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AIRUSE

Testing and development of air quality mitigation measures in Southern Europe

TECHNICAL GUIDE FOR INDUSTRIAL EMISSIONS REDUCTION

REPORT 26

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1. SUMMARY

Although the current Industrial Emissions Directive (IED), former Integrated Pollution Prevention and Control (IPPC Directive), and other EU and National actions have led to a huge reduction in industrial emissions in the last decade, the results from AIRUSE on source apportionment Action B2 have revealed that the total industrial contribution to ambient PM10 and PM2.5 exceeds 20% of the annual ambient air concentrations in most cases and in some cases its importance increases during pollution episodes

Besides the study on source apportionment, an in-depth study has been conducted on industrial sources. The goal of this study was to carry out an industrial PM emissions inventory and subsequent quantification of the industrial emissions of primary PM (PM10 and PM2.5). These actions have been complemented with the development of the present report, which belongs to Action B7, “Technical guide for industrial emissions reduction”.

In this guide (one of the five technical guides related to PM mitigation measures), mitigation strategies have been revised and proposed for the relevant and identified industrial emissions sources. Moreover, the content of this technical guide has been extended to also take into account other activities which, though not actually deemed industrial, are considered relevant in PM emissions due to their vicinity to the cities. These activities are: works, shipping and port activities (bulk solids unloading and loading operations, transport and storage).

The present guide does not claim to be an exhaustive list of mitigation measures for industrial and other activities emissions but to provide a useful and practical overview of mitigation measures and/or good practices for each activity in order to reduce the environmental impact of associated sources. Several recommendations for public authorities are also included to improve further environmental information.

2. TECHNICAL GUIDE FOR INDUSTRIAL EMISSIONS REDUCTION

The AIRUSE project seeks to improve air quality levels through the proposal of mitigation strategies for PM emissions focusing on Southern European Countries. The study has been carried out in five cities: Barcelona (Spain), Porto (Portugal), Florence and Milan (Italy), and Athens (Greece), called the AIRUSE cities (Figure 1). One of the main objectives of the project has been to determine the aerosol sources affecting each of these cities and to identify those aerosol sources that lead to exceedances of EU air quality limit values.

Figure 1. AIRUSE cities. Source: www.airuse.eu.

Regarding industrial sources, although the current Industrial Emissions Directive (IED), former Integrated Pollution Prevention and Control (IPPC Directive), and other EU and National actions have led to a huge reduction in industrial emissions in the last decade, the results from AIRUSE on source apportionment Action B2 have revealed that if the direct industrial contributions from specific sources, the shipping and industrial contributions from heavy oil burning, a relevant fraction of the non-traffic and non-biomass related nitrate and a relevant fraction of the regional secondary sulphate and OC source contributions (Figure 2) are grouped together, the total industrial contribution to ambient PM10 and PM2.5 exceeds 20% of the annual ambient air concentrations in most cases.

Besides the study on source apportionment from Action B2, the industrial sources contribution in the AIRUSE cities has been analysed in depth, developing an industrial PM emissions inventory and subsequent quantification of the industrial emissions of primary PM (PM10 and PM2.5).

City	Values in % contributions to 2013 annual mean	
	TOTAL*	
	PM_{10}	$PM_{2.5}$
POR-TR	< 12	< 14
BCN-UB	< 36	< 39
FI-UB	< 23	< 26
MLN-UB	n.a.	< 22
AIRUSE cities: Porto (PO), Barcelona (BCN), Firenze (FI) and Milan (MLN).		
Air Quality Cabins: Traffic (TR) and Urban Background (UB)		
n.a.: not available		
*Contributions for sources directly/indirectly and totally/partially related with industrial source		

Figure 2. Results from the receptor model. More information: www. airuse.eu

The study also provides a qualitative assessment of the degree of implementation of Best Available Techniques (BATs) with regard to PM emissions, the industrial profile that could most contribute to primary PM levels in the AIRUSE cities, and a quantification from E-PRTR data of the most relevant precursors of secondary aerosol and tracer elements for most current industrial emissions.

All these actions have been complemented with the development of the present report, which belongs to Action B7, “Technical guide for industrial emissions reduction”. This guide is one of the five technical guides related to PM mitigation measures, in which mitigation strategies have been revised and proposed for the relevant and identified industrial emissions sources. Moreover, the content of this technical guide has been extended to also take into account other activities which, though not actually deemed industrial, are considered relevant in PM emissions due to their vicinity to the cities. These activities are: works, shipping and port activities (bulk solids unloading and loading operations, transport and storage).

