



**Australian Government**

**Department of the Environment and Heritage**



National Pollutant Inventory

# **Emissions Estimation Technique Manual**

**for**

**Glass and Glass Fibre  
Manufacturing**

**Version 2.0  
17 May 2004**

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## **Disclaimer**

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## Erratum for this manual

Updates in Version 2.0 (published 15 April 2004) compared to the version published in August 1998.

<b>Part of manual</b>	<b>Outline of alteration</b>
Various EF tables	Replaced the term Neg (i.e. Negligible emissions factors) with 0.0. The tables have more descriptive headings.
1. Introduction	Updated and highlighted that the NPI Guide should be used as the first stage in reporting to the NPI.
4. Emission Estimation	Decreased the content of this section as it duplicated information in the NPI Guide.
	Removed section of emissions factor rating.
Table 4	Included the NPI substance Total Volatile Organic Compounds (TVOCs) into the speciation and removed the VOC row. Removed reference to the CASR numbers.
Table 5	Updated emissions factors from the original reference.
Table 9	A new table providing information about the emissions of the NPI substance polychlorinated dioxins and furans.
6. Pollution control technologies	This section now focuses on issues that relate to estimating emissions for the NPI and has a significant amount of material removed. A new table has been added to this section.
7. References	Added new reference.
8. Terms and Abbreviations	This is a new section.
Table 10	Provides some information about pollution equipment control efficiencies.

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**EMISSION ESTIMATION TECHNIQUES  
FOR  
GLASS AND GLASS FIBRE MANUFACTURING**

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## GLASS AND GLASS FIBRE MANUFACTURING

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## 1 Introduction

The purpose of National Pollutant Inventory (NPI) Emission Estimation Techniques (EET) manuals is to assist Australian facility operators estimate the emissions of NPI substances from their facility. This manual describes the approaches for estimating emissions from two sectors: glass and glass product manufacturing facilities, and glass fibre and glass wool manufacturing.

The first step in reporting to the NPI is to determine if your facility is required to report and if so, for which substances. Use the NPI Guide to determine if your facility needs to report to the NPI. The NPI Guide and all industry manuals are on the web at: [www.npi.gov.au](http://www.npi.gov.au)

Other NPI EET manuals need to be used to estimate emissions for NPI reporting for the sectors covered by this manual. Manuals that may need to be referred to are:

- Fugitive emissions
- Combustion in boilers
- Combustion Engines

This manual includes facilities primarily engaged in the manufacture of glass, glass products, glass fibre and glass wool:

- Glass containers
- Motor vehicle glass
- Domestic glassware
- Glass and glass products
- Industrial glass
- Glass wool and associated insulation products

When reporting to the NPI you need to provide the four digit Australian and New Zealand Standard Industrial Classification (ANZSIC) code for your facility. For more information about ANZSIC codes see the NPI website ([www.npi.gov.au](http://www.npi.gov.au)). The codes relevant for this manual are:

2610 – Glass and glass product manufacturing  
2640 – Glass fibre and glass wool manufacturing

This EET manual is part of the Glass and Glass Product Industry NPI handbook that covers ANZSIC codes 261 and 264.

This manual was drafted by the Queensland Department of Environment on behalf of the Australian Government. It was developed through a process of national consultation involving State and Territory environmental authorities and key stakeholders, and has been considered by independent reviewers.

Version 2.0 was published to address some issues in relation to emission factors in the first version of the manual. The Erratum on page ii detail changes made compared to the first version.

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## 2 Process Description

The glass industry includes a variety of manufacturing facilities. Facilities range from those engaged in primary glass manufacturing, to those that create glass products.

The two broad sectors (glass product and glass fibre manufacturing) included in this manual share the same initial process steps:

- Mixing (section 2.1)
- Melting (section 2.2)

All glass product and fibre manufacturing includes a cooling step at the end of the process.

A major component of the glass product sector is flat glass production. Flat glass is marketed in its original state, or subjected to further processing to produce toughened (tempered), laminated, decorative, surface coated, double glazed, and mirrored products.

The glass fibre sector produces two main products: textile glass fibres and insulation glass fibre. Textile glass fibre is used in the production of fireproof cloth, while insulation glass fibre is used in thermal and acoustic insulation, including tank and swimming pool shells.

Sections 2.3, 2.4 and 2.5 outline the steps involved in glass container manufacture, flat glass manufacture and glass fibre manufacture respectively.

Raw material extraction and manufacture, while integrally related to the manufacture of glass, is outside the scope of this manual. These steps are addressed in other NPI manuals.

