



1.0 Environmental

1.1 Air Emissions and Ambient Air Quality

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the spatial characteristic of the source including point sources, fugitive sources, and mobile sources and, further, by process, such as combustion, materials storage, or other industry sector-specific processes.

Where possible, facilities and projects should avoid, minimize, and control adverse impacts to human health, safety, and the environment from emissions to air. Where this is not possible, the generation and release of emissions of any type should be managed through a combination of:

- Energy use efficiency
- Process modification
- Selection of fuels or other materials, the processing of which may result in less polluting emissions
- Application of emissions control techniques

Applicability and Approach

This guideline applies to facilities or projects that generate emissions to air at any stage of the project life-cycle. It complements the industry-specific emissions guidance presented in the Industry Sector Environmental, Health, and Safety (EHS) Guidelines by providing information about common techniques for emissions management that may be applied to a range of industry sectors. This guideline provides an approach to the management of significant sources of emissions, including specific guidance for assessment and monitoring of impacts. It is also intended to provide additional information on approaches to emissions management in projects located in areas of poor air quality, where it may be necessary to establish project-specific emissions standards.

Emissions of air pollutants can occur from a wide variety of activities during the construction, operation, and decommissioning phases of a project. These activities can be categorized based on

The selected prevention and control techniques may include one or more methods of treatment depending on:

- Regulatory requirements
- Significance of the source
- Location of the emitting facility relative to other sources
- Location of sensitive receptors
- Existing ambient air quality, and potential for degradation of the airshed from a proposed project
- Technical feasibility and cost effectiveness of the available options for prevention, control, and release of emissions

Ambient Air Quality

General Approach

Projects with significant^{5,6} sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that:

- Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards⁹ by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines¹⁰ (see Table 1.1.1), or other internationally recognized sources¹¹;
- Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25 percent of the applicable air quality standards to allow

additional, future sustainable development in the same airshed.¹²

At facility level, impacts should be estimated through qualitative or quantitative assessments by the use of baseline air quality assessments and atmospheric dispersion models to assess potential ground level concentrations. Local atmospheric, climatic, and air quality data should be applied when modeling dispersion, protection against atmospheric downwash, wakes, or eddy effects of the source, nearby¹³ structures, and terrain features. The dispersion model applied should be internationally recognized, or comparable. Examples of acceptable emission estimation and dispersion modeling approaches for point and fugitive sources are

Table 1.1.1: WHO Ambient Air Quality Guidelines^{7, 8}

	Averaging Period	Guideline value in mg/m ³
Sulfur dioxide (SO ₂)	24-hour	125 (Interim target-1) 50 (Interim target-2) 20 (guideline)
	10 minute	500 (guideline)
Nitrogen dioxide (NO ₂)	1-year	40 (guideline)
	1-hour	200 (guideline)
Particulate Matter PM ₁₀	1-year	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (guideline)
	24-hour	150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (guideline)
Particulate Matter PM _{2.5}	1-year	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (guideline)
	24-hour	75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (guideline)
Ozone	8-hour daily maximum	160 (Interim target-1) 100 (guideline)

⁵ Significant sources of point and fugitive emissions are considered to be general sources which, for example, can contribute a net emissions increase of one or more of the following pollutants within a given airshed: PM₁₀: 50 tons per year (tpy); NO_x: 500 tpy; SO₂: 500 tpy; or as established through national legislation; and combustion sources with an equivalent heat input of 50 MWh or greater. The significance of emissions of inorganic and organic pollutants should be established on a project-specific basis taking into account toxic and other properties of the pollutant.

⁶ United States Environmental Protection Agency, Prevention of Significant Deterioration of Air Quality, 40 CFR Ch. 1 Part 52.21. Other references for establishing significant emissions include the European Commission. 2000. "Guidance Document for EPER implementation." <http://ec.europa.eu/environment/ppc/eper/index.htm>; and Australian Government. 2004. "National Pollutant Inventory Guide." <http://www.npi.gov.au/handbooks/pubs/npiguide.pdf>

⁷ World Health Organization (WHO). Air Quality Guidelines Global Update, 2005. PM 24-hour value is the 99th percentile.

⁸ Interim targets are provided in recognition of the need for a staged approach to achieving the recommended guidelines.

