Technical Support Document for the Titanium Dioxide Production Sector: Proposed Rule for Mandatory Reporting of Greenhouse Gases

Office of Air and Radiation

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CONTENTS

1. Industry Description

Titanium Dioxide (TiO_2) is a metal oxide commonly used as a white pigment in paint manufacturing, paper, plastics, rubber, ceramics, fabrics, floor covering, printing ink, and other applications (IPCC 2006). The majority of titanium dioxide production is for the manufacturing of white paint. National production of titanium dioxide in 2006 was approximately 1,400,000 metric tons (mt) (USGS 2006).

Titanium dioxide is produced through two processes: the chloride process and the sulfate process. The chloride process emits process-related carbon dioxide (CO_2) through the use of petroleum coke and chlorine as raw materials, while the sulfate process does not emit any process-related greenhouse gases (U.S. EPA 2008b, IPCC 2006). The sulfate process does not use petroleum coke or other forms of C as a raw material and does not emit CO_2 (U.S. EPA 2008b). Hence, the sulfate process may result in combustion-related emissions as calcining is done late in the sulfate process (IPCC 2006. During the chloride process, petroleum coke is oxidized as the reducing agent in the first reaction in the presence of chlorine and crystallized iron titanium oxide ($FeTiO_3$) to form CO_2. A special grade of petroleum coke (known as calcined petroleum coke, CPC) is used for this chloride process (U.S. EPA 2008b). The chloride process is based on the following chemical reactions:

$$2\ FeTiO_3 + 7\ Cl_2 + 3\ C \rightarrow 2\ TiCl_4 + 2\ FeCl_3 + 3\ CO_2$$

$$2\ TiCl_4 + 2\ O_2 \rightarrow 2\ TiO_2 + 4\ Cl_2$$

The titanium tetrachloride ($TiCl_4$) produced in the first reaction is oxidized at about 1,000°C, and the resulting TiO_2 is calcinated to remove residual chlorine and any hydrochloric acid that may have formed in the reaction (USGS 2006).

Total U.S. production of titanium dioxide pigment through the chloride process was approximately 1.4 million metric tons in 2006, a 7 percent increase compared to 2005 (USGS 2006). As of 2004, the last remaining sulfate-process plant in the United States had closed. As a result, all U.S. current titanium dioxide pigment production results from the chloride process (USGS 2005). Four companies produce of titanium dioxide pigment in the U.S.: DuPont, Louisiana Pigment Co. L.P., Millennium Inorganic Chemicals Inc., and Tronox Inc. These companies operate a total of eight facilities. Their titanium dioxide capacity data is presented in Table 1.

Table 1. U.S. Producers of Titanium Dioxide Pigment (metric tons/year)

Company	Plant Location	Year End Capacity (metric tons) [a,b]
Du Pont Titanium Technologies, De Lisle Plant	De Lisle, MS	340,000
Du Pont Titanium Technologies, Edge Moor Plant	Edge Moor, DE	154,000
Du Pont Titanium Technologies, New Johnsonville Plant	New Johnsonville, TN	380,000
Louisiana Pigment Co. L.P. (a joint venture of NL Industries, Inc. and Huntsman Corp.)	Lake Charles, LA	146,000
Millennium Inorganic Chemicals Inc., Ashtabula Plant I and II	Ashtabula, OH	220,000
Millennium Inorganic Chemicals Inc., Hawkins Point Plant	Baltimore, MD	50,000
Tronox Inc.	Hamilton, MS	225,000
Tronox Inc. (formerly Kerr-McGee)	Savannah, GA	110,000
Total		**1,625,000**

Note: Estimated operating capacity based on 7-day-per-week full production. Table does not include TOR Minerals International Inc.'s Corpus Christi, TX, production capacity of about 26,400 mt per year of buff that is produced by refining and fine grinding of synthetic rutile. [note that there is an emission factor for synthetic rutile in Table 2.]

[a] Data are rounded to no more than three significant digits; may not add to totals shown.

[b] All plants use the chloride process to manufacture TiO_2 pigment.

Source: USGS 2006.

