test protocol shall be used for the annual test.

Since this methodology requires the extraction of ODS from the foam to a concentrated form prior to destruction the overall Recovery and Destruction Efficiency will be achieved when the destruction facility meets the requirements of *UNEP Technology and Economic Assessment Panel (TEAP) Report of the Task Force on Destruction Technologies*, UNEP, 2002. A minimum Recovery and Destruction Efficiency (RDE) of 85% shall be achieved otherwise no credits can be generated for the respective monitoring period.

### **Destruction Facility Requirements**

Destruction of ODS must occur at a facility that has a valid host country permit for ODS destruction and meets the screening criteria for destruction technologies set out in the report, as may be updated from time to time, by the UNEP Technology and Economic Assessment Panel (TEAP) Task Force on Destruction Technologies (reproduced in full in Appendix III from *TEAP Report of the Task Force on Destruction Technologies*, Chapter 2 (2002)).

Operating parameters of the destruction unit while destroying ODS material shall be monitored and recorded as described in the Code of Good Housekeeping<sup>5</sup> (as reproduced in full in Appendix II) approved by the Montreal Protocol.

## **10 REFERENCES**

Scheutz, C. et al. (2007a) Release of fluorocarbons from insulation foam in home appliances during shredding. *J of the Air & Waste Mgmt Assn*, 57: 1452-1460

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<sup>5</sup> TEAP, Code of Good Housekeeping in *Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer - 7th Edition* (2006)

Scheutz, C., et al. (2007b) Attenuation of insulation foam released fluorocarbons in landfills. *Environ Sci & Tech.*, 41:7714-7722)

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

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

*UNEP Technology and Economic Assessment Panel (TEAP) Report of the Task Force on Destruction Technologies*, UNEP, 2002. Available at:  
[http://ozone.unep.org/teap/Reports/Other\\_Task\\_Force/TEAP02V3b.pdf](http://ozone.unep.org/teap/Reports/Other_Task_Force/TEAP02V3b.pdf)

## APPENDIX I: ODS (ANNEX I, GROUPS) AND THEIR GWP

Substance terms and ODP (Ozone-Depleting Potential) values and based on The Montreal Protocol on Substances that Deplete the Ozone Layer <http://ozone.unep.org/en/handbook-montreal-protocol-substances-deplete-ozone-layer/27571>

GWP (Global warming potential) values based on the IPCC Fourth assessment report 2007 - Working group I report "The physical science basis of climate change" - Chapter 2 "Changes in Atmospheric Constituents and in Radiative Forcing" table 2.14/page 212 <http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-chapter2.pdf>

<b>Annex A: Controlled substances – Group I</b>			
<b>Substance</b>		<b>ODP</b> Ozone-Depleting Potential	<b>GWP</b> Global warming potential for 100 year Kyoto time horizon
CFCI3	CFC-11	1.0	4750
CF2CI2	CFC-12	1.0	10900
C2F3CI3	CFC-113	0.8	6130
C2F4CI2	CFC-114	1.0	10000
C2F5CI	CFC-115	0.6	7370

<b>Annex B: Controlled substances – Group I</b>			
<b>Substance</b>		<b>ODP</b> Ozone-Depleting Potential	<b>GWP</b> Global warming potential for 100 year Kyoto time horizon
CF3CI	CFC-13	1.0	14400
C2FCI5	CFC-111	1.0	n.a.
C2F2CI4	CFC-112	1.0	n.a.
C3FCI7	CFC-211	1.0	n.a.
C3F2CI6	CFC-212	1.0	n.a.
C3F3CI5	CFC-213	1.0	n.a.
C3F4CI4	CFC-214	1.0	n.a.
C3F5CI3	CFC-215	1.0	n.a.

C3F6Cl2	CFC-216	1.0	n.a.
C3F7Cl	CFC-217	1.0	n.a.