### 2.1 Mixing

The two principle methods of mixing are wet mixing and batch agglomeration. Materials are mixed in a rotating pan or drum.

The mixed material is moved to holding hoppers above the melting furnace by conveyor belts. These hoppers are situated above the furnace and the material is fed into the furnace by a pusher-type apparatus. This step differs somewhat from facility to facility.

### 2.2 Melting

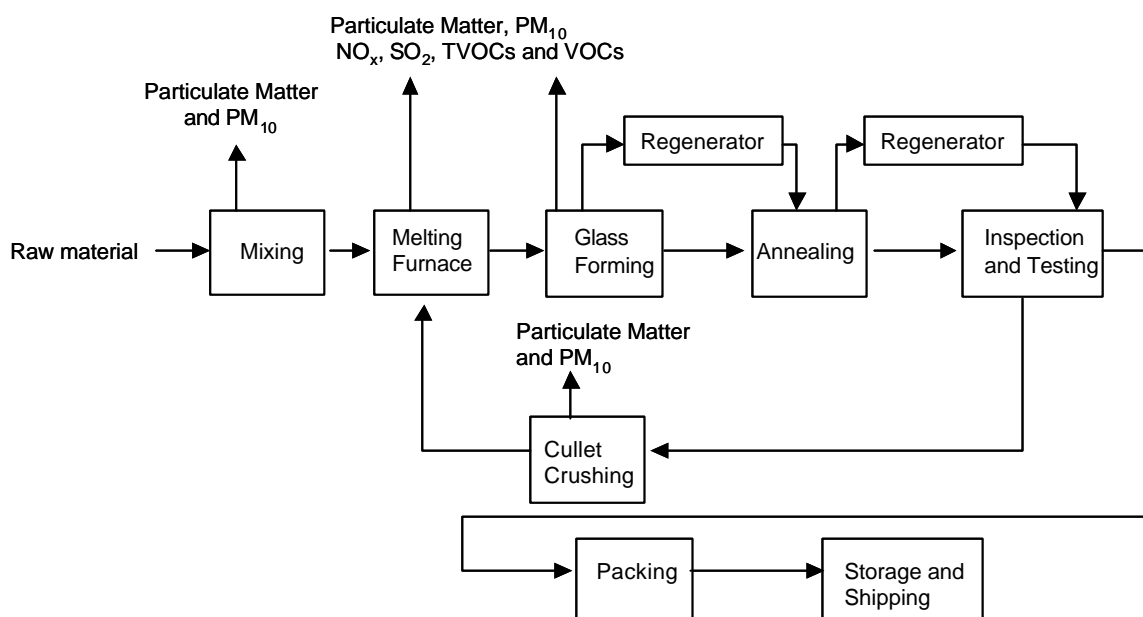
The type of melting unit used depends on the quantity and quality of glass to be processed. Flat glass manufacturers usually have the largest furnaces, followed by container glass manufacturers, and glass fibre manufacturers. The size and depth of the furnaces differs appreciably depending on the process. Generally speaking, container glass furnaces in Australia are cross-fired regenerative which means waste heat from the furnace is utilised to improve the efficiency of the process.

Fibreglass manufacture may rely more on electric melting to enable them to more accurately control the furnace conditions, but container and flat glass manufacturers tend to use gas as the primary fuel. Some facilities will have additional electric melting to assist the gas firing.

### 2.3 Container manufacturing: forming and annealing

From the melting furnace, the glass flows (still inside the furnace) into the refining section of the furnace. At this point, the gas trapped inside the glass body from the melting operation is released. The glass then flows from the main melter/refiner into shallow channels called fore-hearths, and the glass is fired to ensure temperature equilibrium through the glass.

Figure 1 is a process flow diagram for a typical glass manufacturing step. It highlights the likely emission points for particulate matter (PM<sub>10</sub>). Because every facility in Australia is likely to be unique, you are encouraged to develop a flow diagram for your own operations detailing the input of materials and listed substances, and the waste sources and emissions resulting from the operation of each step.



**Figure 1. A Typical Glass Container Manufacturing Process**

Reference: USEPA AP42 (S11) (1995)

### 2.4 Flat Glass Manufacturing

Flat glass is typically made using the Float process. The raw materials used include silica sand, soda ash, limestone, dolomite, scrap glass, and small amounts of other materials. These materials are mixed and fed into the melting furnace where temperatures of about 1600 °C melt the raw material to form glass. Colouring agents can be added at this time to produce differing degrees of translucence.