2. Total Emissions

Total CO_2 emissions from titanium dioxide production were approximately ~ 3.6 $MMTCO_2e$ (3,628,054 metric tons CO_2e) in 2006 (U.S. EPA 2008b). These emissions were closely divided between process emissions of 1.87 $MMTCO_2e$ and combustion emissions of 1.8 $MMTCO_2e$. Emissions have increased 57 percent since 1990, and 7 percent since 2005 (U.S. EPA 2008b). Emissions from on-site CO_2 combustion are not currently accounted for separately in the U.S. Inventory. However, the processing of titanium dioxide requires boilers, dryers, and other equipment that use natural gas, and hence, results in emissions from combustion.

2.1 Process Emissions

Titanium dioxide is produced through two processes: the chloride process and the sulfate process. The sulfate process does not produce any significant process-related greenhouse gas emissions (IPCC 2006) although the sulfate process may produce emissions from stationary combustion. The chloride process emits process-related carbon dioxide (CO_2) through the use of CPC and chlorine as raw materials (U.S. EPA 2008b).

2.2 Stationary Combustion

Stationary combustion emissions occur when fossil fuels are combusted to provide energy for manufacturing equipment, as well as to provide heat for the manufacturing process. This heat is used in the previously discussed chloride process to produce titanium dioxide. These combustion emissions of greenhouse gases are limited to the natural gas fuel inputs used to fire boilers, spray dryers, oxygen preheaters, $TiCl_4$ vaporizer trains and other necessary equipment of the production process.

3. Review of Existing Programs and Methodologies

Protocols and guidance reviewed for this analysis include the *2006 IPCC Guidelines*, the DOE 1605(b) Reporting Program, the U.S. Greenhouse Gas Inventory system, the Australian Government's National Mandatory Greenhouse and Energy Reporting System, and the Government of Canada's Greenhouse Gas Reporting Program. Several of these methodologies consider one of two approaches, based on measuring either the input or output of the production process. The output method involves multiplying production data by emission factors. The input method involves measuring the consumption and the carbon content of the reducing agent. The IPCC, Australian Government's National Mandatory Greenhouse and Energy Reporting System, the Government of Canada's Greenhouse Gas Reporting program, and *U.S. Inventory* guidelines are discussed in more detail below. The DOE 1605(b) program did not list a protocol for titanium dioxide production and therefore is not discussed below.

3.1 2006 IPCC Guidelines

The IPCC considers two different methods for calculating process-related emissions from titanium dioxide production (IPCC 2006). The Tier 1 method uses a default emission factor per unit of output multiplied by production activity data. The Tier 2 method calculates process emissions through facility-level data collection. The emissions can be calculated from the consumption of the calcined petroleum coke as well as the carbon content and oxidation factor of the calcined petroleum coke.

The IPCC Tier 1 method was used to determine process-related CO_2 emissions from the facilities presented in Table 1, because production capacity was the only facility-level data available (see note on Table 1). IPCC guidance supports the use of default emission factors when plant-level information on calcined petroleum coke use is not available (IPCC 2006). These factors are presented in Table 2.

Table 2. Default Emission Factors for Titanium Dioxide Production

Product	Emission Factor (mtCO_2 per ton product)
Titanium slag [a]	Not available
Synthetic rutile	1.43
Rutile titanium dioxide (chloride route)	1.34

[a] A default emission factor is not available because there are only two plants using this production method and they are outside of the US in Richards Bay (South Africa) and Allard Lake (Canada), and plant data are confidential.

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories

3.2 2008 U.S. Inventory of Greenhouse Gas Emissions and Sinks

The U.S. Greenhouse Gas Inventory system requires reporting of CO_2 emissions from titanium dioxide production. This program is not a industry reporting program but instead utilizes the national titanium dioxide production data and percent of industry using the chloride process (100%) (USGS 2006).

3.3 Australian National Greenhouse and Energy Reporting System

The Australian Government's National Greenhouse and Energy Reporting System (NGER 2007) requires reporting of CO_2 emissions from titanium dioxide production. Registration and reporting under this system is required for corporations if: they control facilities that emit at least 25,000 metric tons CO_2e, or produce or consume at least 100 terajoules of energy; or their corporate group emits at least 125,000 metric tons CO_2e, 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 uses the following equation:

$$E = A \times EC \times EF / 1000$$

Where:

E = CO_2 emissions from the production of titanium dioxide ($MTCO_2$e)

A = carbon reducing agent usage (metric tons)

EC = energy content of the reducing agent (gigajoules/mt)

EF = emission factor for the reducing agent (including effects of oxidation) (kg/gigajoule)

Facilities may use the default emission factors (presented in Table 3), but the higher-order method would be to develop facility-specific emission factors from the carbon content of the reducing agent.