<b>Annex C: Controlled substances – Group I</b>			
<b>Substance</b>		<b>ODP</b> Ozone-Depleting Potential	<b>GWP</b> Global warming potential for 100 year Kyoto time horizon
CHFCl2	HCFC-21**	0.04	
CHF2Cl	HCFC-22**	0.055	1810
CH2FCI	HCFC-31	0.02	n.a.
C2HFCl4	HCFC-121	0.01-0.04	n.a.
C2HF2Cl3	HCFC-122	0.02-0.08	n.a.
C2HF3Cl2	HCFC-123	0.02-0.06	n.a.
CHCl2CF3	HCFC-123**	0.02	77
C2HF4Cl	HCFC-124	0.02-0.04	n.a.
CHFClCF3	HCFC-124**	0.022	609
C2H2FCI3	HCFC-131	0.007-0.05	n.a.
C2H2F2Cl2	HCFC-132	0.008-0.05	n.a.
C2H2F3Cl	HCFC-133	0.02-0.06	n.a.
C2H3FCI2	HCFC-141	0.005-0.07	n.a.
CH3CFCl2	HCFC-141b**	0.11	725
C2H3F2Cl	HCFC-142	0.008-0.07	n.a.
CH3CF2Cl	HCFC-142b**	0.065	2310
C2H4FCI	HCFC-151	0.003-0.005	n.a.
C3HFCl6	HCFC-221	0.015-0.07	n.a.
C3HF2Cl5	HCFC-222	0.01-0.09	n.a.
C3HF3Cl4	HCFC-223	0.01-0.08	n.a.
C3HF4Cl3	HCFC-224	0.01-0.09	n.a.
C3HF5Cl2	HCFC-225	0.02-0.07	n.a.
CF3CF2CHCl2	HCFC- 225ca**	0.025	122

CF2ClCF2CHClF	HCFC-225cb**	0.033	595
C3HF6Cl	HCFC-226	0.02-0.10	n.a.
C3H2FCl5	HCFC-231	0.05-0.09	n.a.
C3H2F2Cl4	HCFC-232	0.008-0.10	n.a.
C3H2F3Cl3	HCFC-233	0.007-0.23	n.a.
C3H2F4Cl2	HCFC-234	0.01-0.28	n.a.
C3H2F5Cl	HCFC-235	0.03-0.52	n.a.
C3H3FCl4	HCFC-241	0.004-0.09	n.a.
C3H3F2Cl3	HCFC-242	0.005-0.13	n.a.
C3H3F3Cl2	HCFC-243	0.007-0.12	n.a.
C3H3F4Cl	HCFC-244	0.009-0.14	n.a.
C3H4FCl3	HCFC-251	0.001-0.01	n.a.
C3H4F2Cl2	HCFC-252	0.005-0.04	n.a.
C3H4F3Cl	HCFC-253	0.003-0.03	n.a.
C3H5FCl2	HCFC-261	0.002-0.02	n.a.
C3H5F2Cl	HCFC-262	0.002-0.02	n.a.
C3H6FCl	HCFC-271	0.001-0.03	n.a.

\*\* Identifies the most commercially viable substances with ODP values listed against them to be used for the purposes of the Montreal Protocol.

## APPENDIX II: CODE OF GOOD HOUSEKEEPING<sup>6</sup>

To provide additional guidance to facility operators, in May 1992 the Technical Advisory Committee prepared a “Code of Good Housekeeping” as a brief outline of measures that should be considered to ensure that environmental releases of ozone-depleting substances (ODS) through all media are minimized. This Code, updated by the Task Force on Destruction Technologies and amended by the Parties at their Fifteenth Meeting, in 2003, is also intended to provide a framework of practices and measures that should normally be adopted at facilities undertaking the destruction of ODS.

Not all measures will be appropriate to all situations and circumstances and, as with any code, nothing specified should be regarded as a barrier to the adoption of better or more effective measures if these can be identified.

### **Pre-delivery**

This refers to measures that may be appropriate prior to any delivery of ODS to a facility.

The facility operator should generate written guidelines on ODS packaging and containment criteria, together with labelling and transportation requirements. These guidelines should be provided to all suppliers and senders of ODS prior to agreement to accept such substances.

The facility operator should seek to visit and inspect the proposed sender’s stocks and arrangements prior to movement of the first consignment. This is to ensure awareness on the part of the sender of proper practices and compliance with standards.

### **Arrival at the facility**

This refers to measures that should be taken at the time ODS are received at the facility gate. These include an immediate check of documentation prior to admittance to the facility site, coupled with a preliminary inspection of the general condition of the consignment. Where necessary, special or “fast-track” processing and repackaging facilities may be needed to mitigate risk of leakage or loss of ODS. Arrangements should exist to measure the gross weight of the consignment at the time of delivery.

