Calcium Carbide

STEP 4 ESTIMATING CO_2 EMITTED FROM CALCIUM CARBIDE PRODUCTION

1 Obtain an estimate of the Amount of Carbide Produced in tonnes and enter this value in column A.

2 Enter the corresponding Emission Factor, in tonnes CO_2 per tonne of chemical produced, in column B. For calcium carbide the emission factor must include all necessary components, such as heating of calcium carbonate, reduction of lime and/or use of product (see Table 2-8 for emission factors). Do not include emissions from lime production, if lime is produced at a different plant from the calcium carbide.

3 Multiply column A by column B to obtain CO_2 Emitted in tonnes and enter this value in column C.

4 Divide column C by 10^3 to convert to units of gigagrams CO_2, and enter this value in column D.

5 Sum the values in column D and enter the result in the bottom of that column to obtain the total CO_2 Emitted.

2.12 Production of Other Chemicals

Introduction

The production of other chemicals such as carbon black, styrene, polyvinylchloride, sulphuric acid, etc. can be sources of CH_4, N_2O, NO_x, NMVOC, CO and SO_2.

Data Sources

International production data are available from the United Nations (1988) and from the US Bureau of Mines (1988). The Standard Nomenclature for Air Pollution (SNAP) (EMEP/CORINAIR, 1996) codes for the processes are given in the tables.

2.12.1 Methodology for Estimating Emissions of CH_4

Although most CH_4 sources from industrial processes individually are small, collectively they may be significant.

Few data on emission factors are presently available. These are presented in Table 2-9 (see the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories Reference Manual* for sources).

TABLE 2-9
EMISSION FACTORS FOR CH_4 FROM OTHER CHEMICAL PRODUCTION
(KG CH_4/TONNE PRODUCTION)

Carbon black	11
Ethylene	1
Dichloroethylene	0.4
Styrene	4
Methanol	2
Coke	0.5

Emissions are determined by multiplying an emission factor by the annual production.

2.12.2 Methodology for Estimating Emissions of N_2O

Production of chemicals other than nitric acid and adipic acid may be sources of N_2O, but more studies are needed to determine whether they represent significant sources.

2.12.3 Methodology for Estimating Emissions of NO_x, NMVOC, CO and SO_2

This section is concerned with emissions from small point sources. Total national emissions from these sources may be important and a simple methodology is suggested here.

A summary of default emission factors, as well as emission factor ranges where applicable, is provided in Table 2-10. Ranges given for NMVOC emissions from many processes are quite large. Emission factors are likely to be quite process specific.

TABLE 2-10
EMISSION FACTORS FOR MISCELLANEOUS PRODUCTION PROCESSES IN CHEMICAL INDUSTRIES
(KG/TONNE PRODUCT)

SOURCE	SNAP	NO_X	NMVOC	CO	SO_2
Acrylonitrile	40520	-	1 (0.4-100)	-	-
Acrylonitrile Butadiene Styrene (ABS) Resins	40515	-	27.2 (1.4-27.2)	-	-
Carbon black	40409	0.4	40 (5-90)	10 (5-14)	3.1
Ethylbenzene	40518	-	2 (0.1-2)	-	-
Ethylene and propylene	40501/40502	-	1.4	-	-
Formaldehyde	40517	-	5 (0-8)	-	-
Graphite	40411	-	NAV	-	-
Phtalic anhydride	40519	-	6.0 (1.3-6.0)	-	-
Polypropylene	40509	-	12 (0.35-12)	-	-
Polystyrene	40511	-	5.4 (0.2-5.4)	-	-
Polyethene - Low density	40506	-	3	-	-
Polyethene - Linear low density	-	-	2	-	-
Polyethene - High density	50507	-	6.4	-	-
Polyvinylchloride	40508	-	8.5 (0.14-8.5)	-	-
Styrene	40510	-	18 (0.25-18)	-	-
Styrene butadiene	40512-14	-	NAV	-	-
1,2, dichloroethane	40503	-	7.3 (0.2-7.3)	-	-
Sulphuric acid	40401	-	-	-	17.5 (1-25)
Titanium dioxide	40410	-	-	-	14.6 (0.9-14.6)
Urea	40408	NAV	NAV	NAV	NAV
Vinyl chloride [a]	40504				
1,2, dichloroethane	40505	-	2.2	-	-

Note: Ranges in brackets

See the *Revised 1996 IPCC Guidelines for Greenhouse Gas Inventories Reference Manual* for sources.