Table 3. Australian National Greenhouse Account Default Emission Factors

Reducing Agent Used	Energy Content (gross) GJ/t	Emission Factor kg CO_2e/GJ (all gases)
Lignite-Brown coal	10.2	93.2
Coking coal (metallurgical coal)	30.0	90.2
Black coal	27.0	88.5
Brown coal briquettes	22.1	93.6
Coke oven gas	27.0	117.4
Coal tar	37.5	81.3

Source: Australia National Greenhouse and Energy Reporting System 2007 (http://www.greenhouse.gov.au/reporting/publications/pubs/nger-techguidelines.pdf)

3.4 Government of Canada's Greenhouse Gas Reporting Program

The Government of Canada's Greenhouse Gas Reporting Program (EC 2006) uses the same approach to the 2006 IPCC guidelines. Rather than offering specific guidance, the program references the 2006 IPCC guidelines.

4. Options Considered for Reporting Threshold

4.1 Emissions Thresholds

For the reporting of process CO_2 emissions from titanium dioxide production, threshold options considered included emissions-based thresholds of 100,000, 25,000, 10,000, and 1,000 metric tons CO_2e for both combustion and process emissions. The results of the threshold analysis are summarized in Table 4.

A summary of the emissions and facilities covered per option is presented in Table 4. Emission estimates were calculated based on the 2006 CO_2 Emissions from Titanium Dioxide provided by the *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2006* (EPA 2008b) and individual plant capacity data (USGS 2006). At the threshold levels of 1,000, 10,000, and 25,000 metric tons, all facilities exceed the threshold, therefore covering 100 percent of total emissions. However, at the 100,000 metric ton level, one facility would not exceed the threshold – the Baltimore, Maryland plant of Millennium Inorganic Chemicals Inc., which produces an estimated 57,723 metric tons CO_2e emissions per year. At the 100,000 metric ton threshold level, 98 percent of emissions would be covered.

Table 4. Emissions Threshold Analysis for Titanium Dioxide

Threshold Level (metric tons CO_2e/yr)	Process Emissions (metric tons CO_2e/yr)	Combustion CO_2 Emissions (metric tons CO_2e/yr)	Total National Emissions (metric tons CO_2e)	Number of Entities	Emissions Covered		Entities Covered	
					Metric tons CO_2e/yr	Percent	Number	Percent
100,000	1,876,000	1,809,777	3,685,777	8	3,628,054	98%	7	88%
25,000	1,876,000	1,809,777	3,685,777	8	3,685,777	100%	8	100%
10,000	1,876,000	1,809,777	3,685,777	8	3,685,777	100%	8	100%
1,000	1,876,000	1,809,777	3,685,777	8	3,685,777	100%	8	100%

In order to determine stationary combustion CO_2 emissions from combustion related to the titanium dioxide process, background research was conducted on several of the facilities. GHG emissions from on-site fossil fuel combustion were estimated using data collected through Title V permitting for two representative facilities, Tronox (Savannah, GA) and Millennium Inorganic Chemicals, Inc. (Ashtabula, OH) with high capacity (225,000 mt/year) and medium capacity (154,000 mt/year), respectively. The Tronox facility reported 17 small natural gas devices with the following ratings: 10 MMBtu/hour (4 devices), 5 MMBtu/hour (11 devices), 1 MMBtu/hour (2 devices) as well as two large natural gas boilers of 181 MMBtu/hour and 128 MMBtu/hour ratings (Georgia DNR 2002). These devices were assumed to run 24 hours/day, 365 days/year at 90 percent of capacity, totaling 3,200,904 MMBtu/year and GHG emissions of 146,466 $MTCO_2$e.