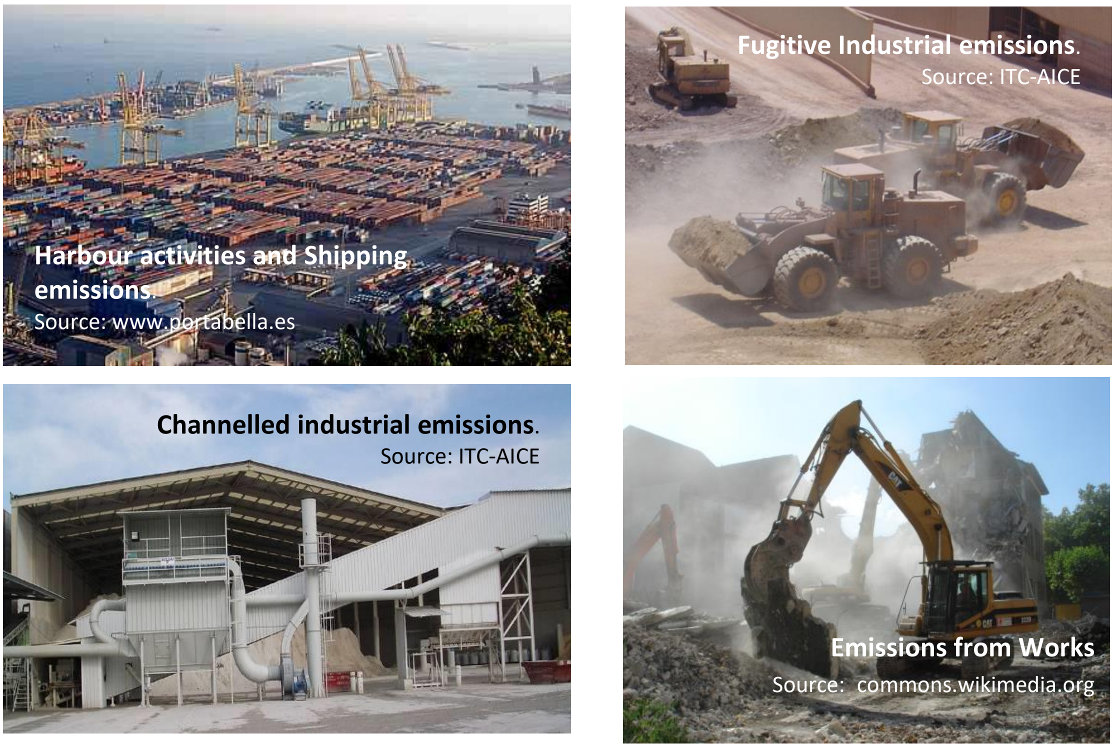


Figure 3. Activities included in this guide

The present guide does not claim to be an exhaustive list of mitigation measures for industrial and other activities emissions but to provide a useful and practical overview of mitigation measures and/or good practices for each activity in order to reduce the environmental impact of associated sources.

The structure and content of the present technical guide has been adapted to the current situation for each activity (Figure 4). The detailed information depends mainly on the maturity of the applicable legislation and on the social pressure that demands mitigation measures to improve current environmental impact.

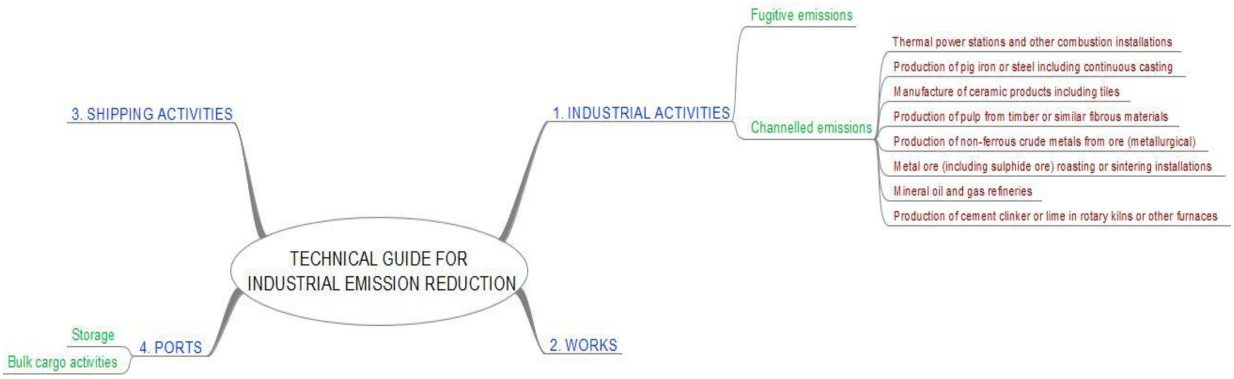


Figure 4. Scheme of the contents of the present technical guide.

