

**TECHNICAL SUPPORT DOCUMENT FOR
IMPORTS AND EXPORTS OF FLUORINATED
GREENHOUSE GASES (GHGs) IN PRE-
CHARGED EQUIPMENT AND CLOSED-CELL
FOAMS**

**MANDATORY REPORTING OF GREENHOUSE
GASES: ADDITIONAL SOURCES OF
FLUORINATED GREENHOUSE GASES**

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Office of Air and Radiation
U.S. Environmental Protection Agency

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1. Source Description

A variety of products containing fluorinated greenhouse gases (GHGs), sulfur hexafluoride (SF₆), nitrous oxide (N₂O), and carbon dioxide (CO₂) are imported into and exported from the United States.

HFCs are used as refrigerants in a wide range of air-conditioning and refrigeration equipment. In this application, HFCs serve as substitutes for ozone-depleting substances (ODSs), which are being phased out under the Montreal Protocol. Because some ODSs (i.e., HCFCs) are only beginning to be phased out, the use of HFCs in equipment such as window and residential air-conditioners is expected to grow very quickly over the next decade. Imports and exports of pre-charged equipment may grow as well. Although the quantities of chemical contained in each unit are small in absolute terms (i.e., a few pounds or less), they are more significant in CO₂-equivalent terms, ranging up to eleven mtCO₂e per unit for pre-charged commercial air-conditioners. This significance is due to the high GWPs of the HFCs.

HFCs are also used as blowing agents during the manufacture of foams. Open-cell foams are assumed to emit 100 percent of the blowing agent in the year they are manufactured, whereas closed-cell foams emit only a fraction of their total HFC content upon manufacture. Foam products that are closed-cell and imported or exported as a finished foam product therefore have potential to emit the blowing agent remaining in the foam after manufacture. Closed cell foams that are imported or exported include: polyurethane (PU) rigid foam used as insulation in domestic refrigerators and freezers; commercial refrigeration foam; PU rigid sandwich panel continuous and discontinuous foam; extruded polystyrene (XPS) sheet foam; and XPS boardstock foam.

SF₆ is used as an electrical insulator and arc-quenching gas in electrical transmission equipment, including circuit breakers and gas-insulated substations. Again, the quantities of SF₆ in each unit are often small in absolute terms (around 14 pounds per circuit breaker), but are larger in CO₂-equivalent terms (around 150 mtCO₂e per circuit breaker). (Discussions with manufacturers of electrical equipment indicate that one-fifth of gas-insulated switchgear may be imported with a partial “holding” charge of about one ton of SF₆, equivalent to 28,000 mtCO₂e. However, the extent to which this occurs in practice is uncertain.)

Products containing N₂O may also be imported into or exported from the United States. N₂O is used primarily in two major end-use applications—1) as a carrier gas with oxygen to administer more potent inhalation anesthetics and as an anesthetic in various dental and veterinary applications, and 2) as a propellant in pressure and aerosol products, the largest application being pressure-packaged whipped cream. As such, imported or exported products containing N₂O may include pre-charged anesthetic equipment for medical applications and in aerosol cans such as pressure-packaged whipped cream products. Other potential products precharged with N₂O may include fuel oxidizer canisters for auto applications and blowtorches containing N₂O used by jewelers and others (Heydorn 1997; EPA 2008).

Table 1-1 provides the number of refrigeration and air-conditioning (AC) units that are projected to be imported into and exported from the United States in 2010, as well as the total mtCO₂e of HFC refrigerant projected to be inside the equipment in that year. This equipment may also include closed-cell foams, which are quantified in Table 1-2. The number of refrigeration and AC units imported or exported in 2010 was assumed to equal the number of units imported or exported in 2006 (the most recent year for which data was available). The refrigeration and AC units traded in 2006 were pre-charged with both HFCs and HCFCs. (HCFCs are ozone-depleting substances that are regulated under the Montreal Protocol and are exempt from the proposed definition of fluorinated GHG.) However, by 2010 EPA expects that all imported or exported refrigeration and AC units will be precharged with HFCs, because many imports or exports pre-charged with HCFCs will not be permitted starting in that year.