The Millennium facility reported two titanium dioxide facilities. The first plant operates natural gas boilers of 69 MMBtu/hour rating and one natural gas boiler of 90 MMBtu/hour rating as well as five spray dryers of 5.9, 7, 9.5, 24 and 37 MMBtu/hour ratings; a chlorination unit of 17.6 MMBtu/hour rating; an oxygen preheater of 14.6 MMBtu/hour rating; and $TiCl_4$ Vaporizer Train of 7 MMBtu/hour rating (Ohio EPA 2002). The second plant operates three natural-gas fired combustion turbines of 65, 37, and 21 MMBtu/year, as well as a 55 MMBtu/hour heater, 16.8 MMBtu/hour $TiCl_4$ Vaporizer, a 9.5 MMBtu/year oxygen preheater, a 2.2 MMBtu/hour oxygen preheater and a 6 MMBtu/hour dryer (Ohio EPA 2004). The devices in these plants were assumed to run 24 hours/day, 365 days/year at 90 percent of capacity, totaling 4,440,269 MMBtu/year and GHG emissions of 203,176 metric tons CO_2e.

The energy requirements of the Tronox Facility and Millennium Facility were weighted based on their respective capacities. This factor was to determine an average energy requirement for a titanium dioxide facility and applied to the remaining 6 facilities based on their capacity. The average energy requirements are 7,641,173 MMBtu/year. The average emissions per unit of capacity is 1.13 metric tons CO_2e per ton of capacity. The weighted energy requirements are likely overestimates of actual requirements because: 1) no information is known concerning the chlorine production process used by these facilities; 2) the facilities are assumed to operate at near capacity; and 3) the Millennium Facility is also believed to operate a cogeneration unit. The total estimated CO_2 emissions from combustion totaled approximately 1,809,777 metric tons CO_2e. This amount, combined with the total facility-level calculated emissions, produced a sum of 3,685,777 metric tons CO_2e or total national emissions.

Emissions were estimated by multiplying the energy consumption (MMBtu/year) by the carbon content of natural gas (14.47 Tg C/QBtu) provided by the *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2006* (EPA 2008b) as well as CH_4 and N_2O emission factors provided by Table 2.3 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006) (Table 6). These emissions were then multiplied by the national capacity utilization rate of 86 percent. The utilization rate was calculated using total titanium dioxide production for 2006 (1,400,000 metric tons), which was provided by the *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2006* (EPA 2008b), and total titanium dioxide capacity (1,625,000 metric tons), which was provided by the USGS 2006 *Minerals Yearbook: Titanium Dioxide Annual Report* (USGS 2006).

Table 5. Default Emission Factors for Stationary Combustion in Manufacturing Industries and Construction

Fuel	CH_4 Default Emission Factor (kg/TJ)	N_2O Default Emission Factor (kg/TJ)
Natural Gas	1	0.1

Source: From Table 2.3 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

4.2 Capacity Thresholds

Four capacity threshold levels were considered for the titanium dioxide production sector. These thresholds were 300,000, 200,000, 100,000, and 50,000 metric tons of titanium dioxide produced per year. The results of the capacity threshold analysis are shown in Table 6.

For the capacity thresholds analysis for titanium dioxide production, EPA considered four different capacities of titanium dioxide production. Capacity is the largest amount of titanium dioxide that a facility can produce on an annual basis. The thresholds considered were 300,000, 200,000, 100,000, and 50,000 metric tons of titanium dioxide produced per year. A threshold of 50,000 metric tons captures all facilities in the inventory. A threshold of 100,000 metric tons captures 97 percent of emissions, and 88 percent of the facilities. A threshold of 200,000 metric tons captures 72 percent of emissions, 50 percent of the facilities. A threshold of 300,000 metric tons captures 44 percent of emissions, 25 percent of the facilities. Note: capacities as provided by USGS (2006) analysis were estimated based on 7-day-per-week full production. Facility-level CO_2 process emissions (based on capacity) were calculated by multiplying facility capacity by the emission factor for rutile TiO_2 (1.34) in order to determine estimated facility process emissions. These results are presented in Table 6. At the 50,000 metric tons threshold level, 100 percent of emissions would be covered.

Table 6. Capacity Threshold Analysis for Titanium Dioxide

Capacity Threshold Level (metric tons/titanium dioxide/yr)	Process Emissions (metric tons CO_2e/yr)	Number of Entities	Emissions Covered		Entities Covered	
			Metric tons TCO_2e/yr	Percent	Number	Percent
300,000	2,177,500	8	964,800	44%	2	25%
200,000	2,177,500	8	1,561,100	72%	4	50%
100,000	2,177,500	8	2,110,500	97%	7	88%
50,000	2,177,500	8	2,177,500	100%	8	100%

4.3 No Emissions Threshold

The no emissions threshold includes all titanium dioxide production facilities regardless of their emissions or capacity.

