

**Technical Support Document for the
Ferroalloy Production Sector: Proposed Rule for
Mandatory Reporting of Greenhouse Gases**

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

January 22, 2009

CONTENTS

1.	Industry Description	1
2.	Total Emissions	3
2.1	Combustion Emissions.....	3
2.2	Process Emissions.....	4
3.	Review of Existing Programs and Methodologies	5
3.1	2006 IPCC Guidelines	5
3.1.1	Process-related CO ₂ Emissions	5
3.1.2	Process-related CH ₄ Emissions	8
3.2	U.S. EPA’s Inventory of U.S. Greenhouse Gas Emissions and Sinks	9
3.3	Australian National Government’s Greenhouse and Energy Reporting Program.....	9
3.4	Canadian Mandatory Greenhouse Gas Reporting Program.....	9
4.	Options for Reporting Threshold.....	10
4.1	Options Considered	10
4.2	Emissions and Facilities Covered Per Option	10
4.2.1	Combustion Emissions.....	10
4.2.2	Process Emissions.....	10
4.2.3	Emissions Thresholds	11
5.	Options for Monitoring Methods.....	12
5.1	Option 1: Simplified Emission Calculation	12
5.2	Option 2: Facility-Specific Carbon Balance Calculation.....	12
5.3	Option 3: Facility-Specific Emission Factor Using Stack Test Data	12
5.4	Option 4: Direct Measurement Using CEMS.....	14
6.	Procedures for Estimating Missing Data	15
6.1	Procedures for Option 1: Simplified Emission Calculation.....	15
6.2	Procedures for Option 2: Facility-Specific Carbon Balance Calculation	15
6.3	Procedures for Option 3: Facility-Specific Emission Factor Using Stack Test Data.....	15
6.4	Procedures for Option 4: Direct Measurement Using CEMS	15
7.	QA/QC Requirements.....	16
7.1	Combustion Emissions.....	16
7.2	Process Emissions.....	16
7.3	Methods Using Stack Test Data	16
7.4	Methods Using CEMS	16
7.5	Data Management.....	17
8.	Types of Emission Information to be Reported	18
8.1	Types of Emissions to be Reported	18
8.2	Additional Data to be Retained Onsite	18
9.	References	19

1. Industry Description

A ferroalloy is an alloy of iron with at least one other metal such as chromium, silicon, molybdenum, manganese, or titanium. The ferroalloy production source category is defined to consist of facilities that produce either ferroalloys or silicon metal. Ferroalloys are used extensively in the iron and steel industry to impart distinctive qualities to stainless and other specialty steels, and serve important functions during iron and steel production cycles. Silicon metal is included in the ferroalloy metals category due to the similarities between its production process and that of ferrosilicon. Silicon metal is used in alloys of aluminum and in the chemical industry as a raw material in silicon-based chemical manufacturing.

The basic process used at U.S. ferroalloy production facilities is a batch process in which a measured mixture of metals, carbonaceous reducing agents, and slag forming materials are melted and reduced in an electric arc furnace (EAF). Molten alloy tapped from the EAF is casted into solid alloy slabs which are further mechanically processed for sale as product. The molten slag is tapped from the EAF, and then either further processed for sale as a product or disposed in landfill.

The carbonaceous material used to reduce the ore in the EAF is generally coal or coke. However, other carbon containing materials such as charcoal and wood can be used as primary or secondary carbon sources. These carbon materials are charged into the EAF together with the raw ore. While the submerged-arc open-top EAF is most commonly used to produce ferroalloys, this furnace can also be closed or semi-open (IPCC 2006). The open-top consists of a cup-shaped steel shell below a hood, which acts to collect fumes from the process and is approximately 1 meter above the bottom shell (Sjardin 2003). To heat the contents of the furnace, usually three prebaked graphite electrodes or consumable Soderberg electrodes are suspended in the charge material in the bottom shell, and electric currents are passed from one electrode to another. Electricity passes between electrodes through electric arcs. Heat is generated through both the electrodes and resistance from the charge materials. As the charge materials are heated, the coke (or other carbon reducing agents) and the electrodes are consumed and the metallic oxides are reduced.

There are approximately 14 U.S. ferroalloy production facilities (Table 1). Nine U.S. facilities produce ferrosilicon, silicon metal, ferrochromium, ferromanganese, or silicomanganese alloys. The U.S. production of ferrosilicon (25%-55% Si, and 56% 95% Si), and silicon metal alloys in 2006 totaled 400,700 metric tons (mt). Of this total, ferrosilicon (25%-55% Si) accounted for 164,000 mt, ferrosilicon (56% 95% Si) for 88,700 mt, and silicon metal for 148,000 mt (U.S. EPA 2008). Four companies contributed to this production with a total of six plants operating in the United States. In 2006, an additional three facilities produced ferrochromium, ferromanganese, or silicomanganese. Finally, five additional facilities produce ferromolybdenum and ferrotitanium. No production capacity information was available for these 5 facilities.