### 2.5 Glass Fibre Manufacturing

Glass fibre manufacturing involves the high-temperature conversion of raw materials into a homogeneous melt, followed by the fabrication of this melt into glass fibres. The two basic types of glass fibre products, cloth (textile) and wool, are created by similar processes. Glass fibre production can be separated into three phases:

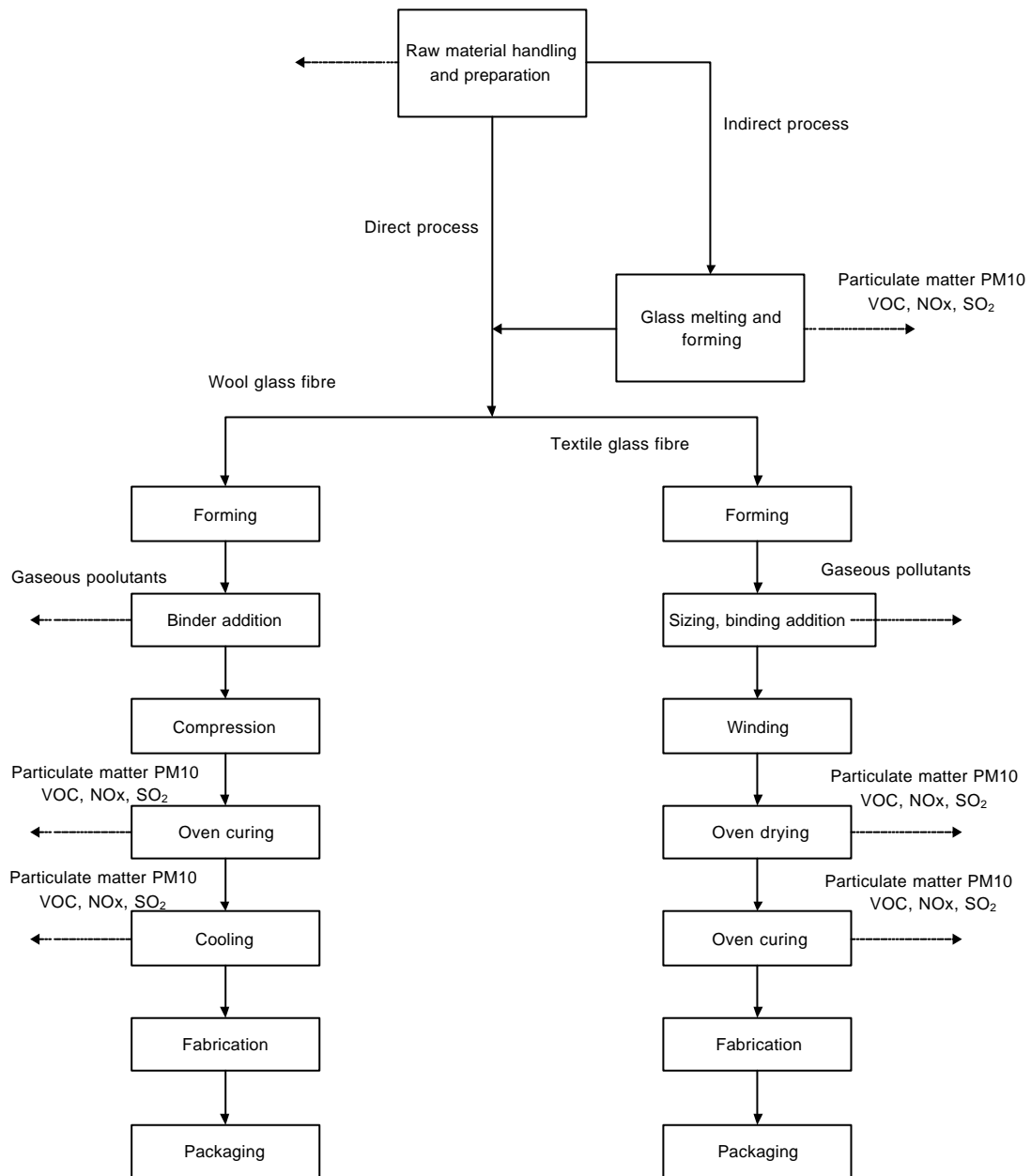
- Raw materials handling mixing
- Melting and refining

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- Fibre forming and finishing