[a] Emission factors should be used for the monomer and polymer separately even if they are produced at the same plant unless otherwise specified.

Completing the Worksheet

Use WORKSHEET 2-10 PRODUCTION OF OTHER CHEMICALS to enter data for this submodule.

STEP 1 ESTIMATING CH_4 EMITTED

1 Obtain an estimate of the Amount of Chemical Produced in tonnes and enter this value in column A.

2 Enter the corresponding Emission Factor from Table 2-9, in kg CH_4 per tonne of chemical produced, in column B.

3 Multiply column A by column B to obtain CH_4 Emitted in kg and enter this value in column C.

4 Divide column C by 10^6 to convert to units of gigagrams CH_4, and enter this value in column D.

5 Sum the values in column D and enter the result in the bottom of that column to obtain the total CH_4 emitted.

STEP 2 ESTIMATING NO_X EMITTED

1 Obtain an estimate of the Amount of Chemical Produced in tonnes and enter this value in column A.

2 Enter the corresponding Emission Factor from Table 2-10, in kg NO_x per tonne of chemical produced, in column B.

3 Multiply column A by column B to obtain NO_x Emitted in kg and enter this value in column C.

4 Divide column C by 10^6 to convert to units of gigagrams NO_x, and enter this value in column D.

5 Sum the values in column D and enter the result in the bottom of that column to obtain the total NO_X emitted.

STEP 3 ESTIMATING NMVOC EMITTED

1 Obtain an estimate of the Amount of Chemical Produced in tonnes and enter this value in column A.

2 Enter the corresponding Emission Factor from Table 2-10, in kg NMVOC per tonne of chemical produced, in column B.

3 Multiply column A by column B to obtain NMVOC Emitted in kg and enter this value in column C.

4 Divide column C by 10^6 to convert to units of gigagrams NMVOC, and enter this value in column D.

5 Sum the values in column D and enter the result in the bottom of that column to obtain the total NMVOC emitted.

STEP 4 ESTIMATING CO EMITTED

1 Obtain an estimate of the Amount of Chemical Produced in tonnes and enter this value in column A.

2 Enter the corresponding Emission Factor from Table 2-10, in kg CO per tonne of chemical produced, in column B.

3 Multiply column A by column B to obtain CO Emitted in kg and enter this value in column C.

4 Divide column C by 10^6 to convert to units of gigagrams CO, and enter this value in column D.

5 Sum the values in column D and enter the result in the bottom of that column to obtain the total CO emitted..

STEP 5 ESTIMATING SO_2 EMITTED

1. Obtain an estimate of the Amount of Chemical Produced in tonnes and enter this value in column A.
2. Enter the corresponding Emission Factor from Table 2-10, in kg SO_2 per tonne of chemical produced, in column B.
3. Multiply column A by column B to obtain SO_2 Emitted in kg and enter this value in column C.
4. Divide column C by 10^6 to convert to units of gigagrams SO_2, and enter this value in column D.
5. Sum the values in column D and enter the result in the bottom of that column to obtain the total SO_2 emitted.

2.13 Metal Production

Introduction

The preferred methodology (Tier 1a) for the estimation of emissions of CO_2 from all types of metal production is given in Section 2.13.1. This method requires information on the quantity of reducing agent used. If this information is not available, methodologies (Tier 1b) for estimating emissions of CO_2 based on the metal production quantities are given in the following sections pertaining to particular metals.