⁹ Ambient air quality standards are ambient air quality levels established and published through national legislative and regulatory processes, and ambient quality guidelines refer to ambient quality levels primarily developed through clinical, toxicological, and epidemiological evidence (such as those published by the World Health Organization).

¹⁰ Available at World Health Organization (WHO). <http://www.who.int/en>

¹¹ For example the United States National Ambient Air Quality Standards (NAAQS) (<http://www.epa.gov/air/criteria.html>) and the relevant European Council Directives (Council Directive 1999/30/EC of 22 April 1999 / Council Directive 2002/3/EC of February 12 2002).

¹² US EPA Prevention of Significant Deterioration Increments Limits applicable to non-degraded airsheds.

included in Annex 1.1.1. These approaches include screening models for single source evaluations (SCREEN3 or AIRSCREEN), as well as more complex and refined models (AERMOD OR ADMS). Model selection is dependent on the complexity and geomorphology of the project site (e.g. mountainous terrain, urban or rural area).

Projects Located in Degraded Airsheds or Ecologically Sensitive Areas

Facilities or projects located within poor quality airsheds¹⁴, and within or next to areas established as ecologically sensitive (e.g. national parks), should ensure that any increase in pollution levels is as small as feasible, and amounts to a fraction of the applicable short-term and annual average air quality guidelines or standards as established in the project-specific environmental assessment. Suitable mitigation measures may also include the relocation of significant sources of emissions outside the airshed in question, use of cleaner fuels or technologies, application of comprehensive pollution control measures, offset activities at installations controlled by the project sponsor or other facilities within the same airshed, and buy-down of emissions within the same airshed.

Specific provisions for minimizing emissions and their impacts in poor air quality or ecologically sensitive airsheds should be established on a project-by-project or industry-specific basis. Offset provisions outside the immediate control of the project sponsor or buy-downs should be monitored and enforced by the local agency responsible for granting and monitoring emission permits. Such provisions should be in place prior to final commissioning of the facility / project.

Point Sources

Point sources are discrete, stationary, identifiable sources of emissions that release pollutants to the atmosphere. They are typically located in manufacturing or production plants. Within a given point source, there may be several individual 'emission points' that comprise the point source.¹⁵

Point sources are characterized by the release of air pollutants typically associated with the combustion of fossil fuels, such as nitrogen oxides (NO_x), sulfur dioxide (SO₂), carbon monoxide (CO), and particulate matter (PM), as well as other air pollutants including certain volatile organic compounds (VOCs) and metals that may also be associated with a wide range of industrial activities.

Emissions from point sources should be avoided and controlled according to good international industry practice (GIIP) applicable to the relevant industry sector, depending on ambient conditions, through the combined application of process modifications and emissions controls, examples of which are provided in Annex 1.1.2. Additional recommendations regarding stack height and emissions from small combustion facilities are provided below.

Stack Height

The stack height for all point sources of emissions, whether 'significant' or not, should be designed according to GIIP (see Annex 1.1.3) to avoid excessive ground level concentrations due to downwash, wakes, and eddy effects, and to ensure reasonable diffusion to minimize impacts. For projects where there are multiple sources of emissions, stack heights should be established with due consideration to emissions from all other project sources, both point and fugitive. Non-significant sources of emissions,

¹³ "Nearby" generally considers an area within a radius of up to 20 times the stack height.

¹⁴ An airshed should be considered as having poor air quality if nationally legislated air quality standards or WHO Air Quality Guidelines are exceeded significantly.

¹⁵ Emission points refer to a specific stack, vent, or other discrete point of pollution release. This term should not be confused with point source, which is a regulatory distinction from area and mobile sources. The characterization of point sources into multiple emissions points is useful for allowing more detailed reporting of emissions information.

including small combustion sources,¹⁶ should also use GIP in stack design.

Small Combustion Facilities Emissions Guidelines

Small combustion processes are systems designed to deliver electrical or mechanical power, steam, heat, or any combination of these, regardless of the fuel type, with a total, rated heat input capacity of between three Megawatt thermal (MWth) and 50 MWth.