The primary component of glass fibre is sand, but it also includes varying quantities of feldspar, sodium sulfate, boric acid, and other materials. These materials are moved to and from storage piles by conveyor belts, screws, and bucket elevators. In the glass-melting furnace, the raw materials are heated and transformed through a series of chemical reactions into molten glass. Glass fibres are made from the molten glass using one of two methods. In the rotary spin process, which dominates the fibreglass sector, centrifugal force causes molten glass to flow through small holes in the wall of a rapidly rotating cylinder to create fibres that are broken into pieces by an air stream. The flame attenuation process uses gravity to force molten glass through small holes to create threads that are attenuated, (or stretched to the point of breaking) by hot air or flame. After the glass fibres are produced, they are sprayed with a chemical resin to hold them together, collected on a conveyor belt in the form of a mat, cured and packaged.

Figure 2 is a process flow diagram for a typical glass fibre manufacturing process.



**Figure 2. A Typical Glass Fibre Manufacturing Process**

Reference: USEPA AP42 (S11) (1995)

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### 3 Emission Sources

Emission sources in the glass industry can be categorised into three groups: materials handling, pollution control equipment, and plant maintenance operations.

#### 3.1 Glass Product Manufacturing

##### 3.1.1 Materials Handling Emissions

Materials handling emissions are the emissions generated during the receipt and transfer of raw materials at your facility for storage or processing, and include those raw materials that are rendered unusable because of spillage. Particulate matter 10 microns or less in diameter (PM<sub>10</sub>) is the main NPI substance emitted from this step. Table 1 shows the type of pollutant emissions from glass product manufacturing.

**Table 1 Glass Product and Fibre Manufacturing: Material Inputs and Pollutant Outputs**

Process	Material Inputs	Air Emissions	Water and Land Emissions	Other Emissions, Wastes, and Transfers
Glass Product Manufacturing	Silica sand, soda ash, limestone, metallic oxides, ammonia.	Particulates, fluorides, sulfur dioxide, oxides of nitrogen, carbon monoxide, solvents.	Heavy metals, spent solvent wastes.	Materials handling wastes and furnace slag.
<b>Notes:</b> 1. Reference: QLD Department of Environment (1998).				

##### 3.1.2 Melting furnaces and Associated Pollution Control Equipment

Furnaces and associated equipment at glass manufacturing plants generates emissions of NPI substances produced during the melting, forming, and finishing steps of the manufacturing process. Waste material containing NPI substances is also generated. The melting of raw materials to produce glass generates air emissions consisting of PM<sub>10</sub>, oxides of nitrogen, sulfur dioxide, and small amounts of carbon monoxide. Emissions are also generated during the forming and finishing of glass products as a result of the thermal decomposition of lubricants during ceramic labelling. These emissions include volatile organic compounds (VOCs), ammonia, chlorine, and hydrochloric acid. Emissions may also include NPI listed metals and small quantities of organic pollutants.

Glass product manufacturing facilities are able to decrease emissions baghouse filters, electrostatic precipitators (ESPs) or using aqueous media (e.g. a wet scrubber). A wet scrubber (sometime called a quench reactor), that combines gaseous sulfur dioxide from furnace emissions with water and sodium carbonate, is an example of an aqueous emission control device. A dry system incorporating injection of sodium carbonate or calcium carbonate may also be used. The final emissions from these systems may contain NPI listed metals such as selenium and compounds, chromium (III) compounds, cadmium and compounds, cobalt and compounds and lead and compounds.

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Glass product manufacturers often use baghouse filters and ESPs to capture particulate emissions. Collected residue can be recycled as feed material for the manufacturing process.

During the forming process, oil is used in the forming machines and often contaminates the air that keeps the machines cool. Excess oil, along with rejected glass is cooled in a vat of water and recycled as feed material for the process.

Trichloroethylene, or other NPI listed substances, might also be used as cleaning agents to remove a thin layer of graphite coating that is applied to the glass forms or moulds. The carryover from the furnace (both particulate and gaseous) is conveyed to the base of the regenerator where it collects and builds up. The material consists of a high level (85-90 percent) of some heavy metals that are NPI substances. This material may need to be treated before it is taken to regulated waste facilities. Treatment is only required if the material does not pass leachate test specified by government environment agencies.

To control oxide of nitrogen ( $\text{NO}_x$  – an NPI substance) emissions the glass product manufacturing industry in Australia has focussed on using low  $\text{NO}_x$  furnace technology such as: low  $\text{NO}_x$  burners, low  $\text{NO}_x$  furnaces, partial oxygen firing or full oxygen firing. Other techniques may be used if the technology is proved suitable.