Table 1-1: Projected 2010 Imports and Exports of Refrigeration and AC Equipment Precharged with HFCs

Product	Number of Units Imported (2010) ^a	Estimated Total GHGs Imported (mtCO ₂ e) (2010)	Number of Units Exported (2010) ^a	Estimated Total GHGs Exported (mtCO ₂ e) (2010)
Dehumidifiers	109,393	28,945	14,427	3,817
Window ACs	9,028,514	7,379,194	298,075	243,623

Product	Number of Units Imported (2010) ^a	Estimated Total GHGs Imported (mtCO ₂ e) (2010)	Number of Units Exported (2010) ^a	Estimated Total GHGs Exported (mtCO ₂ e) (2010)
Residential Unitary ACs	359,189	2,556,198	120,187	855,321
Small Commercial ACs	10,702	121,842	56,975	648,660
Packaged Terminal AC/Heat Pumps	235,487	250,228	55,461	58,933
Ice Makers ^b	27,292	90,473	22,446	74,408
Mobile ACs ^c	3,374,740	4,127,538	557,631	682,021
Refrigerated Appliances	9,382,646	1,762,530	1,867,901	350,885
Small Retail Food	784,281	676,016	167,250	144,162

Sources: Ward's (2010) (Mobile ACs); U.S. Census Bureau (2009) (all other equipment types)

^aNumber of imports/exports in 2010 is set equal to reported imports/exports for 2006. Mobile AC data is for 2008.

^bMost recent data is for 2002; 2006 estimate is estimated by applying the percentage of new units (from Vintaging Model) supplied by imports/exports (from Census) in 2002 to the number of 2006 new units (from Vintaging Model).

^cMotor vehicle import data excludes Canada and Mexico. Export data includes Canada.

Table 1-2 provides the estimated amounts of foam containing HFCs and of electrical equipment containing SF₆ that were imported into or exported from the United States in 2006, as well as the estimated total mtCO₂e of fluorinated GHGs imported or exported inside these products in 2006. This table includes foams inside refrigerators. Refrigerant contained in these products is accounted for in Table 1-1.

Table 1-2: 2006 Foam and Electrical Equipment Imports and Exports Containing Fluorinated GHGs

Product	Fluorinated GHG(s)	Estimated Number of Units Imported (2006)	Estimated Total GHG Imported (mtCO ₂ e) (2006)	Estimated Number of Units Exported (2006)	Estimated Total GHG Exported (mtCO ₂ e) (2006)
XPS Boardstock Foam ^a	HFC-134a	20 MM bd-ft.	183,365	20 MM bd-ft.	183,365
XPS Sheet Foam ^a	HFC-152a	2 MM bd-ft.	2,011	2 MM bd-ft.	2,011
PU Rigid Foam: Domestic Refrigeration ^a	HFC-245fa	36 MM bd-ft.	2,420,135	7 MM bd-ft.	484,027
Commercial Refrigeration Foam ^a	HFC-245fa	5 MM bd-ft.	399,067	5 MM bd-ft.	399,067
PU Rigid Foam: Sandwich Panels ^a	HFC-134fa	3 MM bd-ft.	20,708	3 MM bd-ft.	20,708
Circuit Breakers (72.5 kV to 345 kV) ^b	SF ₆	200	30,665	1,000	153,323
Gas Insulated Substations (GIS)	SF ₆	67	1,858,268	0	0

Source: Jeffs (2010) (Domestic Refrigeration); Russell (2008) (Foams); Bolin (2008) (Electrical Equipment)

^aIn the absence of detailed data, exports were assumed equal to imports. This is probably not the case.