The emissions guidelines in Table 1.1.2 are applicable to small combustion process installations operating more than 500 hours per year, and those with an annual capacity utilization of more than 30 percent. Plants firing a mixture of fuels should compare emissions performance with these guidelines based on the sum of the relative contribution of each applied fuel¹⁷. Lower emission values may apply if the proposed facility is located in an ecologically sensitive airshed, or airshed with poor air quality, in order to address potential cumulative impacts from the installation of more than one small combustion plant as part of a distributed generation project.

¹⁶ Small combustion sources are those with a total rated heat input capacity of 50MWth or less.

¹⁷ The contribution of a fuel is the percentage of heat input (LHV) provided by this fuel multiplied by its limit value.

Table 1.1.2 - Small Combustion Facilities Emissions Guidelines (3MWth – 50MWth) – (in mg/Nm³ or as indicated)

Combustion Technology / Fuel	Particulate Matter (PM)	Sulfur Dioxide (SO ₂)	Nitrogen Oxides (NO _x)	Dry Gas, Excess O ₂ Content (%)
Engine				
Gas	N/A	N/A	200 (Spark Ignition) 400 (Dual Fuel) 1,600 (Compression Ignition)	15
Liquid	50 or up to 100 if justified by project specific considerations (e.g. Economic feasibility of using lower ash content fuel, or adding secondary treatment to meet 50, and available environmental capacity of the site)	1.5 percent Sulfur or up to 3.0 percent Sulfur if justified by project specific considerations (e.g. Economic feasibility of using lower S content fuel, or adding secondary treatment to meet levels of using 1.5 percent Sulfur, and available environmental capacity of the site)	If bore size diameter [mm] < 400: 1460 (or up to 1,600 if justified to maintain high energy efficiency.) If bore size diameter [mm] > or = 400: 1,850	15
Turbine				
Natural Gas =3MWth to < 15MWth	N/A	N/A	42 ppm (Electric generation) 100 ppm (Mechanical drive)	15
Natural Gas =15MWth to < 50MWth	N/A	N/A	25 ppm	15
Fuels other than Natural Gas =3MWth to < 15MWth	N/A	0.5 percent Sulfur or lower percent Sulfur (e.g. 0.2 percent Sulfur) if commercially available without significant excess fuel cost	96 ppm (Electric generation) 150 ppm (Mechanical drive)	15
Fuels other than Natural Gas =15MWth to < 50MWth	N/A	0.5% S or lower % S (0.2%S) if commercially available without significant excess fuel cost	74 ppm	15
Boiler				
Gas	N/A	N/A	320	3
Liquid	50 or up to 150 if justified by environmental assessment	2000	460	3
Solid	50 or up to 150 if justified by environmental assessment	2000	650	6

Notes: -N/A/ - no emissions guideline; Higher performance levels than these in the Table should be applicable to facilities located in urban / industrial areas with degraded airsheds or close to ecologically sensitive areas where more stringent emissions controls may be needed.; MWth is heat input on HHV basis; Solid fuels include biomass; Nm³ is at one atmosphere pressure, 0°C.; MWth category is to apply to the entire facility consisting of multiple units that are reasonably considered to be emitted from a common stack except for NO_x and PM limits for turbines and boilers. Guidelines values apply to facilities operating more than 500 hours per year with an annual capacity utilization factor of more than 30 percent.

Fugitive Sources

Fugitive source air emissions refer to emissions that are distributed spatially over a wide area and not confined to a specific discharge point. They originate in operations where exhausts are not captured and passed through a stack. Fugitive emissions have the potential for much greater ground-level impacts per unit than stationary source emissions, since they are discharged and dispersed close to the ground. The two main types of fugitive emissions are Volatile Organic Compounds (VOCs) and particulate matter (PM). Other contaminants (NO_x, SO₂ and CO) are mainly associated with combustion processes, as described above. Projects with potentially significant fugitive sources of emissions should establish the need for ambient quality assessment and monitoring practices.

Open burning of solid wastes, whether hazardous or non-hazardous, is not considered good practice and should be avoided, as the generation of polluting emissions from this type of source cannot be controlled effectively.