An example of a technique that may be used for  $\text{NO}_x$  control in the future if proved suitable is selective non-catalytic reduction (SNCR). SNCR reduces  $\text{NO}_x$  in flue gas through a reaction with ammonia in a temperature range of 925 – 1040 °C.

### 3.1.3 Facility Maintenance Emissions

Glass product facility's maintenance emissions can include waste oil and solvents.

## 3.2 Glass Fibre Emissions

Glass fibre manufacturers also generate materials handling and, pollution control emissions, as well as plant maintenance wastes and emissions. As in other glass manufacturing, the major air emissions associated with glass fibre production relate to the melting and refining furnace operation. The emissions from this operation include  $\text{PM}_{10}$ , calcium carbonate, sodium fluoride, sodium fluorosilicate, silica, calcium fluoride, aluminium silicate, sodium sulfate, and boron oxides. Gases emitted include fluorides, sulfur dioxide, oxides of nitrogen, boric acid, carbon monoxide, and water vapour.

Table 1 identifies the material inputs and pollutant outputs for glass product and glass fibre manufacturing.

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## 4 Emission Estimation

Estimates of emissions of listed substances to air, water and land should be reported for each substance that trips an NPI reporting threshold. The substance list and detailed information on thresholds are in *The NPI Guide*. The NPI Guide and all manuals are on the NPI website ([www.npi.gov.au](http://www.npi.gov.au)). Refer to the NPI Guide to determine if your facility needs to report to the NPI, and if so, for which substances.

The NPI Guide also details the types of estimation techniques that can be used to estimate emissions of NPI substances.

The following gives information about the type of estimation techniques specifically for glass product and glass fibre manufacturing to allow facility operators to estimate emissions of NPI substances from their facility. The main focus is emissions factors derived from glass manufacturing facilities.

### 4.1 Emission Factors

An emission factor is a tool that is used to estimate emissions to the environment. In this manual, it relates the quantity of substances emitted from a source to some activity associated with those emissions. Emission factors are obtained from US, European, and Australian sources and are usually expressed as the weight of a substance emitted, multiplied by the unit weight, volume, distance, or duration of the activity emitting the substance (e.g. kilograms of PM<sub>10</sub> emitted per tonne of glass product produced).

Emission factors are used to estimate a facility's emissions by the general equation:

$$E = A \times T \times EF \times [1 - (CE/100)] \quad \text{Equation 1}$$

where:

E = emissions;

A = activity rate;

T = time (or another variable)

EF = uncontrolled emission factor; and

CE = control emission reduction efficiency, %.

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Example 1 shows how Equation 1 is used to estimate emissions of TVOCs from a glass melting furnace.

**Example 1.**

Table 3 shows that 0.1kg of TVOCs are emitted for each tonne of decorative glass product produced from a furnace with an electrostatic precipitator control device in place. It is assumed that the glass plant operates for 1 500 hours per year.

EF <sub>VOC</sub>	=	0.1kg/tonne
Glass production rate	=	20 tonnes/hour
TVOC emissions	=	EF <sub>TVOC</sub> x glass production rate x operating time
	=	0.1 (kg/tonne) x 20 (tonnes/hour)
	=	x 1 500 (hours/year)
	=	3,000 kg TVOCs per year

The following tables (Tables 2 and 3 and 5 to 9) provide emission factors for NPI substances. The substances included in each table are in the table heading. Table 5 provides emission factors for a range of metals that are NPI substances. The table headings are in the list of figures and tables on page iv towards the front of this manual.

Table 4 provides the proportion of NPI substances included in typical emissions of TVOCs from glass manufacturing as determined in Table 3.

**Table 2 Emission Factors for Glass and Glass Product Manufacturing:  
oxides of nitrogen, PM<sub>10</sub> and sulfur dioxide**