Table 1. U.S. Ferroalloy Production Facilities

Facility	Ferroalloy Produced	Production Capacity (metric tons per year)
Plant 1	Ferrosilicon	10,000
	Silicon metal	29,000
Plant 2	Ferrosilicon	38,500
	Silicon metal	38,500
Plant 3	Silicon metal	28,500 ^a
Plant 4	Ferrosilicon	102,100 ^a
Plant 5	Ferrosilicon	102,100 ^a
Plant 6	Silicon metal	52,000
Plant 7	Ferrochromium	20,000
Plant 8	Ferromanganese	100,000
	Silicomanganese	100,000
Plant 9	Silicomanganese	150,000
Plant 10	Ferromolybdenum or ferrotitanium	(b)
Plant 11	Ferromolybdenum or ferrotitanium	(b)
Plant 12	Ferromolybdenum or ferrotitanium	(b)
Plant 13	Ferromolybdenum or ferrotitanium	(b)
Plant 14	Ferromolybdenum or ferrotitanium	(b)

^a Production capacity estimated.

^b Production information not available.

Source: USGS 2005, USGS 2006, and personal communication with USGS Commodity Specialists.

2. Total Emissions

Ferroalloy production results in both combustion and process-related GHG emissions. The major source of GHG emissions from a ferroalloy production facility are the process-related emissions from the EAF operations. These GHG emissions, which consist primarily of carbon dioxide (CO₂) with smaller amounts of methane (CH₄), result from the reduction of the metallic oxides and the consumption of the graphite (carbon) electrodes during the process (discussed further in Section 4.2).

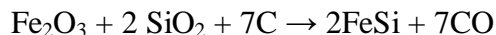
Total nationwide GHG emissions from ferroalloy production in the United States for the year 2006 were estimated to be approximately 2,343,990 metric tons CO₂ equivalent (metric tons CO₂e). This total GHG emissions estimate includes both the process-related emissions (CO₂ and CH₄) resulting from EAF operations at these facilities and the additional combustion emissions (CO₂, CH₄) from stationary combustion units at the facilities. Process-related GHG emissions were 2,025,836 metric tons CO₂e (86 percent of the total emissions). The remaining 318,153 metric tons CO₂e emissions (14 percent of the total emissions) were combustion GHG emissions.

2.1 Combustion Emissions

For some equipment used at ferroalloy production facilities to prepare material for charging to the EAF and to process the molten metal tapped from the EAF, the only source of carbon is the natural gas or another fuel the burned in the unit to produce heat for drying, melting, or casting operations. These types of stationary combustion units can include furnaces (other than EAFs and induction furnaces which use electricity to produce heat for melting), rotary kilns, casting machines, boilers, and space heaters. Ferroalloy production facility owners and operators would report annual CO₂, CH₄, and N₂O emissions from these combustion sources using one the GHG reporting methods discussed in the Technical Support Document (TSD) for Stationary Combustion Sources (refer to EPA-HQ-OAR-2008-0508-004).

2.2 Process Emissions

The production of all ferroalloys results in carbon monoxide (CO) emissions and, for ferrosilicon and silicon metal production, CH₄ emissions. The basic steps to produce ferroalloys involve mixing raw ore, carbonaceous reducing agents, and slag forming materials in a furnace that heats them to high temperatures for reduction and smelting. As the carbon contained in the electrodes is consumed, it captures oxygen from the metal oxides and forms carbon CO emissions. The metal oxides, having lost their oxygen, are reduced to molten base metals and combine to form an alloy. The following is a representative reaction equation for the production of 50% ferrosilicon (FeSi) (U.S. EPA 2008):



In a closed-top EAF, the CO is either recovered and used for energy production, or it is flared, both of which end as in-plant CO₂ emissions (while these CO₂ emissions may end as energy emissions, they are attributed to process emissions because the primary reason for their production was the creation of the alloy, not for the energy) (IPCC 2006; Sjardin 2003). In semi-open or open-top EAFs, this CO burns between the charge surface and the hood through infiltration of air, and produces CO₂ (Sjardin 2003). This basic process results in CO₂ emissions for all ferroalloy production. In addition, when semi-open or open-top EAFs are used to produce both ferrosilicon and silicon metal, the same process produces CH₄ and N₂O emissions.

3. Review of Existing Programs and Methodologies

Four existing GHG emissions reporting programs and methodologies were identified for calculating GHG emissions from ferroalloy production: the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, the U.S. EPA’s Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006, the Australian National Greenhouse Gas Reporting Program, and the Canadian Mandatory Greenhouse Gas Reporting Program.

3.1 2006 IPCC Guidelines

The 2006 IPCC Guidelines present three different methods (identified as “Tiers”) for calculating process-related CO₂ and CH₄ emissions from ferroalloy production (IPCC 2006).

3.1.1 Process-related CO₂ Emissions

The IPCC Tier 1 method for process-related CO₂ emissions is to multiply the applicable default emission factor listed in Table 2 by ferroalloy product type times the total quantity of ferroalloy product produced. The equation is as follows:

$$E_{CO_2} = \sum_i (MP_i \times EF_i)$$

Where:

E_{CO_2} = CO₂ emissions, metric ton

MP_i = Production of ferroalloy type i , metric ton

EF_i = Default emission factor for ferroalloy type i , mtCO₂/mt specific ferroalloy product (Table 2).

Table 2. IPCC Tier 1 CO₂ Emission Factors for Ferroalloy Production

Ferroalloy	Emission Factor (mt CO ₂ / mt ferroalloy product)
Ferrosilicon 45% Si	2.5
Ferrosilicon 65% Si	3.6
Ferrosilicon 75% Si	4.0
Ferrosilicon 90% Si	4.8
Ferromanganese (7% C)	1.3
Ferromanganese (1% C)	1.5
Silicomanganese	1.4
Silicon metal	5.0
Ferrochromium	1.3 (1.6 with a sinter plant)

Note: Only those emission factors applicable to this analysis are presented.