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5. Options for Monitoring Methods

Two separate monitoring methods were considered for this technical support document. One option uses a simplified emission calculation (Option 1) and the other option estimates CO_2 emissions based on the facility-specific quantity of calcined petroleum coke consumed (Option 2). Both of these options require annual reporting. Continuous emissions monitoring systems (CEMS) and/or stack testing were not recommended in the IPCC 2006 for this industry and are thus not discussed further in this technical support document.

5.1 Option 1: Simplified Emissions Calculation

A simplified emissions calculation is based upon the IPCC Tier 1 methodology (IPCC 2006). The Tier 1 method is an output-based approach. The Tier 1 equation is as follows:

$$E_{CO2} = AD \times EF$$

Where:

E_{CO2} = Emissions of CO_2 (metric tons)

AD = Production of rutile TiO_2 (metric tons)

EF = CO_2 emissions per unit of production of rutile TiO_2 (metric ton CO_2/metric ton of product)

Because the chloride process is used exclusively in the U.S., this method relies upon the rutile TiO_2 emission factor (i.e., 1.34) presented earlier in Table 2.

5.2 Option 2: Calcined Petroleum Coke (CPC) Consumed Approach (Annual Reporting)

This approach is based upon the IPCC Tier 2 method, which is an input-based approach. There is no need to calculate the carbon content of the CPC as it is known when purchased (consistently greater than 98 percent carbon, [RTI 2008]). Also, the carbon oxidation factor for the CPC is assumed to be 100 percent, as any amount that is not oxidized is insignificant. The following equation is used to calculate emissions:

$$E_{CO2} = (44/12) \times CCF \times COF \times AD \times (2000/2205)$$

Where:

E_{CO2} = Emissions of CO_2 (metric tons)

44/12 = Ratio of molecular weights, CO_2 to carbon

AD = Quantity of CPC input (tons)

CCF = Carbon content factor of CPC (assumed to be 1)

COF = Carbon oxidation factor for CPC, (fraction, assumed to be 100/100)

2000/2205 = Conversion factor to convert tons to metric tons.

As IPCC states, "to achieve the highest accuracy, good practice is to apply [this equation] at the plant-level with all data input obtained from plant operators" (IPCC 2006). Therefore, the plant-level activity data for the consumption listed above should be provided through plant records or other available data, rather than continuous emissions monitoring or other monitoring methods.

5.3 Option 3: Direct Measurement

For industrial source categories for which the process emissions and/or combustion GHG emissions are contained within a stack or vent, direct measurement constitutes either measurements of the GHG concentration in the stack gas and the flow rate of the stack gas using a CEMS, or periodic measurement of the GHG concentration in the stack gas and the flow rate of the stack gas using periodic stack testing. In the case of silicon carbide, process and combustion GHG emissions are not emitted from the same stack. Process emissions from the product furnaces are emitted from four separate stacks and combustion emissions from the product dryer are emitted from a fifth stack.

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., CO_2) 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. A CEMS continuously withdraws and analyzes a sample of the stack gas and continuously measures the GHG concentration and flow rate of the stack gas.

For direct measurement using stack testing, sampling equipment would be periodically brought to the site and installed temporarily in the stack to withdraw a sample of the stack gas and measure the flow rate of the stack gas. Similar to CEMS, for stack testing the emissions are calculated from the concentration of GHGs in the stack gas and the flow rate of the stack gas. The difference between stack testing and continuous monitoring is that the CEMS data provide a continuous measurement of the emissions, while a stack test provides a periodic measurement of the emissions. A method using periodic, short-term stack testing would be appropriate for those facilities where process inputs (e.g., carbonaceous reducing agents such as petroleum coke) 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.

6. Procedures for Estimating Missing Data

Options and considerations for missing data vary will vary depending on the monitoring method. Each option would require a complete record of all measured parameters as well as parameters determined from company records that are used in the GHG emissions calculations (e.g., carbon contents, monthly fuel consumption, etc.).

6.1 Procedures for Option 1: Simplified Emissions Calculation

For process sources in the titanium dioxide production category that use Option 1, facility-specific production data is required, therefore missing data is not allowed for this option.