Moreover, it has been considered of great interest to complement technical information gathered with some useful links, which provide examples of well-known BATs, codes of good practices from real cases, and guidelines on management activities to prevent source emissions. The link contents are useful for assisting those responsible for the emissions, as well as for public authorities, in searching more or specific information.

Besides the content of this guide, it is important to highlight the role of public authorities in controlling PM sources, through improvement of the available environmental information.

With a view to addressing common weaknesses found in the studied areas, general recommendations have been established.

GENERAL RECOMMENDATIONS TO OVERCOME THE WEAKNESSES FOUND FROM INDUSTRIAL EMISSIONS INVENTORY IN THE STUDIED AREAS

- Updating the list of industrial activities
- Extending the information in public inventories such as E-PRTR
- Improving fugitive emissions data
- Improving the regional inventories of PM industrial emissions
- Harmonising the key control parameters between air quality (PM10 and PM2.5), atmospheric emission limit values (PST) and E-PRTR (PM10)
- Organising awareness-raising activities especially for the industrial sectors

Figure 5. General recommendations to improve industrial emissions inventories.

In this regard, further details on the main gaps and recommendations are given below:

- **Updating the list of industrial activities:** In spite of the measures taken in the last few years, industrial pollution control, reporting and monitoring of IED, and above all non-IED activities, still constitute an important challenge for the study areas; consequently, greater efforts should be made to control these activities. The activities and emissions inventories should not be limited to IED activities as non-IED activities may play an important role in urban areas from an environmental point of view, and the available information reported by the competent bodies in the AIRUSE areas is very scarce.

- Extending the information in public inventories such as E-PRTR

. The public data on specific applied emission limit values (ELVs), implemented BATs, fuels used and output capacity are very poorly reported, even for IED activities. Therefore, the inclusion of this information in a harmonised public system, such as the E-PRTR is highly recommended, in order to improve environmental transparency and facilitate mitigation action proposals.

- **Improving fugitive emissions data.** Even though the E-PRTR specifies that PM fugitive emission should be included in the reported emissions, the E-PRTR emission data are given on a global basis. As a result, it is not possible to ascertain whether these emissions have been included and how they have been quantified. The existing methodologies for quantifying fugitive PM emissions from industrial sources are based on applying data from standard databases, such as the EMEP/EEA, AP 42, combined with other sources such as the Emission estimation technique (EET) manuals for industry approved by the Australian Government.

However, these methodologies compile, in most of the cases, general emission factors for handling bulk solids. It may be noted that improvement in the quality and representativeness of these databases, considering the specific cases of the European industry, would directly entail a substantial upgrading of the quality of the data obtained in the corresponding inventories and of all the consequences (decisions, strategies, or measures) adopted on the basis of these results (Air Quality Improvement Plans, reduction of emission limits, establishment of control requirements, mitigation measures, and new regulations).

The following references demonstrate the importance of having specific emission factors associated with detailed operations and materials (Tier 3), as well as a methodology for obtaining them:

- Monfort, E., Sanfelix, V., Celades, I., Gomar, S., Martín, F., Aceña, B., Pascual, A. 2011. Fugitive PM10 emission factors associated with dust abatement technologies in the ceramic industry. Atmospheric Environment, 45(39), 7286-7292.

- Sanfélix, V., Escrig, A., López-Lilao, A., Celades, I., Monfort, E. 2015. On the source inversion of fugitive surface layer releases. Part I. Model formulation and application to simple sources. Atmospheric Environment, 109, 171-177.

It may be noted that in relatively dry countries, as is the case in the AIRUSE target areas, some specific activities such as the handling of bulk dusty materials in ports, quarries, ceramic or cement facilities, may produce PM fugitive emissions of the same order of magnitude as channelled ones. Moreover, the available emission factors in the standard databases, such as those used in the present study are not accurate enough for PM fugitive emissions; therefore, the improvement of these data should be strongly encouraged.

- **Improving the regional inventories of PM industrial emissions**. The emission information required to develop realistic air quality plans at regional scale, such as the metropolitan areas studied in AIRUSE should be more exhaustive. This improvement could be achieved by estimating the emissions with a bottom-up approach, including those industrial activities and fugitive emissions mentioned previously, which can be relevant in PM emissions. Nevertheless, their estimation is currently based on very limited experimental evidence, and may not always provide a realistic picture. For both reasons, PM emission inventories cannot be deemed fully reliable at present.

- Harmonising the key control parameters between air quality (PM10 and PM2.5), atmospheric emission limit values (PST) and E-PRTR (PM10). Achievement of this aim would require establishing the following ratios for the different industrial activities:

PM10/PST, PM2.5/PST. This information is currently only available for just a few activities in the EMEP/EEA air pollutant emission inventory guidebook–2013.