Data Sources

International production data are available from the United Nations (1988) and from the US Bureau of Mines (1988). The Standard Nomenclature of Air Pollution (SNAP) number for reheating furnaces iron and steel is 30302; gray iron foundries is 30303; production processes - iron & steel industries & collieries is 40200; coke oven is 40201; blast furnace charging is 40202; pig iron tapping is 40203; solid smokeless fuel is 40204; open hearth furnace steel plant is 40205; basic oxygen furnace is 40206; electric furnace steel plant is 40207; rolling mills is 40208; ferroalloys is 40302; ferroalloy production is 40302; aluminium production is 40301; non-ferrous metal industry is 40300(EMEP/CORINAIR, 1996).

2.13.1 Preferred Methodology for Estimating Emissions of CO_2

This preferred methodology requires knowledge of the quantity of reducing agent used in metal manufacturing. If this information is unavailable, refer to Sections 2.13.2 to 2.13.6.

Table 2-11 gives suggested default emission factors for various mass reducing agents.

TABLE 2-11
EMISSION FACTORS FOR CO_2 FROM METAL PRODUCTION
(TONNE CO_2/TONNE REDUCING AGENT)

Reducing Agent	Emission Factor [a]
Coal[b]	2.5
Coke from coal [b]	3.1
Petrol coke	3.6
Prebaked anodes and coal electrodes	3.6

[a] If better information on actual carbon content is not available nationally or cannot be calculated from data in the Energy Chapter.

[b] Derived from data in the Energy Chapter

2.13.2 Iron and Steel

2.13.2.1 Methodology for Estimating Emissions of CO_2

Tier 1a

See Section 2.13.1 if quantity of reducing agent is known.

Tier 1b

Parsons (1977) and ORTECH (1994) have studied the consumption of carbon at iron and steel production facilities. These results have been summarised by Environment Canada 1996. A CO_2 emission factor is shown in Table 2-12.

DOUBLE COUNTING

Additional emissions occur as the limestone flux gives off carbon dioxide during reduction of pig iron in the blast furnace. This source is covered as emissions from limestone use in Section 2.5. Care should be taken not to double count these emissions.

TABLE 2-12
EMISSION FACTOR FOR CO_2 FROM IRON AND STEEL PRODUCTION
(TONNE/TONNE IRON OR STEEL PRODUCT)

Country	Description	Emission Factor	Reference
Canada[a]	Integrated facility[b] (coke plus iron and/or steel production).	1.6	Environment Canada 1996

[a] Includes CO_2 produced by coke and coke oven gas consumption. It does not include any form of conventional energy consumption. The emission factor applies to both iron or iron plus steel production, since uncertainty in the estimates overshadow the sincremental difference in CO_2 emissions.

[b] Environment Canada has reported an emission factor of approximately 1.5 tonnes CO_2 /tonne iron or steel for a non-integrated facility. This is, however, a rather uncertain value.

Note: Figures exclude CO_2 from flux ($CaCO_3$) consumption.

2.13.2.2 Methodology for Estimating Emissions of NO_x, NMVOC, CO and SO_2

Emissions from iron and steel may originate from various stages of the production process. These are described in the tables below. Most of the emissions from rolling mills are from the fuel used to heat the process. However, cold-rolling will emit a range of gases in addition to the emissions from fuel combustion.

The following Tables 2-13 to 2-16 summarise the emission factors reported in the *Revised 1996 IPCC Guidelines for Greenhouse Gas Inventories Reference Manual* for NO_x, NMVOC, CO and SO_2, respectively:

TABLE 2-13
REPORTED NO_X EMISSION RATES FOR THE IRON AND STEEL SECTOR
(G NO_X/TONNE IRON OR STEEL PRODUCED)

Source	Emission Factor (g/tonne produced)	Reference
Iron Production - Pig iron tapping	76	CASPER 1995
Steel Processing - rolling mills	40	EMEP/CORINAIR Guidebook

TABLE 2-14
REPORTED NMVOC EMISSION RATES FOR THE IRON AND STEEL SECTOR
(G NMVOC/TONNE IRON OR STEEL PRODUCED)

Source	Emission Factor (g/tonne produced)	Reference
Iron Production - Blast furnace charging	100	CASPER 1995
Iron Production - Pig iron tapping	20	CASPER 1995
Steel Processing - rolling mills	30	EMEP/CORINAIR Guidebook