Volatile Organic Compounds (VOCs)

The most common sources of fugitive VOC emissions are associated with industrial activities that produce, store, and use VOC-containing liquids or gases where the material is under pressure, exposed to a lower vapor pressure, or displaced from an enclosed space. Typical sources include equipment leaks, open vats and mixing tanks, storage tanks, unit operations in wastewater treatment systems, and accidental releases. Equipment leaks include valves, fittings, and elbows which are subject to leaks under pressure. The recommended prevention and control techniques for VOC emissions associated with equipment leaks include:

- Equipment modifications, examples of which are presented in Annex 1.1.4;

- Implementing a leak detection and repair (LDAR) program that controls fugitive emissions by regularly monitoring to detect leaks, and implementing repairs within a predefined time period.¹⁸

For VOC emissions associated with handling of chemicals in open vats and mixing processes, the recommended prevention and control techniques include:

- Substitution of less volatile substances, such as aqueous solvents;
- Collection of vapors through air extractors and subsequent treatment of gas stream by removing VOCs with control devices such as condensers or activated carbon absorption;
- Collection of vapors through air extractors and subsequent treatment with destructive control devices such as:
 - Catalytic Incinerators: Used to reduce VOCs from process exhaust gases exiting paint spray booths, ovens, and other process operations
 - Thermal Incinerators: Used to control VOC levels in a gas stream by passing the stream through a combustion chamber where the VOCs are burned in air at temperatures between 700° C to 1,300° C
 - Enclosed Oxidizing Flares: Used to convert VOCs into CO₂ and H₂O by way of direct combustion
- Use of floating roofs on storage tanks to reduce the opportunity for volatilization by eliminating the headspace present in conventional storage tanks.

Particulate Matter (PM)

The most common pollutant involved in fugitive emissions is dust or particulate matter (PM). This is released during certain operations, such as transport and open storage of solid materials, and from exposed soil surfaces, including unpaved roads.

¹⁸ For more information, see Leak Detection and Repair Program (LDAR), at: <http://www.ldr.net>

Recommended prevention and control of these emissions sources include:

- Use of dust control methods, such as covers, water suppression, or increased moisture content for open materials storage piles, or controls, including air extraction and treatment through a baghouse or cyclone for material handling sources, such as conveyors and bins;
- Use of water suppression for control of loose materials on paved or unpaved road surfaces. Oil and oil by-products is not a recommended method to control road dust. Examples of additional control options for unpaved roads include those summarized in Annex 1.1.5.

Ozone Depleting Substances (ODS)

Several chemicals are classified as ozone depleting substances (ODSs) and are scheduled for phase-out under the Montreal Protocol on Substances that Deplete the Ozone Layer.¹⁹ No new systems or processes should be installed using CFCs, halons, 1,1,1-trichloroethane, carbon tetrachloride, methyl bromide or HBFCs. HCFCs should only be considered as interim / bridging alternatives as determined by the host country commitments and regulations.²⁰

Mobile Sources – Land-based

Similar to other combustion processes, emissions from vehicles include CO, NO_x, SO₂, PM and VOCs. Emissions from on-road and off-road vehicles should comply with national or regional

¹⁹ Examples include: chlorofluorocarbons (CFCs); halons; 1,1,1-trichloroethane (methyl chloroform); carbon tetrachloride; hydrochlorofluorocarbons (HCFCs); hydrobromofluorocarbons (HBFCs); and methyl bromide. They are currently used in a variety of applications including: domestic, commercial, and process refrigeration (CFCs and HCFCs); domestic, commercial, and motor vehicle air conditioning (CFCs and HCFCs); for manufacturing foam products (CFCs); for solvent cleaning applications (CFCs, HCFCs, methyl chloroform, and carbon tetrachloride); as aerosol propellants (CFCs); in fire protection systems (halons and HBFCs); and as crop fumigants (methyl bromide).

²⁰ Additional information is available through the Montreal Protocol Secretariat web site available at: <http://ozone.unep.org/>

programs. In the absence of these, the following approach should be considered:

- Regardless of the size or type of vehicle, fleet owners / operators should implement the manufacturer recommended engine maintenance programs;
- Drivers should be instructed on the benefits of driving practices that reduce both the risk of accidents and fuel consumption, including measured acceleration and driving within safe speed limits;
- Operators with fleets of 120 or more units of heavy duty vehicles (buses and trucks), or 540 or more light duty vehicles²¹ (cars and light trucks) within an airshed should consider additional ways to reduce potential impacts including:
 - Replacing older vehicles with newer, more fuel efficient alternatives
 - Converting high-use vehicles to cleaner fuels, where feasible
 - Installing and maintaining emissions control devices, such as catalytic converters
 - Implementing a regular vehicle maintenance and repair program