### **Unloading from delivery vehicle**

This refers to measures to be taken at the facility in connection with the unloading of ODS. It is generally assumed that ODS will normally be delivered in some form of container, drum or other vessel that is removed from the delivery vehicle in total. Such containers may be returnable.

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<sup>6</sup> Reproduced in full from: TEAP, Code of Good Housekeeping in *Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer - 7th Edition* (2006)

All unloading activities should be carried out in properly designated areas, to which restricted access of personnel applies. Areas should be free of extraneous activities likely to lead to, or increase the risk of, collision, accidental dropping, spillage, etc. Materials should be placed in designated quarantine areas for subsequent detailed checking and evaluation.

### **Testing and verification**

This refers to the arrangements made for detailed checking of the ODS consignments prior to destruction.

Detailed checking of delivery documentation should be carried out, along with a complete inventory, to establish that delivery is as advised and appears to comply with expectations.

Detailed checks of containers should be made both in respect of accuracy of identification labels, etc, and of physical condition and integrity. Arrangements must be in place to permit repackaging or “fast-track” processing of any items identified as defective. Sampling and analysis of representative quantities of ODS consignments should be carried out to verify material type and characteristics. All sampling and analysis should be conducted using approved procedures and techniques.

### **Storage and stock control**

This refers to matters concerning the storage and stock control of ODS.

ODS materials should be stored in specially designated areas, subject to the regulations of the relevant local authorities. Arrangements should be put in place as soon as possible to minimize, to the extent practicable, stock emissions prior to destruction.

Locations of stock items should be identified through a system of control that should also provide a continuous update of quantities and locations as stock is destroyed and new stock delivered. In regard to storage vessels for concentrated sources of ODS, these arrangements should include a system for regular monitoring and leak detection, as well as arrangements to permit repackaging of leaking stock as soon as possible.

### **Measuring quantities destroyed**

It is important to be aware of the quantities of ODS processed through the destruction equipment. Where possible, flow meters or continuously recording weighing equipment for individual containers should be employed. As a minimum, containers should be weighed “full” and “empty” to establish quantities by difference.

Residual quantities of ODS in containers that can be sealed and are intended to be returned for further use, may be allowed. Otherwise, containers should be purged of residues or destroyed as part of the process.

## Facility design

This refers to basic features and requirements of plant, equipment and services deployed in the facility.

In general, any destruction facility should be properly designed and constructed in accordance with the best standards of engineering and technology and with particular regard to the need to minimize, if not eliminate, fugitive losses.

Particular care should be taken when designing plants to deal with dilute sources such as foams. These may be contained in refrigeration cabinets or may be part of more general demolition waste. The area in which foam is first separated from other substrates should be fully enclosed wherever possible and any significant emissions captured at that stage.

*Pumps:* Magnetic drive, sealers or double mechanical seal pumps should be installed to eliminate environmental releases resulting from seal leakage.

*Valves:* Valves with reduced leakage potential should be used. These include quarter-turn valves or valves with extended packing glands.

*Tank vents (including loading vents):* Filling and breathing discharges from tanks and vessels should be recovered or vented to a destruction process.

*Piping joints:* Screwed connections should not be used and the number of flanged joints should be kept to the minimum that is consistent with safety and the ability to dismantle for maintenance and repair.

*Drainage systems:* Areas of the facility where ODS are stored or handled should be provided with sloped concrete paving and a properly designed collection system. Water that is collected should, if contaminated, be treated prior to authorized discharge.

## Maintenance

In general, all maintenance work should be performed according to properly planned programmes and should be executed within the framework of a permit system to ensure proper consideration of all aspects of the work.

ODS should be purged from all vessels, mechanical units and pipework prior to the opening of these items to the atmosphere. The contaminated purge should be routed to the destruction process or treated to recover the ODS.

All flanges, seals, gaskets and other sources of minor losses should be checked routinely to identify developing problems before containment is lost. Leaks should be repaired as soon as possible.

Consumable or short-life items, such as flexible hoses and couplings, must be monitored closely and replaced at a frequency that renders the risk of rupture negligible.