Source: IPCC 2006

The IPCC Tier 2 method for estimating process-related CO₂ emissions is considered more accurate than the IPCC Tier 1 method and is based upon production and default emission factors for carbonaceous reducing agents listed in Table 3. The equation is as follows:

$$E_{CO_2} = \sum_i (M_{\text{reducing agent, } i} \text{ EF}_{\text{reducing agent, } i}) + \sum_h (M_{\text{ore, } h} \times \text{CContent}_{\text{ore, } h}) \times (44/12) \\ + \sum_j (M_{\text{slag forming material, } j} \times \text{CContent}_{\text{slag forming material, } j}) \times (44/12) \\ - \sum_k (M_{\text{product, } k} \text{ CContent}_{\text{product, } k}) \times (44/12) \\ - \sum_l (M_{\text{non-product outgoing stream, } l} \times \text{CContent}_{\text{non-product outgoing stream, } l}) \times (44/12)$$

Where:

E_{CO_2} = CO₂ emissions from ferroalloy production, metric ton

$M_{\text{reducing agent, } i}$ = Mass of reducing agent i , metric ton

$\text{EF}_{\text{reducing agent, } i}$ = Emission factor of reducing agent i , mtCO₂/mt reducing agent

$M_{\text{ore, } h}$ = mass of ore h , metric ton

$\text{CContent}_{\text{ore, } h}$ = Carbon content in ore h , mt C/mt ore

$M_{\text{slag forming material, } j}$ = Mass of slag forming material j , metric ton

$\text{CContent}_{\text{slag forming material, } j}$ = Carbon content in slag forming material j , mt C/mt material j

$M_{\text{product, } k}$ = Mass of product k , metric ton

$\text{CContent}_{\text{product, } k}$ = Carbon content in product k , mt C/ mt product k

$M_{\text{non-product outgoing stream, } l}$ = Mass of non-product outgoing stream l , metric ton

$\text{CContent}_{\text{non-product outgoing stream, } l}$ = Carbon content in non-product outgoing stream l , mt C/ mt non-product outgoing stream l

Table 3. IPCC Tier 2 CO₂ Emission Factors for Ferroalloy Production

Reducing Agent (usage)	Emission Factor (mt CO ₂ / mt ferroalloy product)
Coal (for FeSi and Si metal)	3.1
Coal (for other ferroalloys)	(a)
Coke (for Si and FeSi)	3.3-3.4
Coke (for other ferroalloys)	(a)
Prebaked electrodes	3.54
Electrode Paste	3.4
Petroleum Coke	3.5

^a IPCC Guidelines note that inventory compilers are encouraged to use producer-specific values based on average blend of coal and/or coke for each ferroalloy producer.

Source: IPCC 2006

The IPCC Tier 3 method estimates process related CO₂ emissions based on facility-specific emission factors for each carbonaceous agent and its mass. The equation is as follows:

$$\begin{aligned}
 E_{CO_2} = & \sum_i (M_{\text{reducing agent, } i} \times CContent_{\text{reducing agent, } i}) \times (44/12) \\
 & + \sum_h (M_{\text{ore, } h} \times CContent_{\text{ore, } h}) \times (44/12) \\
 & + \sum_j (M_{\text{slag forming material, } j} \times CContent_{\text{slag forming material, } j}) \times (44/12) \\
 & - \sum_k (M_{\text{product, } k} \times CContent_{\text{product, } k}) \times (44/12) \\
 & - \sum_l (M_{\text{non-product outgoing stream, } l} \times CContent_{\text{non-product outgoing stream, } l}) \times (44/12)
 \end{aligned}$$

Where:

E_{CO_2} = CO₂ emissions from ferroalloy production, metric ton

$M_{\text{reducing agent, } i}$ = Mass of reducing agent i , metric ton

$CContent_{\text{reducing agent, } i}$ = carbon content in reducing agent i , mt C/mt reducing agent

$M_{\text{ore, } h}$ = Mass of ore h , metric ton

$CContent_{\text{ore, } h}$ = Carbon content in ore h , mt C/mt ore

$M_{\text{slag forming material, } j}$ = Mass of slag forming material j , metric ton

$CContent_{\text{slag forming material, } j}$ = Carbon content in slag forming material j , mt C/mt material j

$M_{\text{product, } k}$ = Mass of product k , metric ton

$CContent_{\text{product, } k}$ = Carbon content in product k , mt C/ mt product k

$M_{\text{non-product outgoing stream, } l}$ = Mass of non-product outgoing stream l , mt

$CContent_{\text{non-product outgoing stream, } l}$ = Carbon content in non-product outgoing stream l , mt C/ mt

44/12 = Constant for mass of CO₂ emitted for each mass unit of total carbon used.