^bThis product is the only size circuit breaker that is assumed to be imported or exported precharged with SF₆. Larger equipment is not imported or exported with a full charge since they are assembled on site in the field; small equipment uses insulators other than SF₆.

a. Total Inventory

The number of importers and exporters shipping products containing fluorinated GHGs varies depending on the gas and product in question. Based on conversations with multiple industry experts, EPA estimates that eight original equipment manufacturers are importing high voltage circuit breakers or gas insulated substations that contain a holding charge of SF₆ (i.e., estimated as a charge of about 5 psig, which translates into approximately 20-25% of nameplate capacity). There are also 10 entities exporting high voltage circuit breakers, an upper bound estimate based on EPA's knowledge of 10 equipment manufacturers operating in the U.S. It is estimated that there are approximately 50 entities importing and 25 entities exporting refrigeration and AC equipment containing a fluorinated GHG refrigerant and foam products containing a fluorinated GHG blowing agent. Entities trading pre-charged equipment and foam products are assumed to be distinct, although the possibility for overlap exists. Similarly, exporters are assumed to be distinct from and approximately half the number of importers (ICF 2008a).

EPA estimates that annually, approximately 17 million mtCO₂e of HFCs are imported in pre-charged refrigeration and AC equipment, three million mtCO₂e of HFCs are imported in closed-cell foams, and two million mtCO₂e of SF₆ imported in pre-charged electrical equipment. EPA also estimates that there are approximately three million mtCO₂e of HFCs exported in pre-charged refrigeration and AC equipment, one million mtCO₂e of HFCs exported in closed-cell foams, and 150 thousand mtCO₂e exported in pre-charged electrical equipment.

Table 1-3 compares imports and exports of fluorinated GHGs in pre-charged equipment and foams to other U.S. supply flows of these gases, while Table 1-4 compares imports and exports in pre-charged equipment and foams to a bottom-up estimate of U.S. consumption of these gases from the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006 (EPA 2008). As shown in Table 1-3 and Table 1-4, imports in pre-charged equipment and foam are estimated to account for between seven and 10 percent of the net U.S. supply or consumption of fluorinated GHGs, while exports in pre-charged equipment and foam are estimated to account for one to two percent of the U.S. net supply or consumption.

Table 1-3: Imports and Exports of Pre-Charged Equipment and Foams as Share of U.S. Fluorinated GHG Supply (Top-Down, 2006)

Supply Flow	Quantity (mtCO₂e)
Domestic Production	350,000,000
Imports in Bulk	110,000,000
Exports in Bulk	175,000,000
Imports in Pre-Charged Equipment, Foams	22,000,000
Exports in Pre-Charged Equipment, Foams	4,000,000
Net supply (all flows)	303,000,000
Equipment, Foam Imports as Share of Net Supply	7%
Equipment, Foam Exports as Share of Net Supply	1%

Table 1-4: Imports and Exports of Pre-Charged Equipment and Foams as Share of U.S. Fluorinated GHG Consumption (Bottom-Up, 2006)

Consumption Component	Quantity (mtCO₂e)
Total U.S. Consumption (2006, US Inventory)	215,000,000
Equipment, Foam Imports as Share of Consumption	10%
Equipment, Foam Exports as Share of Consumption	2%

Although EPA does not have data on the amount of CO₂ or N₂O imported or exported in products (e.g., carbonated sodas and cans of whipped cream), the relatively small quantities of CO₂ or N₂O contained in each unit and the relatively low GWPs of these gases (compared to those of the fluorinated GHGs) imply that the CO₂-equivalent quantities imported or exported are likely to be small both nationally and per entity. This conclusion is supported by the fact that 2006 production and bulk imports of CO₂ and N₂O were one percent or less of those of the fluorinated GHGs in CO₂-equivalent terms (see Technical Support Documents EPA-HQ-OAR-2008-0508-012 and EPA-HQ-OAR-2008-0508-042).

2. Review of Existing Reporting Programs and Methodologies

Protocols/guidance reviewed for this analysis include the *2006 IPCC Guidelines*, Title VI of the Clean Air Act (CAA), Part 75 Appendix D (measurement requirements for oil and natural gas), the Toxic Release Inventory (TRI), the Toxic Substances Control Act (TSCA) Inventory Update Rule, and the Australian Commonwealth Government Ozone Protection and Synthetic Greenhouse Gas Reporting Program.