- **Organising awareness-raising activities especially for the industrial sectors** through workshops in cooperation with business associations, or specific info-days for industrial activities. These events need to explain to each industry involved the importance, generally, of providing accurate information on its environmental impact (atmospheric emissions) and to explain, in detail, the end use of this information and the consequences of not providing it.

2.1. INDUSTRIAL ACTIVITIES

Industrial manufacturing processes have been systematically regulated with regard to air emissions. The application of the IPPC Directive has led to the introduction of a variety of technologies to PM emissions, defined as BATs. These techniques are included in the European Reference Documents on Best Available Techniques (BREFs), drawn up as part of the implementation of the IPPC Directive.

The mechanism aimed at establishing and updating the BATs for each industrial sector basically involves regular meetings, consisting of "an exchange of information between EU Member States, industries and non-governmental organisations (NGOs) concerned with BATS" (Decision 2012/119/EU) (Figure 6). However, in the IPPC Directive, by definition, a BREF is a descriptive document that does not prescribe the use of any specific technique or technology.

In 2010, the EU Parliament approved the Industrial Emissions Directive (IED 2010/75/EU), which abrogated the IPPC Directive. The aim was to establish stricter policies with regard to the emission of industrial pollutants, especially in key sectors such as power generation, combustion and co-combustion of different fossil fuels and biofuels (large combustion plants), organic solvents management and others. One important change introduced by the IED can be found in articles 13 to 16. These articles require that BREFs are the reference for setting permit conditions and that emission limit values (ELVs) do not exceed the emission levels associated with the BATs (BAT-AELs) as described in those BREFs. This information is set out in the BAT conclusions document (Commission Implementing Decision).

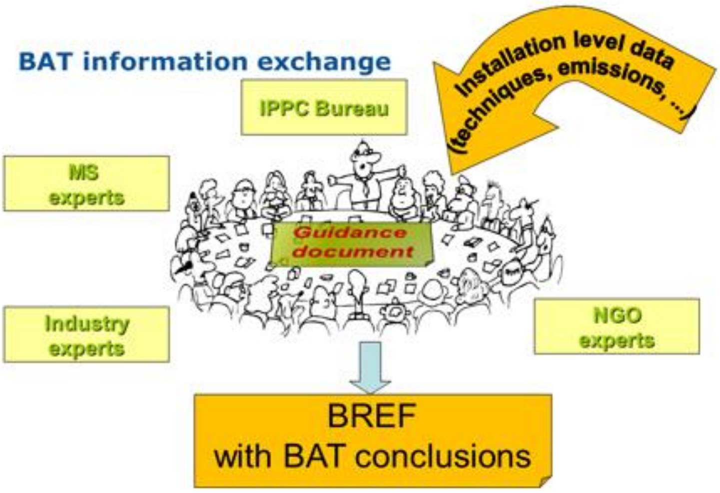


Figure 6. *BAT information exchange (known as "Seville process). Source: www.era.int.*

It may be noted, however, that although the above policies have led to an improvement in the environmental impact of the industrial sectors across Europe, according to several European Commission studies and reports (EEA, 2013 & 2014), these efforts are not enough, it being detected that it is necessary to foster and raise awareness among the industries to implement and ensure the maintenance of BATs in order to reduce (both channelled and fugitive) industrial emissions (see Figure 7) to acceptable levels and also to reduce their impact on air quality levels.

Figure 7. *Channelled (top) and fugitive (bottom) PM emissions from industrial sites. Source: ITC-AICE*

In the case of channelled emissions, different cleaning technologies are available for the treatment of PM emissions. The selection of the most appropriate system depends, among other factors, on the size of the particles to be separated, operating conditions, costs, capital outlay, waste recycling possibilities, spatial requirements, etc.

In order to reduce the environmental impact associated with the fugitive emissions, individual measures or a combination of different techniques can be implemented, thus assuring an abatement of the fugitive dust emissions arising in the storage and handling operations of particulate materials such as raw materials.

In order to select the sectors and activities that contribute to PM10 emissions at European level, those above 2% in the E-PRTR 2012 data (Figure 8) have been considered. These comprise: thermal power stations and other combustion installations (54%), production of pig iron or steel including continuous casting (9%), manufacture of ceramic products including tiles (7%), production of pulp from timber or similar fibrous materials (4%), production of non-ferrous crude metals from ore (metallurgical) (3%), metal ore (including sulphide ore) roasting or sintering installations (3%), mineral oil and gas refineries (3%) and production of cement clinker or lime in rotary kilns or other furnaces (2%).