TABLE 2-15
REPORTED CO EMISSION RATES FOR THE IRON AND STEEL SECTOR
(G CO/TONNE IRON OR STEEL PRODUCED)

Source	Emission Factor (g/tonne produced)	Reference
Iron Production - Blast furnace charging	1300	CASPER 1995
Iron Production - Pig iron tapping	112	CASPER 1995
Steel Processing - rolling mills	1	EMEP/CORINAIR Guidebook

TABLE 2-16
REPORTED SO_2 EMISSION RATES FOR THE IRON AND STEEL SECTOR
(G SO_2/TONNE IRON OR STEEL PRODUCED)

Source	Emission Factor (g/tonne produced)	Reference
Iron Production - Blast furnace charging	1000-3000	Environment Canada
Iron Production - Pig iron tapping	30	CASPER 1995
Steel Processing - rolling mills	45	EMEP/CORINAIR Guidebook

Emission factors for steel production (open hearth furnace, basic oxygen furnace steel plant and electric furnace steel plants) are not provided.

2.13.3 Ferroalloys

Introduction

Ferroalloy production involves a metallurgical reduction process which results in significant carbon dioxide emissions.

Primary emissions in covered arc furnaces consist almost entirely of CO as opposed to CO_2, due to the strong reducing environment (ORTECH, 1994). All CO is assumed, however, to be converted to CO_2, within days afterwards.

2.13.3.1 Methodology for Estimating Emissions of CO_2

Tier 1a

See Section 2.13.1 if quantity of reducing agent is known.

Tier 1b

The suggested emission factors (Table 2-17) assume (if not otherwise specified) that all carbon is fossil, and are derived from a material balance made by SINTEF (SINTEF 1991a) and Streibel, 1974.

TABLE 2-17
EMISSION FACTORS FOR CO_2 FROM FERROALLOY PRODUCTION

Type Ferroalloy	Emission Factor (tonnes/tonne product)
Ferrosilicon - 50%Si	2-2.7
Ferrosilicon - 75%Si	3.9
Ferrosilicon - 90%Si	4.8-6.5
Silicon metal[a]	4.3
Ferromanganese	1.6
Silicon manganese	1.7
Ferrochromium	1.3
Ferrochromium-silicon	NAV

[a] All producers probably use some biocarbon in order to obtain the desired product properties. 1.6 tonne bio-CO_2/tonne silicon may be considered as a minimum value and is not included in the emission factor in the table.

2.13.4 Aluminium

Introduction

Primary aluminium is produced in two steps. First bauxite ore is ground, purified and calcined to produce alumina. Following this, the alumina is electrically reduced to aluminium by smelting in large pots.

Most carbon dioxide is evolved from the reaction of the carbon anode with alumina, but some is formed as the anode reacts with other sources of oxygen (especially air). This occurs during cell operation and, in the case of prebaked electrodes, during anode production at the aluminium plant.

2.13.4.1 Methodology for Estimating Emissions of CO_2

Tier 1a

See Section 2.13.1 if quantity of reducing agent is known.

Tier 1b

If information on quantity of reducing agent is not known, the emissions of CO_2 may be estimated from the production volume of primary metal and the specific consumption of carbon. Emissions factors for CO_2 are suggested in Table 2-18 based on SINTEF 1991b and ORTECH 1994.

TABLE 2-18
EMISSION FACTORS FOR CO_2 FROM PRIMARY ALUMINIUM PRODUCTION
(TONNE/TONNE PRODUCT)

Pollutant	Soderberg Process	Prebaked Anode Process
CO_2	1.8	1.5

2.13.4.2 Methodology for Estimating Emissions of PFCs

Introduction

Two PFCs, carbon tetrafluoride (CF_4) and carbon hexafluoride (C_2F_6), are known to be emitted from the process of primary aluminium smelting.

Tier 1a - Measured Emission Data

TIER 1a

Tier 1a is the preferred methodology. Every effort should be made to obtain measurement data.

The *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories Reference Manual* gives details on the variability of emissions of PFCs. Since emissions of CF_4 and C_2F_6 vary so significantly from one aluminium smelter to the next, depending on cell type and anode effects (AE) parameters, the estimations will be highly uncertain unless actual emission measurements have been made.