These programs vary in their treatment of products containing chemicals whose bulk import or export must be reported. The Australian program requires reporting of all ODSs and GHGs imported in pre-charged equipment, including the type of equipment, the identity of the refrigerant, the number of pieces of equipment, and the charge size. However, the program does not cover the export of this equipment. The TSCA Inventory Update Rule requires reporting of chemicals contained in products if the chemical is designed to be released from the product when it is used (e.g., ink from a pen). EPA's ozone protection regulations do not currently require reporting of ODSs contained in imported or exported equipment or other products; however, (1) EPA has prohibited the introduction into interstate commerce, including import, of certain non-essential products typically pre-charged with these chemicals, and (2) EPA has prohibited the sale or distribution in interstate commerce, including import, of equipment pre-charged with HCFCs (74 FR 66450, December 15, 2009).

For the full review of existing programs, please refer to (EPA-HQ-OAR-2008-0508-054).

3. Types of Products Considered

In determining which products should be subject to reporting, EPA believes it is appropriate to consider three criteria: (1) the quantity of GHGs likely to be imported or exported in the product nationally and per importer or exporter, (2) the ease with which the GHG in the product can be identified, and (3) the ease with which the GHG in the product can be quantified.

As noted above, the CO₂-equivalent quantities of CO₂ and N₂O imported or exported in products are likely to be small both nationally and per entity due to the relatively small quantities of CO₂ and N₂O contained in each unit and the relatively low GWPs of these gases (compared to those of the fluorinated GHGs). EPA's review of other protocols and guidance affecting imports and exports did not identify any programs that quantify or restrict trade of CO₂ or N₂O in products.

As discussed above, the quantities of fluorinated GHGs imported or exported in equipment are potentially significant both overall and per product type. For example, EPA estimates that 7 million metric tons CO₂e are imported inside pre-charged window air-conditioners. Other types of equipment that are imported or exported containing significant quantities of fluorinated GHGs include mobile air-conditioners, refrigerated appliances, residential air-conditioners, and gas-insulated switchgear. The identities and amounts of fluorinated GHGs contained in equipment are generally well known; this data is typically listed on the nameplate affixed to every unit. The information is also available in servicing manuals and other paperwork that the entity would be expected to have on file.

Closed cell foams, such as polyurethane (PU) appliance foams (used to insulate refrigerators and freezers) and extruded polystyrene (XPS) insulation boardstock (used to insulate buildings), also contain significant amounts of fluorinated GHGs. Again, manufacturers and importers or exporters would generally be expected to be able to identify and quantify the amounts in their products. (The identities and quantities of chemical inside the foam directly affect its insulating capability.) Since many importers or exporters of refrigerators would already be required to report based on the refrigerant contents of the equipment, the additional effort required to track and quantify the GHGs contained in the foam would probably not be excessively burdensome.

4. Options for Reporting Threshold

EPA evaluated a range of threshold options for imports or exports of fluorinated GHGs in products, including thresholds based on the quantity of chemical imported or exported (1,000; 10,000; 25,000; and 100,000 mtCO₂e) and on the number of pieces of equipment or volume of foam imported or exported. Additionally, EPA considered setting no threshold (requiring reporting of all imports or exports), which is the approach used under the Australian Synthetic Greenhouse Gas Reporting Program.

Table 4-1 and Table 4-2 present the total masses of HFCs and SF₆, in mtCO₂e, that EPA estimates are contained in imported and exported pre-charged equipment, both nationally and by entity. The amount of total gas imported or exported was estimated by summing the product of the average charge size (as detailed below) and the quantity of imports or exports (as detailed in Table 1-3 and Table 1-4) for each equipment type. Where products include foam as well as refrigerant (e.g., household refrigerators), the fluorinated GHG in the foam was also included in the closed-cell foam category. Information on the number of entities was obtained from ICF (2008a) for HFC equipment and from Phil Bolin (2008) for SF₆ equipment. In the absence of entity-specific data, the analysis below assumes that each entity imports or exports the same quantity of HFC or SF₆ equipment.