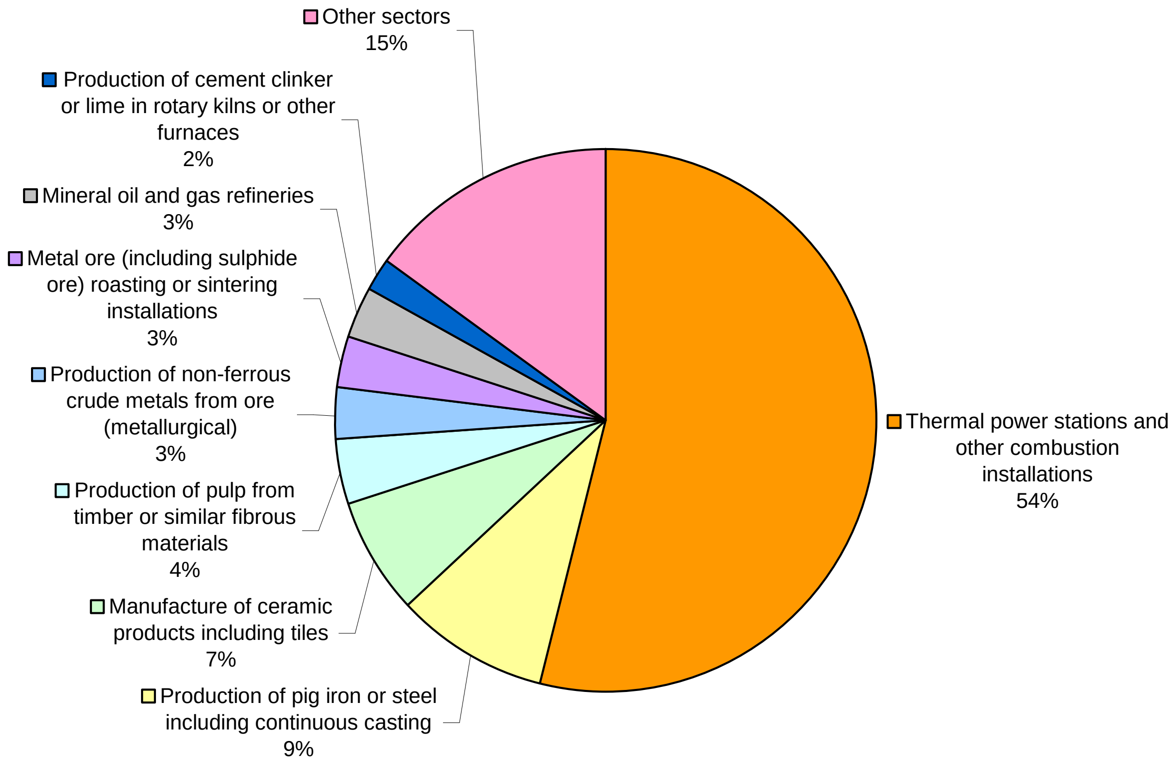


Figure 8. *The most relevant sectors and activities that contribute to PM10 emissions at European level. Source: EPRTR, 2012.*

The AIRUSE industrial activities inventory compiled in the B.5 first report from AIRUSE project "Industrial Activities Inventory in AIRUSE cities" was used to obtain the number of facilities for each sector and activities identified above (Table 1).

Table 1. *Number of facilities for the sectors and activities contributing to PM10 emissions in the five AIRUSE study areas.*

Activity	Total for the five AIRUSE Cities
1.(a) Mineral oil and gas refineries	3
1.(c) Thermal power stations and other combustion installations	8
2. (a) Metal ore (including sulphide ore) roasting or sintering installations	0
2.(b) Production of pig iron or steel including continuous casting	3
2.(e)(i) Production of non-ferrous crude metals from ore (Metallurgical)	0
3.(c) Production of cement clinker or lime in rotary kilns or other furnaces	5
3.(g) Manufacture of ceramic products including tiles, bricks, stoneware or porcelain	13
6.(a) Production of pulp from timber or similar fibrous materials	0

This identification has been made in order to select the BATs for the activities that have the highest impact in PM10 emissions and are present in AIRUSE cities. These techniques are included in the BREFs drawn up as part of the implementation of the IPPC currently abrogated by IED Directive (Figure 9).

Figure 9. *Some BREF documents considered in the present Guide. Source: eippcb.jrc.ec.europa.eu*

To identify the BATs, the specific BREFs developed for each industrial sector, focusing in the selected activities, and the horizontal BREF developed for emissions from storage and handling, have been consulted. Table 2 shows the BREFs and activities considered.