Greenhouse Gases (GHGs)

Sectors that may have potentially significant emissions of greenhouse gases (GHGs)²² include energy, transport, heavy industry (e.g. cement production, iron / steel manufacturing, aluminum smelting, petrochemical industries, petroleum refining, fertilizer manufacturing), agriculture, forestry and waste management. GHGs may be generated from direct emissions

²¹ The selected fleet size thresholds are assumed to represent potentially significant sources of emissions based on individual vehicles traveling 100,000 km / yr using average emission factors.

²² The six greenhouse gases that form part of the Kyoto Protocol to the United Nations Framework Convention on Climate Change include carbon dioxide (CO₂); methane (CH₄); nitrous oxide (N₂O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulfur hexafluoride (SF₆).

from facilities within the physical project boundary and indirect emissions associated with the off-site production of power used by the project.

Recommendations for reduction and control of greenhouse gases include:

- Carbon financing;²³
- Enhancement of energy efficiency (see section on 'Energy Conservation');
- Protection and enhancement of sinks and reservoirs of greenhouse gases;
- Promotion of sustainable forms of agriculture and forestry;
- Promotion, development and increased use of renewable forms of energy;
- Carbon capture and storage technologies;²⁴
- Limitation and / or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy (coal, oil, and gas).

Monitoring

Emissions and air quality monitoring programs provide information that can be used to assess the effectiveness of emissions management strategies. A systematic planning process is recommended to ensure that the data collected are adequate for their intended purposes (and to avoid collecting unnecessary data). This process, sometimes referred to as a data quality objectives process, defines the purpose of collecting the data, the

decisions to be made based on the data and the consequences of making an incorrect decision, the time and geographic boundaries, and the quality of data needed to make a correct decision.²⁵ The air quality monitoring program should consider the following elements:

- *Monitoring parameters:* The monitoring parameters selected should reflect the pollutants of concern associated with project processes. For combustion processes, indicator parameters typically include the quality of inputs, such as the sulfur content of fuel.
- *Baseline calculations:* Before a project is developed, baseline air quality monitoring at and in the vicinity of the site should be undertaken to assess background levels of key pollutants, in order to differentiate between existing ambient conditions and project-related impacts.
- *Monitoring type and frequency:* Data on emissions and ambient air quality generated through the monitoring program should be representative of the emissions discharged by the project over time. Examples of time-dependent variations in the manufacturing process include batch process manufacturing and seasonal process variations. Emissions from highly variable processes may need to be sampled more frequently or through composite methods. Emissions monitoring frequency and duration may also range from continuous for some combustion process operating parameters or inputs (e.g. the quality of fuel) to less frequent, monthly, quarterly or yearly stack tests.
- *Monitoring locations:* Ambient air quality monitoring may consist of off-site or fence line monitoring either by the project sponsor, the competent government agency, or by collaboration between both. The location of ambient air

²³ Carbon financing as a carbon emissions reduction strategy may include the host government-endorsed Clean Development Mechanism or Joint Implementation of the United Nations Framework Convention on Climate Change.

²⁴ Carbon dioxide capture and storage (CCS) is a process consisting of the separation of CO₂ from industrial and energy-related sources; transport to a storage location; and long-term isolation from the atmosphere, for example in geological formations, in the ocean, or in mineral carbonates (reaction of CO₂ with metal oxides in silicate minerals to produce stable carbonates). It is the object of intensive research worldwide (Intergovernmental Panel on Climate Change (IPCC), Special Report, Carbon Dioxide Capture and Storage (2006).

²⁵ See, for example, United States Environmental Protection Agency, Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4, EPA/240/B-06/001 February 2006.

quality monitoring stations should be established based on the results of scientific methods and mathematical models to estimate potential impact to the receiving airshed from an emissions source taking into consideration such aspects as the location of potentially affected communities and prevailing wind directions.