Process	Oxides of nitrogen (kg/tonne)	PM <sub>10</sub> (kg/tonne)	Sulfur dioxide (kg/tonne)
Raw materials handling (all types of glass)	0.0	Note 3	0.0
Melting furnace for Container glass (uncontrolled)	3.1	0.66	1.7
-with low energy scrubber	3.1	0.38	0.9
-with venturi scrubber	3.1	0.095	0.1
-with baghouse	3.1	0.0	1.7
-with electrostatic precipitator	3.1	0.0	1.7
Melting Furnace Flat (uncontrolled)	4.0	0.95	1.5
-with low energy scrubber	4.0	0.475	0.8
-with venturi scrubber	4.0	0.0	0.1
-with baghouse	4.0	0.0	1.5
-with electrostatic precipitator	4.0	0.0	1.5
Melting furnace for pressed and blown glass <sup>4</sup> (uncontrolled)	4.3	7.98	2.8
-with low energy scrubber	4.3	3.99	1.3
-with venturi scrubber	4.3	0.475	0.1
-with baghouse	4.3	0.095	2.8
-with electrostatic precipitator	4.3	0.095	2.8
Forming and finishing			
-Container	0.0	0.0	0.0
-Flat	0.0	0.0	0.0
-Pressed and blown	0.0	0.0	0.0
Lead glass manufacturing (all processes)	ND	ND	ND
<b>Notes:</b>			
1. Reference: USEPA AP-42 Section 11.15 (1995).			
2. Factor units are kg of substance emitted per tonne of glass or glass product manufactured.			
3. See other NPI manuals (e.g. NPI EET manual for fugitive emissions).			
4. In Australia these types of process steps are likely to be called “press and blow and blow and blow” or “narrow neck press and blow”.			
5. ND = no data; PM <sub>10</sub> = particulate matter 10 microns or less in diameter.			

**Table 3 Emission Factors for Glass and Glass Product Manufacturing: carbon monoxide, hydrochloric acid, lead & compounds and TVOCs<sup>5</sup>**

Process	Carbon monoxide (kg/tonne) <sup>2</sup>	Hydrochloric acid (kg/tonne) <sup>2</sup>	Lead & compounds (kg/tonne) <sup>2</sup>	TVOCs <sup>5</sup> (kg/tonne) <sup>2</sup>
Raw materials handling (all types of glass)	0.0	0.0	ND	0.0
Melting furnace for container glass (uncontrolled)	0.1	0.0	ND	0.1
-with low energy scrubber	0.1	0.0	ND	0.1
-with venturi scrubber	0.1	0.0	ND	0.1
-with baghouse	0.1	0.0	ND	0.1
-with electrostatic precipitator	0.1	0.0	ND	0.1
Melting furnace for flat glass (uncontrolled)	0.1	0.0	ND	0.1
-with low energy scrubber	0.1	0.0	ND	0.1
-with venturi scrubber	0.1	0.0	ND	0.1
-with baghouse	0.1	0.0	ND	0.1
-with electrostatic precipitator	0.1	0.0	ND	0.1
Melting furnace for pressed and blown glass (uncontrolled)	0.1	0.0	ND	0.2
-with low energy scrubber	0.1	0.0	ND	0.2
-with venturi scrubber	0.1	0.0	ND	0.2
-with baghouse	0.1	0.0	ND	0.2
-with electrostatic precipitator	0.1	0.0	ND	0.2
Forming and finishing				
-Container <sup>4</sup>	0.0	0.1	ND	4.4
-Flat	0.0	0.0	ND	0.0
-Pressed and blown <sup>4</sup>	0.0	0.1	ND	4.5
Lead Glass Manufacture (all processes)	ND	ND	2.5	ND
<b>Notes:</b>				
1. Reference: USEPA AP-42 Section 11.15 (1995).				
2. Units are kg of substance emitted per tonne of glass or glass product manufactured.				
3. TVOC emissions occur only from decorating processes using solvents and can be controlled by incineration, absorption or condensation, but efficiencies are not known.				
4. See other NPI manuals (e.g. NPI EET manual for fugitive emissions).				
5. ND = No data; TVOCs = Total Volatile Organic Compounds.				

**Table 4 Composition Profile for VOCs in Glass Manufacturing: benzene, cyclohexane, formaldehyde, n-hexane, Toluene (methylbenzene) and TVOCs**

NPI Substance	Weight %
Benzene	2.86
Cyclohexane	0.20
Formaldehyde	1.60
<i>n</i> -Hexane	3.14
Toluene (methylbenzene)	0.78
TVOCs	100.00

**Notes:**

- Reference: USEPA (1992). VOC / PM Speciation Data System – Version 1.50.
- VOC = Volatile Organic Compounds; TVOCs = Total Volatile Organic Compounds.
- Note that TVOCs is a NPI substance that needs to be considered and reported separately, even if other substances that are VOCs are reported. See the NPI Guide to determine which substances need to be reported to the NPI.

To report emissions of the substances in Table 4 above, first determine the emissions of TVOCs from Table 3, and then multiply the weight percent of each individual substance listed above by the TVOC emissions figure.