In order to calculate an average CO₂-equivalent charge size for each equipment type, data on gas-specific charge sizes were first collected from three separate sources, depending on the equipment type. For refrigeration and AC equipment, charge size estimates were taken from EPA's Vintaging Model (VM) (EPA 2008). The average HFC density of each foam type was estimated based on engineering judgment (ICF 2008b). For SF₆-containing equipment (i.e., circuit breakers and gas insulated substations), the average charge size was calculated using the assumption provided by Phil Bolin (2008) that the average shipping charge is 20 percent of the equipment's total nameplate capacity. These data were then weighted by the percentage of new units in 2010 using the relevant gas, as estimated by EPA's VM, for each equipment type. Finally, the charge sizes were converted in mtCO₂e using SAR GWPs and summed to develop an average CO₂-equivalent charge size for each equipment type. The numbers of pieces of equipment to trigger reporting at various thresholds is simply the threshold divided by this calculated average charge size.

EPA believes that a threshold based on the total quantity of chemical imported or exported is likely to be more practical and equitable than one based on the number of pieces of equipment or volume of foam imported or exported. This conclusion is based on the fact that entities may import or export multiple types of equipment and/or foam, which may contain different quantities of refrigerant and/or blowing agent per unit. If a threshold based on numbers of pieces of equipment were established, it could exclude entities that imported or exported large quantities of GHGs spread out among multiple types of equipment. Alternatively, it could require a complicated formula to prevent such exclusions.

Based on the assumptions outlined above, all importers or exporters of equipment pre-charged with HFCs or SF₆ would be required to report all imports or exports of this equipment under all thresholds considered. In reality, imports or exports are likely to be concentrated among a relatively small number of entities, decreasing the number of reporters and the amount reported. This is the pattern that EPA has seen for bulk imports of fluorinated GHGs, where approximately 40 percent of the importers import almost 100 percent of the imports at an import threshold of 25,000 mtCO₂e (Technical Support Document EPA-HQ-OAR-2008-0508-042). In general, as thresholds decrease, smaller entities representing successively smaller shares of total national imports or exports are required to report. The drawback of requiring reporting of all imports or exports (i.e., setting no threshold) is that it could substantially increase the burden of the rule without substantially increasing the quantity of imports or exports reported.

Table 4-1: Import Threshold Summary: Masses of GHGs that would be covered by the Various Thresholds

Product Type	Imports (mtCO ₂ e)	Number of Importers	GHG per Importer (mtCO ₂ e)	Total Amount Meeting Threshold (mtCO ₂ e)			
				1,000	10,000	25,000	100,000
Pre-charged Equipment							
HFC Refrigeration / AC Equipment	16,992,965	50	339,859	16,992,965	16,992,965	16,992,965	16,992,965
SF ₆ Electrical Equipment	1,888,932	8	236,117	1,888,932	1,888,932	1,888,932	1,888,932

Product Type	Imports (mtCO ₂ e)	Number of Importers	GHG per Importer (mtCO ₂ e)	Total Amount Meeting Threshold (mtCO ₂ e)			
				1,000	10,000	25,000	100,000
Closed-cell Foams	3,025,285	50	60,506	3,025,285	3,025,285	3,025,285	

Table 4-2: Export Threshold Summary: Masses of GHGs that would be covered by the Various Thresholds

Product Type	Exports (mtCO ₂ e)	Number of Exporters	GHG per Exporter (mtCO ₂ e)	Total Amount Meeting Threshold (mtCO ₂ e)			
				1,000	10,000	25,000	100,000
Pre-charged Equipment							
HFC Refrigeration / AC Equipment	3,061,830	25	122,473	3,061,830	3,061,830	3,061,830	3,061,830
SF ₆ Electrical Equipment	153,323	10 ^a	Varies ^b	153,323	107,326	0	0
Closed-cell Foams	1,089,177	25	43,657	1,089,177	1,089,177	1,089,177	0

^aIncludes five importers that also export.