Table 2. *Industrial activities considered in identifying the BATs and corresponding BREFs.*

Activity	BREF Reference [Accessed: 16 December 2014; http://eippcb.jrc.ec.europa.eu/reference/]
Thermal power stations and other contribution installations	Large Combustion Plants - BREF (2006)
Production of pig iron or steel including continuous casting	Iron & Steel Production - BREF (2013)
Manufacture of ceramic products including tiles, bricks, stoneware or porcelain	Ceramic Manufacturing Industry - BREF (2007)
Mineral oil and gas refineries	Refining of Mineral Oil and Gas - Final draft BREF (2013) and BAT conclusions (2014)
Production of cement clinker or lime in rotary kilns or other furnaces	Production of Cement Lime and Magnesium Oxide - BREF (2013)
Emissions from storage	Emissions from Storage - BREF (2006)

The following sections briefly describe the generic and specific BATs for the channelled and fugitive PM emissions identified for the activities selected and the horizontal BREF developed for fugitive emissions.

2.1.1. *BATs for fugitive PM emissions*

This section briefly describes the most common generic techniques to prevent or, where this is not practicable, to reduce the environmental impact of installations generated by the PM fugitive emissions that have been considered in determining the BATs. These techniques have been extracted from the horizontal BREF developed for storage and handling emissions, so that these BATs are practically applicable to all activities producing this type of emissions.

The horizontal BREF developed for storage emissions addresses the storage and the transfer/handling of liquids, liquefied gases and solids, regardless of the sector or industry. It addresses emissions to air, soil and water. However, in the present report the attention is focused specifically on PM emissions to air.

In particular, for the solids storage methods, the following are addressed: silos, sheds or roofs, domes, and hoppers (see Figure 10). For the transfer and handling of solids, the techniques considered include grabs, belt conveyors, mechanical shovel, dump pits, and transfer chutes.

Figure 10. Examples of enclosured o semi-enclosured facilities to storage dusty materials. Source: ITC-AICE

All mitigation techniques to reduce fugitive PM emissions are quite horizontal and, as mentioned previously, they can be applied in different industrial sectors or other activities that are affected by these types of emissions such as harbour/port activities.

The storage emission BREF allows three approaches to be distinguished for establishing mitigation strategies to reduce PM emissions:

1. Pre-primary approaches, which start with the production or extraction process and reduce the material’s tendency to produce dust before it leaves the production plant.

2. Primary approaches, involving all the ways of reducing emissions during storage, which can be divided into:
   - organisational: behaviour of the operators.
   - constructional: constructions which prevent dust formation.
   - technical: techniques which prevent dust formation.
3. Secondary approaches, involving abatement techniques for keeping dust from spreading.

Note that the selection of a storage system type and emissions control measures (beforehand ECMs) to reduce dust emissions depends on product properties. Especially for end-products, where customer specifications are crucial, the selection of storage equipment and ECMs is based on many factors, such as product resistance to attrition, ability to break, crush, flow and cake-on, chemical stability, and sensitivity to moisture.

All the measures identified with regard to storage, handling and transfer emissions are shown in Tables 3 and 4.

Table 3. *Approaches and techniques to reduce PM emissions from bulk solids storage.*

<table>
<tr><th>Category</th><th>Type</th><th>Technique</th></tr>
<tr><td rowspan="9">Primary</td><td rowspan="4">Organisational (behaviour of the operators)</td><td>Monitoring</td></tr>
<tr><td>Layout and operation of storage places (by planning and operating personnel)</td></tr>
<tr><td>Reduction of wind attack areas</td></tr>
<tr><td>Maintenance (of prevention/reduction techniques)</td></tr>
<tr><td rowspan="5">Constructional and technical (constructions or techniques which prevent dust formation)</td><td>Large volume silos</td></tr>
<tr><td>Sheds or roofs</td></tr>
<tr><td>Domes</td></tr>
<tr><td>Silos and hoppers</td></tr>
<tr><td>Wind protection mounds, fences and/or plantings</td></tr>
<tr><td rowspan="2">Secondary</td><td rowspan="2">Abatement techniques</td><td>Water spraying/water curtains and jet spraying</td></tr>
<tr><td>Extraction of storage sheds and silos</td></tr>
</table>

***Table 4**. Approaches and techniques to reduce PM emissions from the <u>transfer (including transport activities) and handling bulk materials</u>.*