- *Sampling and analysis methods:* Monitoring programs should apply national or international methods for sample collection and analysis, such as those published by the International Organization for Standardization,²⁶ the European Committee for Standardization,²⁷ or the U.S. Environmental Protection Agency.²⁸ Sampling should be conducted by, or under, the supervision of trained individuals. Analysis should be conducted by entities permitted or certified for this purpose. Sampling and analysis Quality Assurance / Quality Control (QA/QC) plans should be applied and documented to ensure that data quality is adequate for the intended data use (e.g., method detection limits are below levels of concern). Monitoring reports should include QA/QC documentation.

Monitoring of Small Combustion Plants Emissions

- Additional recommended monitoring approaches for **boilers:**

Boilers with capacities between =3 MWth and < 20 MWth:

- Annual Stack Emission Testing: SO₂, NO_x and PM. For gaseous fuel-fired boilers, only NO_x. SO₂ can be calculated based on fuel quality certification if no SO₂ control equipment is used.

²⁶ An on-line catalogue of ISO standards relating to the environment, health protection, and safety is available at: <http://www.iso.org/iso/en/CatalogueListPage.CatalogueList?ICS1=13&ICS2=&ICS3=&scopelist=>

²⁷ An on-line catalogue of European Standards is available at: <http://www.cen.eu/catweb/cwen.htm>.

²⁸ The National Environmental Methods Index provides a searchable clearinghouse of U.S. methods and procedures for both regulatory and non-regulatory monitoring purposes for water, sediment, air and tissues, and is available at <http://www.nemi.gov/>.

- If Annual Stack Emission Testing demonstrates results consistently and significantly better than the required levels, frequency of Annual Stack Emission Testing can be reduced from annual to every two or three years.
- Emission Monitoring: None

Boilers with capacities between =20 MWth and < 50 MWth

- Annual Stack Emission Testing: SO₂, NO_x and PM. For gaseous fuel-fired boilers, only NO_x. SO₂ can be calculated based on fuel quality certification (if no SO₂ control equipment is used)
- Emission Monitoring: SO₂. Plants with SO₂ control equipment: Continuous. NO_x: Continuous monitoring of either NO_x emissions or indicative NO_x emissions using combustion parameters. PM: Continuous monitoring of either PM emissions, opacity, or indicative PM emissions using combustion parameters / visual monitoring.
- Additional recommended monitoring approaches for **turbines:**
 - Annual Stack Emission Testing: NO_x and SO₂ (NO_x only for gaseous fuel-fired turbines).
 - If Annual Stack Emission Testing results show constantly (3 consecutive years) and significantly (e.g. less than 75 percent) better than the required levels, frequency of Annual Stack Emission Testing can be reduced from annual to every two or three years.
 - Emission Monitoring: NO_x: Continuous monitoring of either NO_x emissions or indicative NO_x emissions using combustion parameters. SO₂: Continuous monitoring if SO₂ control equipment is used.
- Additional recommended monitoring approaches for **engines:**
 - Annual Stack Emission Testing: NO_x, SO₂ and PM (NO_x only for gaseous fuel-fired diesel engines).

- If Annual Stack Emission Testing results show constantly (3 consecutive years) and significantly (e.g. less than 75 percent) better than the required levels, frequency of Annual Stack Emission Testing can be reduced from annual to every two or three years.
- Emission Monitoring: NO_x: Continuous monitoring of either NO_x emissions or indicative NO_x emissions using combustion parameters. SO₂: Continuous monitoring if SO₂ control equipment is used. PM: Continuous monitoring of either PM emissions or indicative PM emissions using operating parameters.

Annex 1.1.1 – Air Emissions Estimation and Dispersion

Modeling Methods

The following is a partial list of documents to aid in the estimation of air emissions from various processes and air dispersion models:

Australian Emission Estimation Technique Manuals

<http://www.npi.gov.au/handbooks/>

Atmospheric Emission Inventory Guidebook, UN / ECE / EMEP
and the European Environment Agency

<http://www.aeat.co.uk/netcen/airqual/TFEI/unece.htm>

Emission factors and emission estimation methods, US EPA
Office of Air Quality Planning & Standards

<http://www.epa.gov/ttn/chief>

Guidelines on Air Quality Models (Revised), US Environmental
Protection Agency (EPA), 2005

http://www.epa.gov/scram001/guidance/guide/appw_05.pdf

Frequently Asked Questions, Air Quality Modeling and
Assessment Unit (AQMAU), UK Environment Agency