6.2 Procedures for Option 2: CPC Consumed Approach

For process sources in the titanium dioxide production category that use Option 2, it is assumed that a facility will be able to supply facility-specific data.

6.3 Procedures for Option 3: Direct Measurement

For options involving direct measurement of CO_2 emissions using CEMS, Part 75 establishes procedures for the management of missing data. Specifically, the procedures for managing missing CO_2 concentration data are specified in §75.35. In general, missing data from the operation of the CEMS may be replaced with substitute data to determine the CO_2 emissions during the period for which CEMS data are missing. Section 75.35(a) requires the owner or operator of a unit with a CO_2 CEMS to substitute for missing CO_2 pollutant concentration data using the procedures specified in paragraphs (b) and (d) of §75.35; paragraph (b) covers operation of the system during the first 720 quality-assured operation hours for the CEMS, and paragraph (d) covers operation of the system after the first 720 quality-assured operating hours are completed.

During the first 720 quality-assured monitor operating hours following initial certification at a particular unit or stack location, the owner or operator would be required to substitute CO_2 pollutant concentration data according to the procedures in §75.31(b). That is, if prior quality-assured data exist, the owner or operator would be required to substitute for each hour of missing data, the average of the data recorded by a certified monitor for the operating hour immediately preceding and immediately following the hour for which data are missing. If there are no prior quality-assured data, the owner or operator would have to substitute the maximum potential CO_2 concentration for the missing data.

Following the first 720 quality-assured monitor operating hours, the owner or operator would have to follow the same missing data procedures for SO_2 specified in §75.33(b). The specific methods used to estimate missing data would depend on the monitor data availability and the duration of the missing data period.

7. QA/QC Requirements

Facilities should conduct quality assurance and quality control of the production and consumption data, supplier information (e.g., carbon contents), and emission estimates reported. Facilities are encouraged to prepare an in-depth quality assurance and quality control plan which would 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 listed below.

7.1 Stationary Emissions

For QA/QC options for stationary combustion refer to EPA-HQ-OAR-2008-0508-004.

7.2 Process Emissions

Options and considerations for QA/QC will vary depending on the monitoring method. Each option would require unique QA/QC measures appropriate to the particular methodology employed to ensure proper emission monitoring and reporting.

7.3 Data Management

Data management procedures should be included in the QA/QC Plan. Elements of the data management procedures plan are as follows:

- For measurements of carbonate content, assess representativeness of the carbonate content measurement by comparing values received from supplier and/or laboratory analysis with IPCC default values.
- Check for temporal consistency in production data, carbonate content data, and emission estimate. If outliers exist, they should be explained by changes in the facility's operations or other factors. 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

Based on the existing programs and the emission sources at titanium dioxide production facilities, GHG reporting for these facilities is limited to CO_2, CH_4, and N_2O. Titanium dioxide facilities should report both process (CO_2) and combustion related (CO_2, CH_4, and N_2O) greenhouse gas emissions. The data to be reported may very depending on monitoring options selected. However, a titanium dioxide production facility should report its annual average petroleum coke consumption, number of chloride process lines, annual titanium dioxide production, annual titanium dioxide production capacity, electricity usage (kilowatt-hours), and annual operating hours. For reporting options for stationary combustion refer to EPA-HQ-OAR-2008-0508-004.

8.1 Other Information to be Reported

Each titanium dioxide production facility should report the following:

- Total annual CO_2 emissions from chloride process lines from monthly averages (metric tons);
- Number of chloride process lines;
- Annual calcined petroleum coke consumption from monthly measurements (metric tons);
- Annual production of titanium dioxide (metric tons);
- Annual capacity of titanium dioxide (metric tons);
- Electricity usage, KWhr/yr; and
- Annual operating hours for each titanium dioxide production facility.

8.2 Additional Data to be Retained Onsite

Facilities should be required to retain data concerning monitoring of GHG emissions onsite for a period of at least five years from the reporting year. EPA could use such data to conduct trend analyses and potentially to develop process or activity-specific emission factors for the process. Facilities should retain the following information:

- Records of annual CO_2 emissions (metric tons);
- Monthly production of titanium dioxide (metric tons);
- Production capacity of titanium dioxide (metric tons);
- Records of monthly calcined petroleum coke consumption (metric tons);
- Electricity usage, KWhr/yr; and
- Annual operating hours for each titanium dioxide production facility.

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