### **Quality control and quality assurance**

All sampling and analytical work connected with ODS, the process and the monitoring of its overall performance should be subject to quality assessment and quality control measures in line with current recognized practices. This should include at least occasional independent verification and confirmation of data produced by the facility operators.

Consideration should also be given to the adoption of quality management systems and environment quality practices covering the entire facility.

### **Training**

All personnel concerned with the operation of the facility (with “operation” being interpreted in its widest sense) should have training appropriate to their task. Of particular relevance to the ODS destruction objectives is training in the consequences of unnecessary losses and in the use, handling and maintenance of all equipment in the facility. All training should be carried out by suitably qualified and experienced personnel and the details of such training should be maintained in written records. Refresher training should be conducted at appropriate intervals.

### **Code of transportation**

In the interest of protecting the stratospheric ozone layer, it is essential that used ODS and products containing ODS are collected and moved efficiently to facilities practising approved destruction technologies. For transportation purposes, used ODS should receive the same hazard classification as the original substances or products. In practice, this may introduce restrictions on hazardous waste shipment under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal and this should be consulted separately. In the absence of such specific restrictions, the following proposed code of transportation for ODS from customer to destruction facilities is provided as a guide to help minimize damage caused to the ozone layer as a result of ODS transfers. Additional guidance is contained in the United Nations Transport of Dangerous Goods Model Regulations.

It is important to supervise and control all shipments of used ODS and products containing ODS according to national and international requirements to protect the environment and human health. To ensure that ODS and products containing ODS do not constitute an unnecessary risk, they must be properly packaged and labelled. Instructions to be followed in the event of danger or accident must accompany each shipment to protect human beings and the environment from any danger that might arise during the operation.

Notification of the following information should be provided at any intermediate stage of the shipment from the place of dispatch until its final destination. When making notification, the notifier should supply the information requested on the consignment note, with particular regard to:

- a. The source and composition of the ODS and products containing ODS, including the customer's identity;

- b. Arrangements for routing and for insurance against damage to third parties;
- c. Measures to be taken to ensure safe transport and, in particular, compliance by the carrier with the conditions laid down for transport by the States concerned;
- d. The identity of the consignee, who should possess an authorized centre with adequate technical capacity for the destruction;
- e. The existence of a contractual agreement with the consignee concerning the destruction of ODS and products containing ODS.

This code of transportation does not necessarily apply to the disposal of ODS-containing rigid insulation foams. The most appropriate way to dispose of such products may be by direct incineration in municipal waste incinerators or rotary kiln incinerators.

### **Monitoring**

The objectives of monitoring should be to provide assurance that input materials are being destroyed with an acceptable efficiency generally consistent with the destruction and removal efficiency (DRE) recommendations listed in annex II to the present report and that the substances resulting from destruction yield environmentally acceptable emission levels consistent with, or better than, those required under national standards or other international protocols or treaties.

As there are as yet no International Organization for Standardization (ISO) standards applicable for the sampling and analysis of ODS or the majority of the other pollutants listed in annex IV to the present report, where national standards exist they should be employed. Further, where national standards exist they may be used in lieu of ISO standards provided that they have been the subject of a verification or validation process addressing their accuracy and representativeness.

As ISO develops international standards for pollutants listed in annex IV to the present report, the technical bodies charged with developing such standards should take note of the existing national standards including those identified in appendix F to the report of the Technology and Economic Assessment Panel (TEAP) of April 2002 (volume 3, report of the Task Force on Destruction Technologies) and strive to ensure consistency between any new ISO standards and the existing standard test methods, provided that there is no finding that those existing methods are inaccurate or unrepresentative.

Where national standards do not exist, the Technical Advisory Committee recommends adoption of the following guidelines for monitoring of destruction processes operating using an approved technology.

Recognizing that the United States of America Environmental Protection Agency (EPA) methods have been the subject of verification procedures to ensure that they are reasonably accurate and representative, that they cover all of the pollutants of interest (although not all ODS compounds have been the specific subject of verification activities), that they provide a comprehensive level of detail that should lead to replicability of the methods by trained personnel in other jurisdictions and that they are

readily available for reference and downloading from the Internet without the payment of a fee, applicable EPA methods as described in appendix F to the 2002 report of TEAP may be employed.