**Table 5 Emission Factors for Metals in Glass Manufacturing: metals & compounds, nickel carbonyl and nickel subsulfide**

NPI substance	Emission Factor (kg/tonne) <sup>2</sup>
Arsenic & compounds	1.0e-04
Cadmium & compounds	1.5E-04
Chromium (III) compounds	2.5E-03
Copper & compounds	5.0E-04
Lead & compounds <sup>4</sup>	1.0E-02
Mercury & compounds	5.0E-05
Nickel & compounds	2.0E-03
Nickel carbonyl <sup>1</sup>	0.0
Nickel subsulfide <sup>3</sup>	0.0
Selenium & compounds	2.0E-02
Zinc & compounds	1.0E-02

**Notes:**

- Reference: EMP/CORINAIR (1996).
- Factor units are kilograms of metal emitted per tonne of glass or glass product manufactured.
- The current understanding of the emissions of these substances indicates that they are not emitted from glass manufacturing.
- The emission of lead and compounds is mainly determined by the amount of recycled glass used.
- Scientific notation is used; e.g. 7.38E-02 represents  $7.38 \times 10^{-2}$  or 0.0738.

**Table 6 Emission Factors for Glass Fibre Manufacturing: PM<sub>10</sub>**

Source	PM <sub>10</sub> (kg/tonne) <sup>2</sup>
Unloading and conveying	1.5
Storage bins	0.1
Mixing and weighing	0.3
Crushing and batch charging	0.0
Glass furnace – wool	
Electric	0.25
Gas – regenerative	11
Gas – recuperative	14
Gas – unit melter	4.5
Forming – wool	
Flame attenuation	1
Forming – textile	0.5
Oven curing – wool	
Flame attenuation	3
Rotary spin wool glass manufacturing	
R-19 Building Insulation	18
R-11 Building Insulation	20
Ductboard	28
Heavy density	5
<b>Notes:</b>	
1. Reference: USEPA AP-42 Section 11.13 (1995).	
2. Factor units are kilograms of metal emitted per tonne of glass fibre manufactured.	
3. Factors are from uncontrolled sources unless otherwise noted.	
4. The emission factors are determined from the particulate matter taking into account the proportion of PM <sub>10</sub> in the particulate matter (99.4 wt%) Reference: Emigh and Wilkinson (1997).	
5. PM <sub>10</sub> = particulate matter 10 microns or less in diameter.	

**Table 7 Emission Factors For Glass Fibre Manufacturing: carbon monoxide, oxides of nitrogen and sulfur dioxide**

Source	Carbon monoxide (kg/tonne) <sup>3</sup>	Oxides of nitrogen (kg/tonne) <sup>3</sup>	Sulfur dioxide (kg/tonne) <sup>3</sup>
Glass furnace – wool:			
Electric	0.025	0.14	0.02
Gas-regenerative	0.13	2.5	5
Gas-recuperative	0.13	0.85	5
Gas – unit melter	0.13	0.15	0.3
Glass furnace – textile <sup>b</sup> :			
Gas-recuperative <sup>2</sup>	0.25	10	1.5
Gas-regenerative <sup>2</sup>	0.5	10	15
Gas – unit melter	0.45	10	ND
Forming – wool Flame attenuation	NA	NA	NA
Forming – textile	NA	NA	NA
Oven curing – wool Flame attenuation	1.8	1	ND
Oven curing and cooling – textile	0.75	1.3	NA
<b>Notes:</b>			
1. Reference: USEPA AP-42 Section 11.13 (1995) unless otherwise indicated.			
2. Reference: Economopoulos (1993).			
3. Factor units are kg of substance emitted per tonne of product produced.			
4. Factors are for uncontrolled sources unless otherwise noted.			
5. ND = no data NA = not applicable.			