For the Tier 3 method, emission estimates are based on carbon contents of the reducing agents actually used at the facility for the production processes. However, IPCC guidelines suggest that the analysis be based on percentage of ash and volatiles where:

$$\text{Fix C\%} = 100\% - \% \text{ Ash} - \% \text{ Volatiles}$$

In this case, carbon contents of the reducing agents are calculated by the following equation:

$$CContent_{\text{reducing agent, } i} = F_{\text{FixC, } i} + F_{\text{volatiles, } i} \times C_v$$

Where:

$CContent_{\text{reducing agent, } i}$ = Carbon content in reducing agent i , mt C/mt reducing agent

$F_{\text{FixC, } i}$ = Mass fraction of Fix C in reducing agent i , mt C/mt reducing agent

$F_{\text{volatiles, } i}$ = Mass fraction of volatiles in reducing agent i , mt volatiles/mt reducing agent

C_v = Carbon content in volatiles, mt C/mt volatiles.

3.1.2 Process-related CH₄ Emissions

The IPCC Tier 1 method for process-related CH₄ emissions uses the same equation as the Tier 1 CO₂ emission calculation with the default emission factors shown in Table 4. Emission factors are available for only a smaller group of ferroalloy products.

$$E_{\text{CH}_4} = \sum_i (\text{MP}_i \times \text{EF}_i)$$

Where:

E_{CH_4} = CH₄ emissions, metric ton

MP_i = Production of ferroalloy type i , metric ton

EF_i = Default emission factor for ferroalloy type i , mtCH₄/mt specific ferroalloy product (Table 4)

Table 4. IPCC Emission Factors for Tier 1 CH₄ Emission Estimates

Ferroalloy Type	Emission Factor (mt CH ₄ / mt ferroalloy product)
Si-metal	1.2
FeSi 90	1.1
FeSi 75	1.0
FeSi 65	1.0

Source: IPCC 2006

The IPCC Tier 2 method for process-related CH₄ emissions estimates uses the same equation as the IPCC Tier 1 method only using the default emission factors specific to the facility's EAF operations as presented in Table 5.

Table 5. IPCC Emission Factors for Tier 2 CH₄ Emission Estimates

Ferroalloy Type	Emission Factor (mt CH ₄ / mt ferroalloy product)		
	Batch-charging	Sprinkle-Charging	Sprinkle-Charging and > 750°C
Si-metal	1.5	1.2	0.7
FeSi 90	1.4	1.1	0.6
FeSi 75	1.3	1.0	0.5
FeSi 65	1.3	1.0	0.5

Source: IPCC 2006

The IPCC Tier 3 method for CH₄ emissions estimates recommends taking physical measurements of emissions.

3.2 U.S. EPA’s Inventory of U.S. Greenhouse Gas Emissions and Sinks

The protocol used for the U.S. EPA’s Inventory of U.S. Greenhouse Gas Emissions and Sinks (US EPA 2008) to estimate GHG emissions from U.S. ferroalloy production facilities was the IPCC Tier 1 method (described in Section 3.1).

3.3 Australian National Government’s Greenhouse and Energy Reporting Program

The Australian National Government’s Greenhouse and Energy Reporting Program requires reporting of CO₂ emissions from ferroalloy production facilities that emit at least 25,000 mtCO₂e, or produce or consume at least 100 terajoules of energy; or their corporate group emits at least 125,000 mtCO₂e, or it produces or consumes at least 500 terajoules of energy (Australian DCC 2007). The method used for estimating emissions is based on the National Greenhouse Account (NGA) default method, which calculates emissions based on the following equation:

$$E_I = \sum A_C \times EC_C \times EF_C / 1000$$

Where:

- E_I = Emissions of CO₂ from the production of the metal, metric tons
- A_C = Quantity of each carbon reductant used, metric tons
- EC_C = Energy content of the reductant, gigajoules per metric ton
- EF_C = Emission factor of each carbon reductant used, kilograms of CO₂e per gigajoule

Facilities may use the default emission factor presented in Table 6, but the higher-order method would be to develop facility-specific emission factors from the carbon content of the reducing agent. This higher order method is similar in protocol to IPCC’s Tier 3 method.

Table 6. Australian National Greenhouse Account Default Emission Factors

Carbonaceous Agent	Energy Content (gross) Gj/Mt	Emission Factors ^a (KgCO ₂ -e/Gj)	
		CO ₂	CH ₄
Metallurgical coke	30	90	0.02
Coke oven coke	27	117.1	0.03

^a Only those given emission factors that apply to this analysis are presented.

Source: Australia National Greenhouse and Energy Reporting System 2007)

3.4 Canadian Mandatory Greenhouse Gas Reporting Program

The Canadian Mandatory Greenhouse Gas Reporting Program requires reporting of CO₂ emissions from ferroalloy producing facilities if they emit 100,000 mtCO₂e or more. While an equation is not provided, it is suggested that estimation methods be consistent with IPCC Tier methods (EPA 2008; Environment Canada 2006).

4. Options for Reporting Threshold

4.1 Options Considered

Options considered for reporting threshold include mandatory GHG reporting from ferroalloy production facilities based on GHG emission thresholds of 1,000, 10,000, 25,000, and 100,000 mtCO₂e. For this analysis, process and combustion emissions were estimated for ferroalloy production facilities as presented in Section 4.2.