<table>
<tr><th>Category</th><th>Type</th><th colspan="2">Techniques</th></tr>
<tr><td rowspan="22">Primary</td><td rowspan="13">Organisational (behaviour of the operators)</td><td colspan="2">Reducing or stopping activities depending on weather conditions</td></tr>
<tr><td rowspan="3">Measures (for the crane operator) when using a grab</td><td>Reduction of the drop height when the material is discharged</td></tr>
<tr><td>Total closing of the grab/jaws after material pick-up</td></tr>
<tr><td>Leaving the grab in the hoppers for a sufficient time after discharge</td></tr>
<tr><td rowspan="2">Measures (for the operator) when using a belt conveyor:</td><td>Suitable conveyor speed</td></tr>
<tr><td>Avoiding loading the belt up to its edges.</td></tr>
<tr><td rowspan="2">Measures (for the operator) when using a mechanical shovel:</td><td>Reducing the drop height when the material is discharged</td></tr>
<tr><td>Choosing the right position during discharging into a truck.</td></tr>
<tr><td rowspan="3">Layout and operation of storage sites (by the planner and the operating personnel)</td><td>Reduction of transport distances and adjust the speed of vehicles</td></tr>
<tr><td>Paved roads or roads with hard surfaces</td></tr>
<tr><td>Reduction of wind attack areas</td></tr>
<tr><td colspan="2">Loading and unloading in a closed building</td></tr>
<tr><td colspan="2">Optimised grabs</td></tr>
<tr><td rowspan="8">Technical (techniques which prevent dust formation</td><td colspan="2">Use of closed conveyors (e.g. tube belt conveyors, screw conveyors)</td></tr>
<tr><td colspan="2">Conveyor belt without support pulleys, conventional conveyor belts</td></tr>
<tr><td colspan="2">Transfer chutes</td></tr>
<tr><td colspan="2">Minimising speed of descent and minimisation of free fall heights (e.g. cascade hoppers)</td></tr>
<tr><td colspan="2">Use of dust barriers on dump pits and hoppers</td></tr>
<tr><td colspan="2">Low dust bunker</td></tr>
<tr><td colspan="2">Chassis of vehicles with round tops</td></tr>
</table>

Table 4. *(continued from previous page).*

Category	Type	Techniques
Secondary	Abatement techniques	Screens for open conveyor belts
		Housing or covering of the emission sources
		Applying covers, aprons or cones on fill tubes
		Extraction systems
		Filter systems for pneumatic conveyors
		Dump pits with suction equipment, housing and dust barriers
		Optimised discharge hoppers (in ports)
		The techniques of water spraying/water curtains and jet spraying
		Cleaning conveyor belts
		Fitting trucks with mechanical/hydraulic flaps
		Cleaning of roads
		Cleaning of vehicle tyres

Table 5 shows the efficiencies quantified for some mitigation measures (Environment Australia, 2001; US-EPA, 1995; Orleman and Kalman, 1983).

Table 5. *PM emissions reduction for different operations and implemented mitigation measures.*

Operation	Mitigation measure	Emission PM reduction (%)
Traffic on unpaved road	Watering (>2 litres/m^2/h)	75
	Paving	90
	Paving and dry cleaning	97
	Paving and wet cleaning	99.4
Traffic on paved road	Dry cleaning	70
	Watering	80
	Wet cleaning	94
Handling	Water spraying of piles	50
	Enclosure	70
	Partial enclosure and use of bag filters	83
	Enclosure and use of bag filters	99
Operations performed with dusty materials	Enclosure	70
	Partial enclosure and use of bag filters	83
	Enclosure and use of bag filters	99
Wind resuspension	Windbreaks	30
	Water spraying to keep piles wet	50

In the case of the ceramic industry, experimental studies (Monfort et. al., 2011) were used to obtain PM abatement efficiencies (see Table 6).

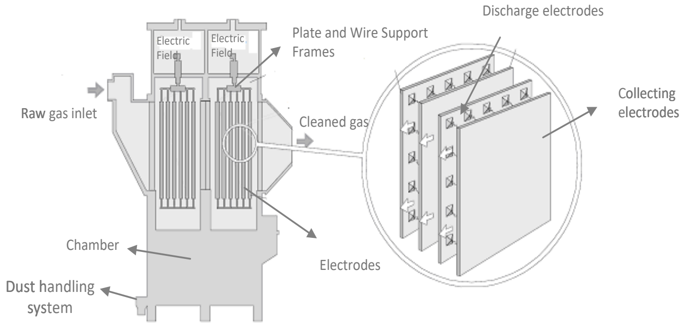
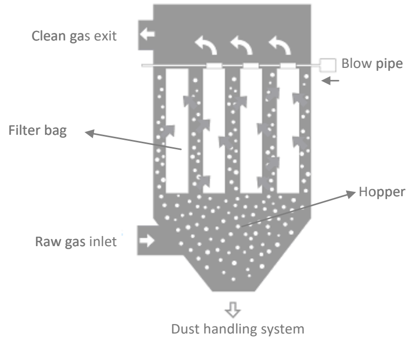
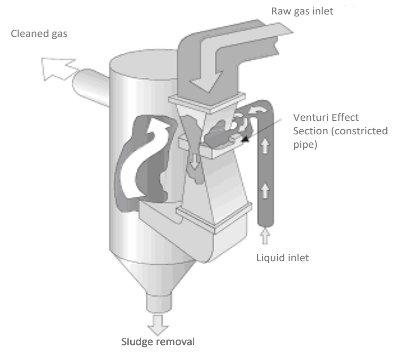
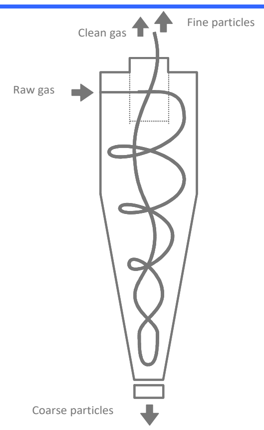
Table 6. *PM10 reduction by different mitigation measures and corresponding technological scenarios.*