Tier 1b - Calculation of Emission Data

It is recognised that measurements are both expensive and time-consuming. It may, however, be much easier to make a limited survey of AE frequency and duration at smelters. In such cases, it is recommended that specific CF_4 emissions for anode effects longer than 2 minutes are calculated as follows (based on the method developed by Tabereaux 1995):

$$\text{kg } CF_4/\text{tonne Al} = 1.698 \times (p / CE) \times AEF \times AED$$

where:

p = average fraction amount of CF_4 in the pot gas during anode effects

Prebaked: p = 0.08 (8%)

Søderberg: p = 0.04 (4%)

CE = current efficiency expressed as a fraction, rather than a percentage

AEF = number of anode effects per pot day

AED = anode effect duration in minutes

It is recommended that the default rate for C_2F_6 emissions be 1/10 that of CF_4.

TABLE 2-19
DEFAULT PARAMETERS TO ESTIMATE CF_4 AND C_2F_6 EMISSIONS FROM ALUMINIUM PRODUCTION

	CF_4		C_2F_6	
Type of Cell	Equation Constant	Average fraction of CF_4 in the pot gas during anode effects	Equation Constant	Average fraction amount of C_2F_6 in the pot gas during anode effects
Prebake	1.698	0.08	0.1698	0.08
Søderberg	1.698	0.04	0.1698	0.04

Tier 1c - Estimated Emission Data

PFC emissions estimates have been reported in several studies. These are briefly discussed in the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories Reference Manual.*

The estimates should be used only when no measured data exist. Specific emission factors should be chosen according to the type of technology used as shown in Table 2-20 and applied to national primary aluminium production data for each technology. The following equation may then be used to give an estimate of the annual CF_4 emissions from a smelter with a given cell technology.

CF4 emission (kg) = EF(tech) (kg CF4 / tonne Al) x pp(tech) tonnes)

where:

$EF_{(tech)}$ = emission factor by technology (from Table 2-20)

$PP_{(tech)}$ = primary aluminium production by technology

TABLE 2-20
ESTIMATED GLOBAL CF_4 EMISSIONS FROM ALUMINIUM SMELTERS WITH VARIOUS CELL TECHNOLOGIES

Type of Cell Technology	Per Cent Of World Production	kg CF_4/tonne Al
Modern Prebaked	20	0.05
HS Søderberg	11	1.0
“Older” Prebaked	40	1.75
VS Søderberg	29	2.0
Weighted average for all plants world-wide	100	1.40

See the *Revised 1996 IPCC 1996 Guidelines for Greenhouse Gas Inventories Reference Manual* for sources.

It is recommended that the default rate for C_2F_6 emissions be 1/10 that of CF_4.

2.13.4.3 Methodology for Estimating Emissions of NO_x, CO and SO_2

Emissions of NO_x, CO and SO_2 can be estimated from the amount of aluminium produced. Emissions may originate from the production process and baking of anodes. No distinction between the Søderberg and prebaked method is given in the EMEP/CORINAIR Guidebook (SNAP 40301). The suggested emission factors are shown in Table 2-21. No information is given about the degree of control.

TABLE 2-21
EMISSION FACTORS FOR NO_x, CO AND SO_2 FROM ALUMINIUM PRODUCTION
(KG/TONNE PRIMARY ALUMINIUM PRODUCED)

Pollutant	Process	Emission Factor (Default)	Emission Factor (Range)
NO_x	Electrolysis	2.15	1.3-3.0
	Anode baking	NE	NE
CO	Electrolysis	135	27-680
	Anode baking	400	NAV
SO_2	Electrolysis	14.2	10-17.5
	Anode baking	0.9	0.8-1.0

NE = negligible. NAV = not available.

2.13.5 Other Metal Production

2.13.5.1 Methodology for Estimating Emissions of CO_2

Tier 1a

See Section 2.13.1 if quantity of reducing agent is known.

Tier 1b

This includes production of all non-ferrous metals except aluminium. The metals may be produced using carbon as reducing agents or by other methodologies.