4.2 Emissions and Facilities Covered Per Option

4.2.1 Combustion Emissions

Nationwide combustion GHG emissions from ferroalloy production facilities were estimated using data provided by U.S. Energy Information Administration Manufacturing Energy Consumption Survey (MECS) (U.S. DOE 2005). The CO₂ emission factors for on-site fossil fuel combustion were derived using heat content and carbon content data presented in the Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2006. The CH₄ and N₂O emission factors were derived from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006). The MECS data provided for NAICS code 331112 are listed in Table 7 by fuel type along with CO₂ emission estimates for the industry sector and CO₂ emission estimates per establishment. The number of ferroalloy production facilities was obtained from the U.S. Census Bureau (2002). Fuels burned at the facilities were distillate fuel oil, natural gas, liquefied petroleum and natural gases, coal, and other. The representative stationary combustion GHG emission estimate of 35,350 mtCO₂e was used for each ferroalloy production facility.

Table 7. Fuel Consumption and CO₂ Emission Estimates for Ferroalloy Production

	Residual Fuel Oil	Distillate Fuel Oil	Natural Gas	LPG and NGL	Coal	Coke and Breeze ^a	Other ^b	Total
Energy Consumption (TBtu)	0.0	0.5*	7.0	0.5*	2.0	0.0	2.0	0.0
CO ₂ Emissions (mtCO ₂ e)	0	15,016	152,092	12,793	77,053	0	61,199	318,153
CO ₂ Emissions/Facility (mtCO ₂ e)	0	1,668	16,899	1,421	8,561	0	6,800	35,350

^a Value is 0.5, but is excluded because assumed to be captured as raw material

^b Emission estimates for "Other" are based on the emission factor for "Other Liquid"

4.2.2 Process Emissions

Nine different ferroalloy types are identified in the *USGS Minerals Yearbook: Ferroalloys*: ferrochromium, ferromanganese, ferromolybdenum, ferronickel, ferrosilicon, silicon metal, ferrotitanium, ferrotungsten, ferrovanadium. However, for the purpose of this analysis, process-related GHG emissions can only be estimated for those alloy types for which the IPCC provides emission factors, and for which industry production capacity information could be obtained from either the *USGS Minerals Yearbooks* or personal communications with commodity specialists at the USGS. While the IPCC Guidelines discuss ferrosilicon and silicon metal as releasing process

emissions of N₂O, the IPCC Guidelines do not provide emission factors for estimating these emissions.

Nationwide process-related CO₂ emissions from U.S. ferroalloy production facilities were estimated using the IPCC Tier 1 method (see Section 3.1). Production capacity data for the nine U.S. facilities that produce ferrosilicon, silicon metal, ferrochromium, ferromanganese, or silicomanganese alloys as presented in Table 1 and default emission factors in Table 2, by ferroalloy product type, were used.

4.2.3 Emissions Thresholds

Table 8 presents the estimated emissions and number of facilities that would be subject to GHG emissions reporting, based upon emission estimates using production capacity data for a total of nine U.S. facilities that produce ferrosilicon, silicon metal, ferrochromium, ferromanganese, or silicomanganese alloys. The five additional facilities that produce ferromolybdenum and ferrotitanium alloys were not included in the analysis because no production data were available to be able to estimate emissions. Table 8 shows that eight of the nine facilities exceed a threshold of 100,000 metric tons CO₂e/year. All nine facilities exceed a threshold of 25,000 metric tons CO₂e/year.

Table 8. Threshold Analysis for Ferroalloy Production Facilities

Threshold Level (mtCO ₂ e/yr)	Nationwide Annual GHG Emissions (mtCO ₂ e/yr)			Total Number of Facilities	Subject to GHG Reporting			
	Process Emissions	Combustion Emissions	Total		GHG Emissions		Facilities	
					mtCO ₂ e/yr	Percent	Number	Percent
100,000	2,025,836	318,153	2,343,990	9	2,276,639	97%	8	89%
25,000	2,025,836	318,153	2,343,990	9	2,343,990	100%	9	100%
10,000	2,025,836	318,153	2,343,990	9	2,343,990	100%	9	100%
1,000	2,025,836	318,153	2,343,990	9	2,343,990	100%	9	100%

5. Options for Monitoring Methods

As described in Section 4, ferroalloy production facilities can release both combustion and process-related GHG emissions. The major source of GHG emissions from a ferroalloy production facility are the process-related CO₂ emissions from the EAF operations. This section describes monitoring method options for estimating process-related GHG emissions from the ferroalloy production source category.

5.1 Option 1: Simplified Emission Calculation

This is a simplified emission calculation method using the IPCC Tier 1 method described in Section 3.1 to estimate CO₂ and CH₄ emissions. The method requires multiplying the amount of each ferroalloy product type produced by the appropriate default emission factors shown in Tables 2 and 3. This method may not fully capture emissions from all ferroalloy production types, because the IPCC Guidelines provide default emission factors for the most common, but not all types of ferroalloy production.

5.2 Option 2: Facility-Specific Carbon Balance Calculation

The monitoring option requires performing a monthly carbon balance using measurements of the carbon content of specific process inputs and process outputs and the amounts of these materials consumed or produced during a specified reporting period. This option is applicable to estimating only CO₂ emissions from an EAF, and is the IPCC Tier 3 method and the higher order methods in the Canadian and Australian reporting programs. Implementation of this method requires you to determine the carbon contents of carbonaceous material inputs to and outputs from the EAFs. Facilities determine carbon contents through analysis of representative samples of the material or from information provided by the material suppliers. In addition, the quantities of these materials consumed and produced during production would be measured and recorded. To obtain the CO₂ emission estimate, the average carbon content of each input and output material is multiplied by the corresponding mass consumed and a conversion of carbon to CO₂. The difference between the calculated total carbon input and the total carbon output is the estimated CO₂ emissions to the atmosphere. This method assumes that all of the carbon is converted during the process. For estimating the CH₄ emissions from the EAF, selection of this option for estimating CO₂ emissions would still require using the Option 1 method of applying default emission factors to estimate CH₄ emissions.