^bBased on data from Rich York (2008), five manufacturers are assumed to account for a majority of the exports.

5. Options for Monitoring Methods

Options for tracking imports and exports of products include reporting the total amount of each fluorinated GHG imported or exported inside the products and/or the quantity of the product imported or exported (e.g., number of pieces of equipment), along with information on the identity and quantity of the fluorinated GHG in each unit or piece. EPA has reviewed existing reporting programs and methodologies that take one or both of these approaches, as described above.

The quantities of fluorinated GHGs contained in imported or exported products could be reported by chemical in tons or in mtCO₂e. Reporting in tons of chemical would provide more transparency and reduce mistakes such as arithmetic errors or the use of inappropriate GWPs. Entities importing equipment that contained both a fluorinated GHG refrigerant and a foam blown with a fluorinated GHG (e.g., household refrigerators) could separately report these GHGs (which are generally different). Similarly, total exports of chemical actually contained in exported equipment, foams, or other products could be reported by exporters, by chemical in tons or mtCO₂e.

The equation below could be used to estimate each entity's imports or exports of each fluorinated GHG inside equipment or foams:

$$I = \sum_t S_t * N_t * 0.001$$

where,

I is the total amount of the fluorinated GHG imported or exported by the entity annually (metric tons)

t is the type of equipment/foam containing the fluorinated GHG

S_t is the shipping charge per unit of equipment or foam type t

N_t is the number of units of equipment or foam type t imported or exported annually

0.001 is the factor converting kg to metric tons

As is the case for bulk imports, any trans-shipments (i.e., products containing GHGs that originate in a foreign country and enter the United States en route to an ultimate destination in another foreign country) could be exempt from reporting. Similarly, entities could report their imports or exports on the corporate level.

6. Procedures for Estimating Missing Data

A complete record of all measured parameters used in the GHG emissions calculations would be required; no data should be missing as the data are required for importing and exporting in the United States.

7. QA/QC Requirements

Options for QA/QC requirements includes reviewing inputs to the annual submission against the import and export transaction records to ensure that the information submitted to EPA is being accurately transcribed as the correct chemical or blend in the correct units and quantities (metric tons).

8. Options for Reporting Procedures

Along with their formal report, entities could be required to submit the following supplemental data to document and verify their import or export estimates:

- Quantities of products imported or exported, in appropriate units;
- The name of the fluorinated GHG, charge size (holding charge, if applicable), and number imported or exported for each type of equipment; and
- The name of the fluorinated GHG, and the quantity imported or exported (cu. ft and kg/ft² or tons) for each type of foam.

Importers could be required to keep the following records to document and verify their import estimates:

- The information reported (as indicated above);
- The port of entry through which the fluorinated GHGs passed;
- The country from which the imported fluorinated GHGs were imported;
- The importer number for the shipment;
- A copy of the bill of lading for the import;
- The invoice for the import; and
- The U.S. Customs entry form.

Along with their formal report, exporters could be required to submit the following supplemental data to document and verify their export estimates:

- Quantities of products exported, in appropriate units;
- The name of the fluorinated GHG, charge size (holding charge, if applicable), and number exported for each type of equipment; and
- The name of the fluorinated GHG, and the quantity exported (cu. Ft and kg/ft² or tons) for each type of foam.

Exporters could be required to keep the following records to document and verify their export estimates:

- The information reported above;
- The names and addresses of the exporter and the recipient of the exports;
- The exporter's Employee Identification Number;
- The date on which, and the port from which, the products containing the fluorinated GHGs were exported from the United States or its territories;
- The country to which the products containing the fluorinated GHGs were exported; and
- The invoice for the export.

Persons who transship products containing fluorinated GHGs could be required to maintain records that indicated that the products originated in a foreign country and was destined for another foreign country and did not enter into commerce in the United States.

9. References

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