Whether carbon is emitted or not depends on the production process. Some ores are not reduced with carbon. Hence, CO_2 emissions from these processes are low. The general methodology suggested where emissions are calculated from the consumption of reducing agents and the carbon content of ores is recommended. An overview of production processes is given in Table 2-22. Some metals may be produced from alternative production methods.

CARBONATE ORES

In the case of *magnesium* and other metals in a carbonate ore, the carbon emitted from the ore should be taken into account in addition to the coke reducing agent.

TABLE 2-22
PRODUCTION PROCESSES FOR SOME METALS

Metal	Main Ore(s)	Carbon reduction	Electrolysis (without carbon)	Other (non-CO_2)
Chromium[a]	$FeCr_2O_4$, $PbCrO_4$	x		
Copper	Cu_2S, $CuFeS_2$, Cu_2O, carbonate		x	x (SO_2)
Gold	Element		x	x
Lead	PbS	x		x (SO_2)
Magnesium	Carbonate	x	x	
Mercury	HgS			x (SO_2)
Molybdenum	MoS_2			x (SO_2)
Nickel	NiS, NiO	x	x	x (SO_2)
Platinum	Element, PtS			x
Silicon[b]	SiO_2, Si-O-alkali	x		
Silver	Ag_2S, element			x
Tin	SnO_2	x		
Titanium	TiO_2, $FeTiO_3$	x[c]		
Tungsten	WO_3			x
Uranium	U_xO_y			x
Zinc	ZnS, $ZnCO_3$	x	x	x (SO_2)

[a] See also ferroalloy production

[b] See also ferroalloy production and carbide production

[c] Two step reduction process, involving first C + Cl_2, then Mg

Note: The appearance of (SO_2) in the final column indicates that the production process is a major world-wide source of SO_2 emissions.

2.13.6 SF_6 Used in Aluminium and Magnesium Foundries

2.13.6.1 Methodology for Estimating Emissions of SF_6

In the aluminium industry SF_6 is used as a cover gas only for special foundry products. Since SF_6 is assumed to be inert, SF_6 emissions should equal consumption:

Emission of SF_6 = Consumption of SF_6 in magnesium and aluminium foundries

Completing the Worksheet

Use WORKSHEET 2-11 METAL PRODUCTION to enter data for this submodule.

STEP 1 ESTIMATING CO_2 EMITTED - TIER 1a

1 Estimate the Mass of Reducing Agent and enter this value in column A in tonnes.

Enter the corresponding Emission Factor (Table 2-11) in column B in tonnes CO_2/tonne reducing agent.

3 If the information is available, estimate the Carbon Content of Ore (in tonnes) (C_{ore}) and subtract the Carbon Content of Metal (in tonnes)(C_{metal}). Multiply the result by 3.67 and enter the result in column C.

If this information is not available, the product of column A and column B will probably be sufficient for making a first estimate of the emissions.

4 Multiply column A by column B and add column C (if available) to obtain CO_2 Emitted in tonnes CO_2, and enter this value in column D.

5 Divide column C by 10^3 to convert to units of gigagrams CO_2, and enter this value in column E.

USING THE WORKSHEET

- Copy the Worksheet at the end of this section to complete the inventory.
- Keep the original of the Worksheet blank so you can make further copies if necessary.

Tier 1b - Based on Iron or Steel Production

STEP 2 ESTIMATING CO_2 EMITTED

1 Estimate the Amount of Iron or Steel Produced and enter this value in column A in tonnes.

2 Enter the corresponding Emissions Factor (Table 2-12) in column B in tonne CO_2 per tonne of iron or steel produced.

3 Multiply column A by column B to obtain CO_2 Emitted in tonnes of CO_2 and enter this value in column C.

4 Divide column C by 10^3 to convert to units of gigagrams CO_2, and enter this value in column D.

STEP 3 ESTIMATING NO_x, NMVOC, CO AND SO_2 EMITTED

1 Estimate the Amount of Iron or Steel Produced and enter this value in column A in tonnes.

2 Enter the corresponding Emission Factor (Tables 2-13 and 2-16) in column B in grams pollutant per tonne of iron or steel produced for NO_x, NMVOC, CO and SO_2.