For this method, the facility owner or operator would report in addition to GHG emissions, the facility ferroalloy product produced, carbon content of reducing agents consumed, and quantity of carbon recovered for downstream use, if any. In addition, each facility owner or operator would be required to conduct quality assurance (QA) of supplier-provided information on the carbon content of the input materials by collecting a composite sample of material and sending it to a third-party, independent laboratory for chemical analysis to verify the supplier's information. This QA procedure could be conducted on a periodic basis (e.g., annually).

5.3 Option 3: Facility-Specific Emission Factor Using Stack Test Data

This monitoring method is applicable to certain ferroalloy production facility sources for which the GHG emissions are contained within a stack or vent. If a ferroalloy production facility uses an open or semi-open EAF depending on the capture effectiveness of the overhead (i.e., a

significant portion of CO₂ emissions escape captured by the overhead hood and subsequent discharge to a stack or vent), then another GHG emission estimation method other than direct measurement may need to be applied.

The monitoring method uses CO₂ emissions data from a stack test performed using U.S. EPA reference test methods to develop a site-specific process emissions factor which is then applied to quantity measurement data of feed material or product for the specified reporting period. This method can offer a higher level of accuracy than either Options 1 or 2 since actual stack test data are used for each facility to obtain facility-specific GHG emission factors. The performing of a stack test requires additional cost and time to implement the method compared to Options 1 and 2. However, the method may not be appropriate for all ferroalloy production facility sources depending on the site-specific operations conducted at the facility. A method using periodic, short-term stack testing would be appropriate for those facilities where process inputs (e.g., feed materials, carbonaceous reducing agents) and process operating parameters remain relatively consistent over time. In cases where there is the potential for significant variations in the process input characteristics or operating conditions, continuous measurements would be needed to accurately record changes in the actual GHG emissions from the sources resulting from any process variations.

To implement this method, a CO₂ emissions measurement stack test would be performed concurrently with measuring the input material feed rate or product output rate during the test. For stack testing, sampling equipment is installed temporarily in the stack to collect a sample of the stack gas for analysis to determine the CO₂ concentration in the gas stream. During the test, the flow rate of the stack gas is also measured allowing the calculation of the CO₂ mass emission rate for the source. The total annual CO₂ process emissions for the source is calculated by multiplying the calculated site-specific CO₂ emission factor by the total amount of the appropriate input material or product quantity, as applicable to the emissions factor, recorded for the operation of the source during the specified reporting period.

The facility-specific emission factor would be required to be redetermined on a periodic basis (e.g., annually) by performing a new stack test and recalculating the facility-specific CO₂ emission factor. In addition, a new stack test and facility-specific CO₂ emission factor determination would be required whether there is a significant change in the source's process input characteristics or operating conditions (e.g., changing the type or proportions of the carbonaceous reducing agents used). The facility owner or operator would report for each completed stack test the measured GHG concentrations in the stack gas, the monitored stack gas flow rate for each monitored emission point, and the time period during which the stack test was conducted. The process operating conditions (e.g., input material types and feed rates) during the time period when the test was conducted would also be reported.

5.4 Option 4: Direct Measurement Using CEMS

Another monitoring method applicable to ferroalloy production facility sources for which the GHG emissions are contained within a stack or vent is direct measurement using a continuous emissions monitoring system (CEMS). Direct measurements of the GHG concentration in the stack gas and the flow rate of the stack gas can be made using a CEMS. The difference between this option and Option 3 is using a CEMS provides a continuous measurement of the emissions while a stack test provides a periodic measurement of the emissions. Because a CEMS continuously measures actual CO₂ emissions from a given ferroalloy production facility source when it is in operation, this method is the most accurate monitoring method for determining GHG emissions from a specific source. The costs for installing and operating a CEMS for direct measurements of GHG emissions from a given ferroalloy production facility would be higher than for using one of the other monitoring method options.

Elements of a CEMS include a platform and sample probe within the stack to withdraw a sample of the stack gas, an analyzer to measure the concentration of the GHG (e.g., CO₂) in the stack gas, and a flow meter within the stack to measure the flow rate of the stack gas. The emissions are calculated from the concentration of GHGs in the stack gas and the flow rate of the stack gas. The CEMS continuously withdraws and analyzes a sample of the stack gas and continuously measures the GHG concentration and flow rate of the stack gas. Under a CEMS approach, the results of the recorded emissions measurement data would be reported annually.

6. Procedures for Estimating Missing Data

Procedures for estimating missing data vary depending on the monitoring method used for determining annual GHG emissions from a source. Each of the options described in Section 5 would require a complete record of measured parameters as well as parameters determined from company records that are used in the GHG emissions calculations (e.g., reducing agent carbon contents). Therefore, whenever a quality-assured value of a required parameter is unavailable, a substitute data value for the missing parameter must be used in the calculations.