**Table 8 Emission Factors for Glass Fibre Manufacturing: formaldehyde, fluoride compounds, phenol and TVOCs**

Source	Formaldehyde (kg/tonne) <sup>2</sup>	Fluoride compounds (kg/tonne) <sup>2</sup>	Phenol (kg/tonne) <sup>2</sup>	TVOCs (kg/tonne) <sup>2</sup>
Glass furnace – wool Electric				
Gas-regenerative	ND	0.001	ND	ND
Gas-recuperative	ND	0.06	ND	ND
Gas-unit melter	ND	0.06	ND	ND
	ND	0.06	ND	ND
Glass furnace – textile <sup>b</sup>				
Gas-recuperative	ND	1	ND	ND
Gas-regenerative	ND	1	ND	ND
Gas-unit melter	ND	1	ND	ND
Forming – wool Flame attenuation	ND	ND	ND	0.15
Forming – textile	ND	NA	ND	0.0
Oven curing – wool Flame attenuation	ND	ND	ND	3.5
Oven curing and cooling – textile	ND	ND	ND	0.0
Rotary spin wool glass fibre manufacturing <sup>4</sup> :				
R-19	0.75	ND	4.17	0.75
R-11	1.23	ND	7.13	1.23
Ductboard	1.80	ND	14.50	1.80
Heavy density	0.43	ND	1.41	0.43
<b>Notes:</b>				
1. Reference: USEPA AP-42 Section 11.13 (1995).				
2. Units are kg of substance emitted per tonne of product manufactured.				
3. Factors represent uncontrolled emissions unless otherwise noted.				
4. As formaldehyde is a TVOC, the TVOC emission factor has to be at least as high as the formaldehyde emission factor (see the NPI Guide for more information about TVOCs).				
5. ND = no data; NA = not applicable; TVOCs = Total Volatile Organic Compounds.				

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**Table 9 Emission Factors For Glass Manufacturing: polychlorinated dioxins and furans**

<b>Source</b>	<b>Polychlorinated Dioxins and Furans (kg/tonne of product)</b>
Cyclone/no dust control	2.0E-08
Good dust abatement	1.5E-09
<u>Note</u> 1. Reference: UNEP 2001. 2. Converted emissions in terms of toxic equivalent to total dioxins and furans based on the cogener profile of emissions from glass manufacture. 3. Scientific notation is used; e.g. 7.38E-02 represents $7.38 \times 10^{-2}$ or 0.0738.	

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## 5 Pollution Control Technologies

The control efficiency (CE in Equation 1) of different pollution control technologies should be able to be determined from knowledge of your facility's process steps or information from the manufacturer of the process equipment installed at your facility. Alternatively, measurement and monitoring undertaken at your facility may allow you to determine the control efficiency of the process steps that are part of your facility's operation.

In the absence of knowledge of your facility's equipment or measured data, a particulate matter control efficiency of 50% can be assumed. Table 10 gives some information about control efficiency of particulate matter and more extensive information is detailed in note 3 of the table.

Particulate matter 10 microns or less in diameter ( $PM_{10}$  – an NPI substance) has the same collection efficiency as for particulate matter. Particulate matter includes  $PM_{10}$  and larger size fractions.

Particulate matter usually contains NPI substances, for example metals and their compounds. NPI substances contained in particulate matter released to the environment may need to be included in your facility's NPI reporting.

**Table 10 Control efficiencies for different pollution control equipment for particulate matter and  $PM_{10}$  emissions**

Equipment	Control efficiency (%)
Cyclone – single	50
Cyclones – bank	85
Electrostatic precipitator – low efficiency	90
Fabric filter	99.5

Note

1. The control efficiency (CE) factors are used in equation 1 with the relevant emissions factors to estimate emissions of substances from glass and glass fibre manufacturing.
2. Particulate matter is not reported to the NPI as such, however the  $PM_{10}$  component is an NPI substance and needs to be determined by many facilities reporting to the NPI. Emissions of particulates may need to be determined in order to estimate the emissions of NPI substances contained by particulate matter or  $PM_{10}$ .
3. For more information about the control (or collection) efficiency for pollution control equipment that captures particulates and  $PM_{10}$ , check the equipment specifications or the NPI emission estimation technique manual for Non-Metallic Mineral Product Manufacture (table 19 in the edition published in December 1999).
4.  $PM_{10}$  = particulate matter 10 microns or less in diameter.

Some pollution control equipment also decreases the emissions of other NPI substances not contained in particulate matter emitted. For these emissions, if no other information is available, a control efficiency of 50 % should be assumed.

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## 7 Terms and Abbreviations

<b>Term</b>	<b>Explanation</b>
ANZSIC	Australian and New Zealand Standard Industrial Classification
CE	Control emission reduction efficiency %.
EET	Emission Estimation Technique
ESPs	Electrostatic Precipitators
ND	No data
NPI	National Pollutant Inventory
NO <sub>x</sub>	Oxides of nitrogen – an NPI substance
PM <sub>10</sub>	Particulate matter 10 microns or less in diameter – an NPI substance
SNCR	Selective non-catalytic reduction
TVOCs	Total volatile organic compounds – an NPI substance
UNEP	United Nations Environment Programme
USEPA	United States Environmental Protection Agency
VOCs	Volatile organic compounds