In the interest of ensuring a common international basis of comparison for those pollutants or parameters where ISO standards exist (currently particulates, carbon monoxide, carbon dioxide and oxygen), use of those standards is encouraged and jurisdictions are encouraged to adopt them as national standards or acceptable alternatives to existing national standards.

The use of EPA or other national standards described in appendix F is also considered acceptable, however. The precedence given to the EPA methods in the present code is based on the relative comprehensiveness of the methods available (both in scope and content), and the relative ease of access to those methods.

### **Measurement of ODS**

Operators of destruction facilities should take all necessary precautions concerning the storage and inventory control of ODS-containing material received for destruction. Prior to feeding the ODS to the approved destruction process, the following procedures are recommended:

- a. The mass of the ODS-containing material should be determined, where practicable;
- b. Representative samples should be taken, where appropriate, to verify that the concentration of ODS matches the description given on the delivery documentation;
- c. Samples should be analysed by an approved method. If no approved methods are available, the adoption of United States EPA methods 5030 and 8240 is recommended;
- d. All records from these mass and ODS-concentration measurements should be documented and kept in accordance with ISO 9000 or equivalent.

### **Control systems**

Operators should ensure that destruction processes are operated efficiently to ensure complete destruction of ODS to the extent that it is technically feasible for the approved process. This will normally include the use of appropriate measurement devices and sampling techniques to monitor the operating parameters, burn conditions and mass concentrations of the pollutants that are generated by the process.

Gaseous emissions from the process need to be monitored and analysed using appropriate instrumentation. This should be supplemented by regular spot checks using manual stack-sampling methods. Other environmental releases, such as liquid effluents and solid residues, require laboratory analysis on a regular basis.

The continuous monitoring recommended for ongoing process control, including off-gas cleaning systems, is as follows:

- a. Measurement of appropriate reaction and process temperatures;

- b. Measurement of flue gas temperatures before and after the gas cleaning system;
- c. Measurement of flue gas concentrations for oxygen and carbon monoxide.

Any additional continuous monitoring requirements are subject to the national regulatory authority that has jurisdiction. The performance of online monitors and instrumentation systems must be periodically checked and validated. When measuring detection limits, error values at the 95 per cent confidence level should not exceed 20 per cent.

Approved processes must be equipped with automatic cut-off control systems on the ODS feed system, or be able to go into standby mode whenever:

- a. The temperature in the reaction chamber falls below the minimum temperature required to achieve destruction;
- b. Other minimum destruction conditions stated in the performance specifications cannot be maintained.

### **Performance measurements**

The approval of technologies recommended by TEAP is based on the destruction capability of the technology in question. It is recognized that the parameters may fluctuate during day-to-day operation from this generic capability. In practice, however, it is not possible to measure against performance criteria on a daily basis. This is particularly the case for situations where ODS only represents a small fraction of the substances being destroyed, thereby requiring specialist equipment to achieve detection of the very low concentrations present in the stack gas. It is therefore not uncommon for validation processes to take place annually at a given facility.

With this in mind, TEAP is aware that the measured performance of a facility may not always meet the criteria established for the technology. Nonetheless, TEAP sees no justification for reducing the minimum recommendations for a given technology. Regulators, however, may need to take these practical variations into account when setting minimum standards.

The ODS destruction and removal efficiency<sup>7</sup> for a facility operating an approved technology should be validated at least once every three years. The validation process should also include an assessment of other relevant stack gas concentrations identified in annex II to decision XV/[...] and a comparison with maximum levels stipulated in relevant national standards or international protocols/treaties.

Determination of the ODS destruction and removal efficiency and other relevant substances identified in annex IV to the present report should also be followed when commissioning a new or rebuilt facility or

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<sup>7</sup> Destruction and removal efficiency 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

when any other significant change is made to the destruction procedures in a facility to ensure that all facility characteristics are completely documented and assessed against the approved technology criteria.

Tests shall be done with known feed rates of a given ODS compound or with well-known ODS mixtures. In cases where a destruction process incinerates halogen-containing wastes together with ODS, the total halogen load should be calculated and controlled. The number and duration of test runs should be carefully selected to reflect the characteristics of the technology.