6.1 Procedures for Option 1: Simplified Emission Calculation

If facility-specific production data is missing for one year, an average value using the production data from the year prior the missing year may be calculated. Default emission factors are available from the IPCC guidelines (IPCC 2006).

6.2 Procedures for Option 2: Facility-Specific Carbon Balance Calculation

When assuming a 100% conversion of C to CO₂, no missing data procedures would apply because this factor would be multiplied by the materials input, which are readily available. If the amount of carbonaceous agent input is not available, a facility owner or operator would need to extrapolate a value from previous years operating data taking into consideration any changes in production or process.

6.3 Procedures for Option 3: Facility-Specific Emission Factor Using Stack Test Data

For a method requiring measurement of CO₂ emissions using stack testing, “missing data” is not generally anticipated. Stack testing conducted for the purposes of compliance determination is subject to quality assurance guidelines and data quality objectives established by the U.S. EPA, including the Clean Air Act National Stack Testing Guidance (US EPA 2005). The 2005 Guidance Document states that stack tests should be conducted in accordance with a pre-approved site-specific test plan to ensure that a complete and representative test is conducted. In addition, according to the 2005 Guidance Document, a site-specific test plan would generally include chain of custody documentation from sample collection through laboratory analysis including transport, and should recognize special sample transport, handling, and analysis instructions necessary for each set of field samples. The test plan for a stack test used to obtain data for the purposes of emissions reporting would be made available for review prior to performing the stack test, and the stack test results would be reviewed with respect to the test plan prior to the data being deemed acceptable for the purposes of emissions reporting. Results of stack tests that do not meet pre-established quality assurance guidelines and data quality objectives would generally not be acceptable for use in emissions reporting.

6.4 Procedures for Option 4: Direct Measurement Using CEMS

For a method requiring direct measurement of CO₂ emissions using CEMS, procedures for management of missing data established by the U.S. EPA in 40 CFR Part 75 could be used. These procedures for management of missing data are described in Part 75.35(a), (b), and (d). In general, missing data from operation of the CEMS may be replaced with substitute data to determine the CO₂ flow rates or CO₂ emissions during the period in which CEMS data are missing.

7. QA/QC Requirements

Facility owners and operators could conduct quality assurance (QA) and quality control (QC) of the information used for each GHG emissions determination including production and consumption data, supplier information (e.g., carbon contents), and emission estimates calculations performed. Facility owners and operators could be encouraged to prepare an in-depth quality assurance and quality control plan which could include checks on production data, the carbon content information received from the supplier and from the lab analysis, and calculations performed to estimate GHG emissions. Several examples of QA/QC procedures are described below.

7.1 Combustion Emissions

In general, for determining and reporting emissions (CO₂, CH₄, and N₂O) from stationary combustion sources operated at ferroalloy production facilities, facility owner and operators would follow the guidelines described for the method options presented in the Stationary Combustion Source TSD (refer to EPA-HQ-OAR-2008-0508-004). However, if a method requiring measurement of CO₂ emissions using either stack testing or a CEMS is selected for use at ferroalloy production facilities to report GHG emissions from stationary combustion sources that also release process-related GHG emissions, the reported GHG emissions will be the combined combustion and process-related emissions. For these sources for which the CO₂ emissions resulting from fuel combustion in the source are accounted for by the stack test or CEMS data, the source would not need to be included with the other stationary combustion sources at the ferroalloy production facility for which combustion CO₂ emissions are addressed according using one of the method options presented in the Stationary Combustion Source TSD.

7.2 Process Emissions

The QA/QC requirements vary depending on the monitoring method used for determining annual GHG emissions from a source. Each use of each method option described in Section 5 requires QA/QC measures appropriate to the particular methodology used to ensure proper emission monitoring and reporting.

7.3 Methods Using Stack Test Data

For a method requiring measurement of CO₂ emissions using stack testing (e.g., Option 3), the stack test could be required to be performed according to the quality assurance guidelines and data quality objectives established by the U.S. EPA, including the Clean Air Act National Stack Testing Guidance (U.S. EPA 2005).

7.4 Methods Using CEMS

For a method requiring direct measurement of CO₂ emissions using CEMS (Option 4), the equipment could be tested for accuracy and calibrated as necessary by a certified third party vendor. These procedures would be consistent in stringency and data reporting and documentation adequacy with the QA/QC procedures for CEMS described in Part 75 of the Acid Rain Program (EPA 2008a).

7.5 Data Management

Data management procedures could be included in the QA/QC Plan. Elements of the data management procedures plan could include:

- For measurements of carbon content, assess representativeness of the carbon content measurement by comparing values received from supplier and/or laboratory analysis with IPCC default values.
- Check for temporal consistency in the production data, carbon content data, and emission estimate.
 - A monitoring error is probable if differences between annual data cannot be explained by:
 - § Changes in activity levels,
 - § Changes concerning fuels or input material,
 - § Changes concerning the emitting process (e.g. energy efficiency improvements) (European Commission 2007).
- Determine the “reasonableness” of the emission estimate by comparing it to previous year’s estimates and relative to national emission estimate for the industry:
 - Comparison of data on fuel or input material consumed by specific sources with fuel or input material purchasing data and data on stock changes,
 - Comparison of fuel or input material consumption data with fuel or input material purchasing data and data on stock changes,
 - Comparison of emission factors that have been calculated or obtained from the fuel or input material supplier, to national or international reference emission factors of comparable fuels or input materials
 - Comparison of emission factors based on fuel analyses to national or international reference emission factors of comparable fuels, or input materials,
 - Comparison of measured and calculated emissions (European Commission 2007).
- Maintain data documentation, including comprehensive documentation of data received through personal communication:
 - Check that changes in data or methodology are documented