[http://www.environment-
agency.gov.uk/subjects/airquality/236092/?version=1&lang=_e](http://www.environment-agency.gov.uk/subjects/airquality/236092/?version=1&lang=_e)

OECD Database on Use and Release of Industrial Chemicals

<http://www.olis.oecd.org/ehs/urchem.nsf/>

Annex 1.1.2 – Illustrative Point Source Air Emissions Prevention and Control Technologies

Principal Sources and Issues	General Prevention / Process Modification Approach	Control Options	Reduction Efficiency (%)	Gas Condition	Comments
Particulate Matter (PM)					
Main sources are the combustion of fossil fuels and numerous manufacturing processes that collect PM through air extraction and ventilation systems. Volcanoes, ocean spray, forest fires and blowing dust (most prevalent in dry and semiarid climates) contribute to background levels.	Fuel switching (e.g. selection of lower sulfur fuels) or reducing the amount of fine particulates added to a process.	Fabric Filters	99 - 99.7%	Dry gas, temp <400F	Applicability depends on flue gas properties including temperature, chemical properties, abrasion and load. Typical air to cloth ratio range of 2.0 to 3.5 cfm/ft ² . Achievable outlet concentrations of 23 mg/Nm ³
		Electrostatic Precipitator (ESP)	97 – 99%	Varies depending of particle type	Precondition gas to remove large particles. Efficiency dependent on resistivity of particle. Achievable outlet concentration of 23 mg/Nm ³
		Cyclone	74 – 95%	None	Most efficient for large particles. Achievable outlet concentrations of 30 - 40 mg/Nm ³
		Wet Scrubber	93 – 95%	None	Wet sludge may be a disposal problem depending on local infrastructure. Achievable outlet concentrations of 30 - 40 mg/Nm ³
Sulfur Dioxide (SO₂)					
Mainly produced by the combustion of fuels such as oil and coal and as a by-product from some chemical production or wastewater treatment processes.	Control system selection is heavily dependent on the inlet concentration. For SO ₂ concentrations in excess of 10%, the stream is passed through an acid plant not only to lower the SO ₂ emissions but also to generate high grade sulfur for sale. Levels below 10% are not rich enough for this process and should therefore utilize absorption or 'scrubbing,' where SO ₂ molecules are captured into a liquid phase or adsorption, where SO ₂ molecules are captured on the surface of a solid adsorbent.	Fuel Switching	>90%		Alternate fuels may include low sulfur coal, light diesel or natural gas with consequent reduction in particulate emissions related to sulfur in the fuel. Fuel cleaning or beneficiation of fuels prior to combustion is another viable option but may have economic consequences.
		Sorbent Injection	30% - 70%		Calcium or lime is injected into the flue gas and the SO ₂ is adsorbed onto the sorbent
		Dry Flue Gas Desulfurization	70%-90%		Can be regenerable or throwaway.
		Wet Flue Gas Desulfurization	>90%		Produces gypsum as a by-product

Annex 1.1.2: Illustrative Point Source Air Emissions Prevention and Control Technologies (continued)

Oxides of Nitrogen (NO _x)		Percent Reduction by Fuel Type			Comments				
<p>Associated with combustion of fuel. May occur in several forms of nitrogen oxide; namely nitric oxide (NO), nitrogen dioxide (NO₂) and nitrous oxide (N₂O), which is also a greenhouse gas. The term NO_x serves as a composite between NO and NO₂ and emissions are usually reported as NO_x. Here the NO is multiplied by the ratio of molecular weights of NO₂ to NO and added to the NO₂ emissions.</p> <p>Means of reducing NO_x emissions are based on the modification of operating conditions such as minimizing the resident time at peak temperatures, reducing the peak temperatures by increasing heat transfer rates or minimizing the availability of oxygen.</p>	Combustion modification (Illustrative of boilers)	Coal	Oil	Gas	<p>These modifications are capable of reducing NO_x emissions by 50 to 95%. The method of combustion control used depends on the type of boiler and the method of firing fuel.</p>				
	Low-excess-air firing	10–30	10–30	10–30					
	Staged Combustion	20–50	20–50	20–50					
	Flue Gas Recirculation	N/A	20–50	20–50					
	Water/Steam Injection	N/A	10–50	N/A					
	Low-NO _x Burners	30–40	30–40	30–40					
	Flue Gas Treatment	Coal	Oil	Gas					
	Selective Catalytic Reduction (SCR)	60–90	60–90	60–90		<p>Flue gas treatment is more effective in reducing NO_x emissions than are combustion controls. Techniques can be classified as SCR, SNCR, and adsorption. SCR involves the injection of ammonia as a reducing agent to convert NO_x to nitrogen in the presence of a catalyst in a converter upstream of the air heater. Generally, some ammonia slips through and is part of the emissions. SNCR also involves the injection of ammonia or urea based products without the presence of a catalyst.</p>			
	Selective Non-Catalytic Reduction (SNCR)	N/A	30–70	30–70					