In summary, the destruction and removal efficiency recommended for concentrated sources means that less than 0.1 gram of total ODS should normally enter the environment from stack-gas emissions when 1,000 grams of ODS are fed into the process. A detailed analysis of stack test results should be made available to verify emissions of halogen acids and polychlorinated dibenzodioxin and dibenzofuran (PCDD/PCDF). In addition, a site-specific test protocol should be prepared and made available for inspection by the appropriate regulatory authorities. The sampling protocol shall report the following data from each test:

- a. ODS feed rate;
- b. Total halogen load in the waste stream;
- c. Residence time for ODS in the reaction zone;
- d. Oxygen content in flue gas;
- e. Gas temperature in the reaction zone;
- f. Flue gas and effluent flow rate;
- g. Carbon monoxide in flue gas;
- h. ODS content in flue gas;
- i. Effluent volumes and quantities of solid residues discharged;
- j. ODS concentrations in the effluent and solid residues;
- k. Concentration of PCDD/PCDF, particulates, HCl, HF and HBr in the flue gases;
- l. Concentration of PCDD/PCDF in effluent and solids.

## APPENDIX III: TECHNOLOGY SCREENING PROCESS<sup>8</sup>

### 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 3-1. 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 below.

**Table 3-1: Summary of Technical Performance Qualifications<sup>9</sup>**

Performance Qualification	Units	Diluted Sources	Concentrated Sources
DRE	%	95	99.99
PCDDs/PCDFs	ng-ITEQ/NM <sup>3</sup>	0.5	0.2
HCL/CL <sub>2</sub>	mg/NM <sup>3</sup>	100	100

<sup>8</sup> Reproduced in full from: *UNEP Technology and Economic Assessment Panel (TEAP) Report of the Task Force on Destruction Technologies*, UNEP, 2002. Available at: [http://ozone.unep.org/teap/Reports/Other\\_Task\\_Force/TEAP02V3b.pdf](http://ozone.unep.org/teap/Reports/Other_Task_Force/TEAP02V3b.pdf)

<sup>9</sup> All concentrations of pollutants in stack gases and stack gas flow rates are expressed on the basis of dry gas at normal conditions of 0°C and 101.3 kPa, and with the stack gas corrected to 11% O<sub>2</sub>.

HF	mg/NM <sup>3</sup>	5	5
HBr/Br <sub>2</sub>	mg/NM <sup>3</sup>	5	5
Particulates	mg/NM <sup>3</sup>	50	50
CO	mg/NM <sup>3</sup>	100	100

### ***Destruction and Removal Efficiency***

Destruction Efficiency (DE)<sup>10</sup> 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)<sup>11</sup>. 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 by-products of destruction of CFCs, HCFCs 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<sub>2</sub>F<sub>2</sub>) was measured as 99.9998%, but this was accompanied by a conversion of 25% of the input CFC-12 to CFC-13 (CClF<sub>3</sub>), which has the same

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<sup>10</sup> 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.

<sup>11</sup> 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.

ozone-depleting potential. The interconversion is less severe when hydrogen is present in the process, but can nonetheless be significant.<sup>12</sup> 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<sup>13</sup>.

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,  $DRE = \frac{N_i^{in} - \sum_i N_i^{out}}{N_i^{in}}$  where  $N_i^{in}$  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.

### **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-p-dioxins (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),<sup>14</sup> which is a weighted measure of

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<sup>12</sup> 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.

<sup>13</sup> 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.*

<sup>14</sup> 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.]

the toxicity for all the members of the families of these toxic compounds that are determined to be present.

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

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

- 0.5 ng-ITEQ/Nm<sup>3</sup> for foams; and,
- 0.2 ng-ITEQ/Nm<sup>3</sup> 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<sup>3</sup> (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<sup>3</sup> (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.

### ***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<sup>3</sup> HCl/Cl<sub>2</sub>
- A maximum concentration in stack gases of 5 mg/Nm<sup>3</sup> HF; and,
- A maximum concentration in stack gases of 5 mg/Nm<sup>3</sup> HBr/Br<sub>2</sub>.

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<sup>3</sup>.

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<sup>3</sup>.

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.

### ***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.

## DOCUMENT HISTORY

Version	Date	Comment
v1.0	20 Sep 2011	Initial version released.
v1.1	30 Nov 2017	Updated to account for destruction of unused and stockpiled ODS.