8. Types of Emission Information to be Reported

Ferroalloy production facility owners and operators could report annual CO₂, CH₄, and N₂O emissions. Depending on the monitoring method selected (discussed in Section 5), additional information could be reported to assist in the verification of the reported emissions. Such information could include facility operation information routinely recorded at the facility such as ferroalloy product production quantities, raw material quantities purchased and consumed, and fossil fuel usage. In addition, facility owners and operators would report additional information to assist in QA/QC of any site-specific GHG emissions data used for the reported emissions determination.

8.1 Types of Emissions to be Reported

Ferroalloy production releases both process-related and combustion GHG emissions. The major source of GHG emissions from a ferroalloy production facility are the process-related CO₂ emissions and CH₄ from the EAF operations.

8.2 Additional Data to be Retained Onsite

Owners and operators of facilities reporting GHG emissions could be required to retain certain process configuration information and operating data used for their GHG emissions determinations onsite for a period of at least three years from the reporting year. Process configuration information to be reported includes combustion device types, numbers, and sizes, and identification of process equipment using carbonaceous input materials. Process operating data to be reported includes process raw material feed rates and carbon contents, and ferroalloy product production quantities. These data could be used to conduct trend analyses and potentially to develop process or activity-specific emission factors for ferroalloy production facilities. For method using stack testing, information and data to be reported include stack test reports and associated sampling and chemical analytical data for the stack test. For method using emission monitoring systems, information and data to be reported include measured GHG concentrations and stack gas flow rates, calibration and quality assurance records.

9. References

Australian DCC (2007). National Greenhouse and Energy Reporting System: Technical Guidelines for the Estimation of Greenhouse Emissions and Energy at Facility Level. Commonwealth of Australia. Canberra, Australia.

Environment Canada (2006). Facility Greenhouse Gas Emissions Reporting Program. http://www.ec.gc.ca/pdb/ghg/guidance/calcu_pro_e.cfm. Accessed 4/30/2008

EPA (2008). Communication with EPA on alternative protocols. As cited in draft file: *Metals processes tables 040308 for EPA.xls*. Accessed 4/29/2008.

IPCC (2006) 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The National Greenhouse Gas Inventories Programme, The Intergovernmental Panel on Climate Change, H.S. Eggleston, L. Buendia, K. Miwa, T Ngara, and K. Tanabe (eds.). Hayama, Kanagawa, Japan.

European Parliament (2007). Official Journal of the European Union, August 31, 2007. Commission Decision of 18 July 2007, "Establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council. Available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF>.

Personal communication between ICF International's Charles Cebul and USGS Commodity Specialist John Papp.

Personal communication between ICF International's Charles Cebul and USGS Commodity Specialist Kim Shed.

Personal communication between ICF International's Charles Cebul and USGS Commodity Specialist Lisa Corathers.

Personal communication between ICF International's Charles Cebul and USGS Commodity Specialist Michael Magyar.

Sjardin, M. (2003) CO₂ Emission Factors for Non-Energy Use in the Non-Ferrous Metal, Ferroalloys and Inorganics Industry. Copernicus Institute. Utrecht, the Netherlands.

U.S. DOE (2005) 2002 Manufacturing Energy Consumption Survey. Prepared by Energy Information Administration <http://www.eia.doe.gov/emeu/mecs/mecs2002> 24 Jan 2005. Table3.2.

U.S. Census Bureau. 2002. 2002 NAICS Codes and Titles. <http://www.census.gov/epcd/naics02/naicod02.htm> 23 Mar 2004.

US EPA (2003). Part 75, Appendix B1, Available at <http://www.epa.gov/airmarkt/spm/rule/001000000B.htm>.

U.S. EPA 2005. Clean Air Act National Stack Testing Guidance, U.S. Environmental Protection Agency Office of Enforcement and Compliance Assurance, September 30, 2005, www.epa.gov/compliance/resources/policies/monitoring/caa/stacktesting.pdf

U.S. EPA 2007. Climate Leaders, Inventory Guidance, Design Principles Guidance, Chapter 7 “Managing Inventory Quality”. Available at http://www.epa.gov/climateleaders/documents/resources/design_princ_ch7.pdf.

U.S. EPA (2008) Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006. U.S. Environmental Protection Agency, Washington D.C. USEPA #430-R-08-005.

USGS (2005) Minerals Yearbook: Ferroalloys Annual Report. U.S. Geological Survey, Reston, VA. Available at: <http://minerals.usgs.gov/minerals/pubs/commodity/ferroalloys/feallmyb05.pdf>.

USGS (2006) Minerals Yearbook: Silicon Annual Report. U.S. Geological Survey, Reston, VA. Available at: <http://minerals.usgs.gov/minerals/pubs/commodity/silicon/myb1-2006-simet.pdf>.

USGS (2006) Minerals Yearbook: Titanium Annual Report. U.S. Geological Survey, Reston, VA. Available at: <http://minerals.usgs.gov/minerals/pubs/commodity/titanium/myb1-2006-titan.pdf>.