Note: Compiled by IFC based on inputs from technical experts.

Annex 1.1.3 - Good International Industry Practice (GIIP)

Annex 1.1.4 - Examples of VOC Emissions Controls

Stack Height

(Based on United States 40 CFR, part 51.100 (ii)).

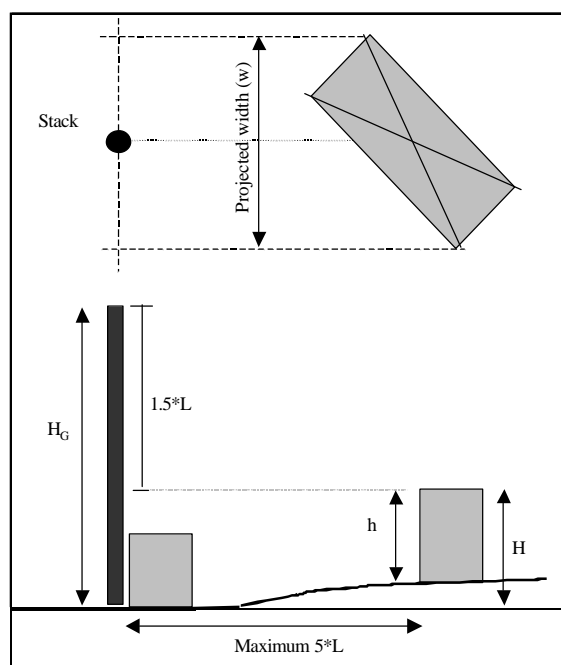
$H_G = H + 1.5L$; where

H_G = GEP stack height measured from the ground level elevation at the base of the stack

H = Height of nearby structure(s) above the base of the stack.

L = Lesser dimension, height (h) or width (w), of nearby structures

"Nearby structures" = Structures within/touching a radius of $5L$ but less than 800 m.



Equipment Type	Modification	Approximate Control Efficiency (%)
Pumps	Seal-less design	100 ²⁹
	Closed-vent system	90 ³⁰
	Dual mechanical seal with barrier fluid maintained at a higher pressure than the pumped fluid	100
Compressors	Closed-vent system	90
	Dual mechanical seal with barrier fluid maintained at a higher pressure than the compressed gas	100
Pressure Relief Devices	Closed-vent system	Variable ³¹
	Rupture disk assembly	100
Valves	Seal-less design	100
Connectors	Weld together	100
Open-ended Lines	Blind, cap, plug, or second valve	100
Sampling Connections	Closed-loop sampling	100
Note: Examples of technologies are provided for illustrative purposes. The availability and applicability of any particular technology will vary depending on manufacturer specifications.		

29 Seal-less equipment can be a large source of emissions in the event of equipment failure.

30 Actual efficiency of a closed-vent system depends on percentage of vapors collected and efficiency of control device to which the vapors are routed.

31 Control efficiency of closed vent-systems installed on a pressure relief device may be lower than other closed-vent systems.

Annex 1.1.5 - Fugitive PM Emissions Controls

Control Type	Control Efficiency
Chemical Stabilization	0% - 98%
Hygroscopic salts Bitumens/adhesives	60% - 96%
Surfactants	0% - 68%
Wet Suppression – Watering	12% - 98%
Speed Reduction	0% - 80%
Traffic Reduction	Not quantified
Paving (Asphalt / Concrete)	85% - 99%
Covering with Gravel, Slag, or "Road Carpet"	30% - 50%
Vacuum Sweeping	0% - 58%
Water Flushing/Broom Sweeping	0% - 96%