Calculating HFC-23 Emissions from the Production of HCFC – 22 Version 2.0

Guide to calculation worksheets (December 2007)

Table of Contents

I. Overview

I.A. Purpose and Domain of this tool

This guideline is written for plant managers and site personnel to facilitate the measurement and reporting of greenhouse gas direct trifluoromethane (HFC-23 or CHF_3) emissions resulting from production of chlorodifluoromethane (HCFC-22 or $CHClF_2$). This sector guideline should be applied to projects whose operations involve HCFC-22 production.

This sectoral guideline only covers process-related HFC-23 emissions from the production of HCFC-22. This guideline does not cover a) direct emissions from the combustion of fossil fuel occurring during the production of HCFC-22 and b) indirect emissions from the purchase of energy (electricity or steam) used for HCFC-22 production. These GHG emissions are covered by the cross-sectoral guideline on stationary combustion.

I.B. Process Description

HCFC-22 is a gas used in refrigeration and air-conditioning systems, in foam manufacturing as a blend component of blowing agents, and in the manufacture of synthetic polymers. Because it is an ozone depleting substance, most developed countries are phasing HCFC-22 out of most end-uses with the exception of use as chemical feedstock.

The production of HCFC-22 involves the reaction of chloroform ($CHCl_3$) and hydrogen fluoride (HF) using antimony pentachloride ($SbCl_5$) as a catalyst. This process generates HFC-23 as a by-product, but the amount varies depending on plant-specific conditions and the amount of HCFC-22 produced. HFC-23 is has a global warming potential (GWP) of 11,700 over a 100-year time horizon, so its potential impact on climate change is significant. In the U.S., HFC-23 constitutes the second largest portion of emissions from the high GWP gases (HFCs, PFCs, and SF_6).

I.C. Applicability of the tool

Approximately 98 to 99 percent of the HFC-23 produced is discharged via the condenser vent after the HFC-23 is separated from the HCFC-22. Leaking compressors, valves, and flanges may be sources of fugitive emissions, but this source is believed to be minor and is not discussed further.

II. Choice of Calculation Methods, Activity Data and Emission Factors

HFC-23 emissions can be estimated based on data readily available to a producer. This guideline describes four approaches, offering reporters the choice between simple and more advanced approaches for estimating HFC-23 emissions from HCFC-22 production. The most appropriate approach depends on the level of accuracy required, and data availability. The four approaches are summarized below in order of decreasing accuracy of the emissions estimates they are expected to produce.

Approach 1: The most accurate and detailed methodology to estimate HFC-23 emissions uses continuous emissions monitoring (CEM) practices. If a plant uses this technology emissions data should be readily available. CEM technologies such as mass flow meters and totalizers are used by many manufacturers in the U.S., Japan, and Europe. Their data should be used when available. No further guidance on this approach is provided by this tool.

Approach 2: If CEM practices are not used, emissions can be estimated by integrating over time plant-specific measurements of the flow and concentration of HFC-23 in the exhaust stream. Because emissions monitoring is not done continuously in this approach, it is necessary to conduct sampling and analysis whenever a plant makes any significant process changes that would affect the generation rate of HFC-23 and sufficiently often otherwise to ensure that operating conditions are constant.

This methodology is summarized as follows:

$$\textit{HFC-23 Emissions} = \Sigma_i(\textit{Flow Rate}_i \times \textit{Concentration}_i \times \textit{Flow Time}_i) \times (1 - \textit{Abatement Factor} \times \textit{Utilization Factor}) \times \textit{Conversion Factor}$$

Where:
i – a vapor stream in the facility
Flow Rate – the flow of HFC-23 in the vapor stream (cubic meters/minute)
Concentration – the concentration of HFC-23 in the vapor stream (grams/cubic meter)
Flow Time – the amount of time that the HFC-23 flowed through the vapor stream (minutes)
Fraction Abated (%) – percent of emissions abated by reduction technologies and practices (if applicable)
Utilization Factor (%) – percent of time the abatement technology was in use (if applicable)
Conversion Factor – the conversion factor from grams to metric tonnes (1 metric tonne/10^6 grams)

This method is implemented in the Excel tool. General guidance on what is needed to develop representative sampling (the periodicity, variability, etc.) can be obtained from the EIIP manuals http://www.epa.gov/ttn/chief/eiip/techrep.htm#pointsrc. In general emissions monitoring and measurement methods need to have careful protocols and Quality Control procedures.

Approach 3: If Approach 2 is not tenable then plants may estimate the HFC-23 emissions using data on the fluorine and carbon balance efficiencies of the manufacturing process. This method also requires estimates of the fractional loss in HCFC-22 production efficiency that is due to the co-production of HFC-23 and of the amount of time that the HFC-23 exhaust stream is vented to the atmosphere, untreated. This approach is implemented in the Excel tool, and defaults for each of its parameters are provided in the Excel tool.

The methodology is summarized as follows:

$$E_{HFC-23} = Q_{HCFC-22} \bullet EF_{approach\ 3} \bullet T \bullet 11700$$

Where:
E_{HFC-23} = Emissions of HFC-23 (metric tonnes)
$Q_{HCFC-22}$ = Amount of HCFC-22 produced by plant (metric tonnes)
$EF_{approach\ 3}$ = Emission factor for HFC-23 production (see below)
T = Amount of time that the HFC-23 exhaust stream is released to the atmosphere, untreated
11700 = The Global Warming Value (GWP) of HFC-23. This value is a measure of the global warming potential of HFC-23 relative to CO_2 over a 100 year timespan.

The emission factor ($EF_{approach\ 3}$) can be derived as follows:

$$EF_{approach3} = \frac{[((100-(CB/100)) \bullet E_{loss} \bullet CC) + \\ + ((100-(FB/100)) \bullet E_{loss} \bullet FC)]}{2}$$

Where:
CB = The carbon balance efficiency of the production process (Default value = 90%)
CC = The carbon content factor (fraction) (Default value = 0.81)
FB = The fluorine balance efficiency of the production process (Default value = 90%)
FC = The fluorine content factor (fraction) (Default value = 0.54)
E_{loss} = The loss in production efficiency of HCFC-22 that is attributable to the co-production of HFC-23 (fraction) (Default value = 1.0)

Approach 4: The simplest, least accurate and most general methodology, which only requires HCFC-22 production data, an appropriate HFC-23 emissions factor and information on the amount of time that the HFC-23 exhaust stream is vented to the atmosphere, untreated. Production data are available from the facility. This approach is implemented in the Excel tool, and default emission factors are provided in the tool.

The methodology is summarized as follows:

HFC-23 Emissions = (HCFC-22 Production x EF) x T x 11700

Where:
HCFC-22 Production =Total amount of HCFC-22 produced by the facility in tonnes

EF = FC-23 Emission factor (tonnes of HFC-23/tonne of HCFC-22 produced)
T = The fraction of time in which the HFC-23 exhaust stream is vented to the atmosphere untreated.
11700 = The GWP for HFC-23 over a 100 tear time horizon.

III. Inventory Quality

To identify calculation errors and omissions, the quality of the emissions data obtained should be controlled. Two simple and effective alternatives are recommended:

1. **Emissions comparisons** -
   Compare the emissions data obtained with emissions data calculated for the same facility in previous years. A calculation error is probable if differences between current data and data from previous years cannot be explained by changes in activity levels or changes in production technologies employed.

2. **Order of magnitude checks**
   If you have used Approaches 1 or 2 to calculate your emissions, you can employ the method proposed in Approach 3 to check whether your results are in the correct range.

IV. References

IPCC (2006), 2006 IPCC Guidelines for National Greenhouse Gas Inventories