3 Multiply column A by column B to obtain Pollutant Emitted in grams of pollutant and enter this value in column C.

4 Divide column C by 10^9 to convert to units of gigagrams of pollutant, and enter this value in column D.

Tier 1b - Based on Ferroalloy Production

STEP 4 ESTIMATING CO_2 EMITTED FROM FERROALLOYS

1 Estimate the Amount of Ferroalloy Produced and enter this value in column A in tonnes.

2 Enter the corresponding Emission Factor (Table 2-17) in column B in tonnes CO_2 per tonne of ferroalloys produced.

3 Multiply column A by column B to obtain CO_2 emitted in tonnes of CO_2 and enter this value in column C.

4 Divide column C by 10^3 to convert to units of gigagrams CO_2, and enter this value in column D.

Tier 1b - Based On Aluminium Production

STEP 5 ESTIMATING CO_2 EMITTED FROM ALUMINIUM TIER 1b

1 Estimate the Amount of Aluminium Produced and enter this value in column A in tonnes.

2 Enter the corresponding Emission Factor (Table 2-18) in column B in tonne CO_2 per tonne of aluminium produced.

3 Multiply column A by column B to obtain CO_2 emitted in tonnes, and enter this value in column C.

4 Divide column C by 10^3 to convert to units of gigagrams CO_2, and enter this value in column D.

Tier 1a - Based On Measurements

Every effort should be made to obtain measurement data due to the uncertainty of emission estimates.

Tier 1b - Based On The Number Of Anode Effects

Table 2-19 provides default data to be used with Tier 1b.

STEPS 6 AND 7 ESTIMATING PFC EMITTED

1 Enter the Type of Cell in column A.

2 Estimate the Amount of Aluminium Produced and enter this value in column B in tonnes.

3 Enter the corresponding Equation Constant (Table 2-19) in column C for CF_4 and C_2F_6 emissions from aluminium production.

4 Enter the corresponding Average Fraction of Pot Gas During Anode Effects of CF_4 or C_2F_6 (Table 2-19) in column D.

5 Enter the Current Efficiency as a fraction in column E.

6 Enter the Number of Anode Effects Per Day in column F.

7 Enter the Anode Effect Duration in minutes in column G.

8 Multiply columns B through G to obtain CF_4 or C_2F_6 Emitted in kg and enter this value in column H.

9 Divide column H by 10^6 to convert to units of gigagrams of CF_4 or C_2F_6, and enter this value in column I.

Tier 1c - Based on Aluminium Production

The method in Step 8 should be used only when no measured data exists.

STEP 8 ESTIMATING CF_4 EMITTED

1 Estimate the Amount of Aluminium Produced and enter this value in column A in tonnes.

2 Enter the corresponding emissions factor (Table 2-20) in column B in kg CF_4 per tonne of aluminium produced.

3 Multiply column A by column B to obtain emissions in kg and enter this value in column C.

4 Divide column C by 10^6 to convert to units of gigagrams, and enter this value in column D.

The method in Step 9 should be used only when no measured data exists. It is assumed that C_2F_6 emissions are approximately 10 per cent of the CF_4 emissions.

STEP 9 ESTIMATING C_2F_6 EMITTED

1 Enter estimated mass of CF_4 Emitted in gigagrams from column D of sheet 8 to column A of Sheet 9.

2 Enter the C_2F_6 emissions factor based on CF_4 emissions (0.1) in column B.

3 Multiply column A by column B to obtain emissions in gigagrams and enter this value in column C.

STEP 10 ESTIMATING NO_X, CO AND SO_2 EMITTED

1 Estimate the Amount of Aluminium Produced and enter this value in column A in tonnes.

2 Enter the corresponding Emission Factor (Table 2-21) in column B in kg pollutant per tonne of aluminium produced.

3 Multiply column A by column B to obtain Pollutant Emitted in kg pollutant and enter this value in column C.

4 Divide column C by 10^6 to convert to units of gigagrams of pollutant , and enter this value in column D.

STEP 11 ESTIMATING SF_6 EMITTED

1 Estimate the Consumption of SF_6 in magnesium and aluminium foundries and enter this value in column A in tonnes.

2 This value is set equal to SF_6 Emitted. Enter this value in column B in tonnes.

3 Divide column B by 10^3 to convert to units of gigagrams, and enter this value in column C.

2.14 Pulp and Paper Industries

Introduction

The production of pulp and paper involves three major processing steps: pulping, bleaching and paper production**.** The type of pulping and the amount of bleaching used depends on the nature of the feedstock and the desired quality of the end product.

There are two main processes: Kraft (sulphate) pulping, the most widely used, and Sulphite pulping. Sulphite pulping may be divided into the acid Sulphite process and the neutral sulphite semi-chemical process.

Data Sources

If site-specific emission data are not available, the emission estimates can be based on the total annual production of dried pulp. The production would have to be broken down by kraft, acid sulphite and neutral sulphite processes.

2.14.1 Methodology for Estimating Emissions of NO_x, NMVOC, CO and SO_2

There is more information on the simpler methodologies in the EMEP/CORINAIR Guidebook.

TABLE 2-23
NON-COMBUSTION EMISSION FACTORS FOR PULP AND PAPER PRODUCTION
KRAFT PULPING (KG/TONNE DRIED PULP)

Pollutant	Emission Factor (Default)	Emission Factor (Range)
NO_x	1.5	0.017-1.5
NMVOC	3.7	0.1-4.9
CO*	5.6	NAV
SO_2	7	0.005-10

Ref: US EPA 1995.
NAV = Not Available

EMISSION FACTORS

Emission factors are based on the production of air dried pulp. The emissions of SO_2 may be lower in new mills than in the older ones (US EPA 1995).

There are at least four types of acid sulphite process: ammonium-based (NH3), calcium-based (Ca), magnesium-based (M_gO) and sodium-based (Na) (US EPA, 1995). Emissions factors from US EPA, 1995 are given in Table 2-24.

TABLE 2-24
NON-COMBUSTION EMISSION FACTORS FROM PULP AND PAPER PRODUCTION
ACID SULPHITE PULPING (KG/TONNE DRIED PULP)

Pollutant	Type of Process	Emission Factor (Default)	Emission Factor (Range)
SO_2	NH_3, Ca, MgO and Na	30	8-50

2.14.2 Detailed Methodology for Estimating Emissions for NO_x and SO_2

The preferred methodology is to use continuous measurements data which may be available for NO_X and SO_2. This is only feasible in modern plants where the number of measurement points to be monitored is limited. Detailed emission factors related to the various processes are given in the EMEP/CORINAIR Guidebook.

Completing the Worksheet

Use WORKSHEET 2-12 PULP AND PAPER INDUSTRIES to enter data for this submodule.

STEP 1 ESTIMATING NO_X, NMVOC AND CO EMITTED

1 Estimate the annual Quantity of Air Dried Pulp Produced in tonnes for the kraft process and enter into column A.

2 Enter the corresponding Emission Factor (Table 2-23), in kilograms of pollutant (NO_X, NMVOC and CO) per tonnes of air dried pulp, in column B.

3 Multiply column A by column B to obtain Pollutant Emitted in kilograms and enter this value in column C.

4 Divide column C by 10^6 to convert to units of gigagrams of pollutant (NO_X, NMVOC and CO) and enter this value in column D.

STEP 2 ESTIMATING SO_2 EMITTED

1 Estimate the annual Quantity of Air Dried Pulp Produced in tonnes broken down into the kraft and acid sulphite processes and enter into the appropriate column A.

2 Enter the corresponding Emission Factor (Table 2-23), in SO_2 kilograms per tonnes of air dried pulp, in column B.

3 Multiply column A by column B to obtain SO_2 Emitted in kilograms and enter this value in column C.

4 Divide column C by 10^6 to convert to units of SO_2 gigagrams and enter this value in column D.

5 Sum the values in column D and enter the result in the bottom of the column to obtain the total SO_2 emitted.