Implemented mitigation techniques	Technological scenario and PM efficiency (%)
Reduction of fugitive dust emissions by using a combination of the following techniques: Measures for dusty operations Bulk storage area measures Measures for dusty materials transport	Enclosed facilities and paved areas: >95% Semi-enclosed facilities and paved areas: 75–80% Open facilities with very few preventive measures: 25–50%

2.1.2. ***BATs for channelled PM emissions***

Channelled PM emissions do not have a horizontal BREF. Tables 7 to 12 present the selected BATs identified from the specific industrial BREFs (Table 2) considered in the present technical guide.

Table 7. BATs for channelled emissions. Source: *Source: eippcb.jrc.ec.europa.eu*

BATs for channelled emissions	Schematic view of the BATs
ESP. Electrostatic precipitator	
FF. Fabric filter	
WS. Wet scrubber	
CYs. Centrifugal separators / cyclones	

Thermal power stations and other contributing installations

Table 8. *BATs, Associated Emission Levels (AELs) and efficiency for dedusting off-gases from coal- and lignite-fired combustion plants, depending on the plant capacity (MW).*

Capacity (MW)	Combustion technique	BATs for reaching associated PM emission levels	BAT-associated PM levels (mg/Nm^3)*		Efficiency (%)
			New plants	Existing plants	
50–100	Pulverised combustion	ESP or FF	5–20 mg/Nm^3	5–30 mg/Nm^3	The efficiency associated with an: - ESP is 99.5 % or higher - FF is 99.95 % or higher
	Circulating fluidised bed combustion				
100–300	Pulverised combustion	ESP or FF (in combination with wet flue-gas desulphurisation, flue-gas desulphurisation by using a spray dryer or by dry sorbent injection)	5–20 mg/Nm^3	5–25 mg/Nm^3	
	Circulating fluidised bed combustion	ESP or FF	5–20 mg/Nm^3	5–25 mg/Nm^3	
>300	Pulverised combustion	ESP or FF (in combination with wet flue-gas desulphurisation)	5–10 mg/Nm^3	5–20 mg/Nm^3	
	Circulating fluidised bed combustion	ESP or FF	5–20 mg/Nm^3	5–20 mg/Nm^3	

*Values given in concentrations for high temperature process stages (hot emissions) apply under the following standard conditions (dry gas, temperature of 273.15 K, pressure of 101.3 kPa) and 6% oxygen by volume.

Production of pig iron or steel including continuous casting & metal ore (including sulphide ore) roasting or sintering installations

Table 9. *BATs, Associated Emission Levels (AELs) and efficiency for dedusting off-gases from production of pig iron or steel plants.*

<table>
<tr><th>Activities</th><th colspan="2">BATs for reaching associated PM emission levels</th><th>BAT-associated PM levels (mg/Nm^3)*</th><th>Efficiency (%)</th></tr>
<tr><td rowspan="4">Sinter Plants</td><td colspan="2" rowspan="2">Primary emissions from sinter strand waste gas:
- FFs
- Advanced ESPs (when FFs are not applicable)</td><td>FF: <1 – 15 mg/Nm^3</td><td>FF: >98.5%</td></tr>
<tr><td>ESP: <20– 40 mg/Nm^3</td><td>ESP: >95% ~99%</td></tr>
<tr><td colspan="2" rowspan="2">Secondary emissions from sinter strand discharge, sinter crushing, cooling, screening and conveyor transfer points:
- Hooding and/or enclosure
- ESPs or FFs.</td><td>FF: <10 mg/Nm^3</td><td>FF: >98.5%</td></tr>
<tr><td>ESP: <30 mg/Nm^3</td><td>ESP: >95% ~99%</td></tr>
<tr><td rowspan="2">Pelletisation Plants</td><td rowspan="2">ESPs, FFs and WSs</td><td>For crushing, grinding and drying</td><td><20 mg/Nm^3</td><td rowspan="2">ESP: >95% ~99%
FF: >98.5%
WSs no efficiency data available</td></tr>
<tr><td>Other process steps or gases treated together</td><td><10 – 15 mg/Nm^3</td></tr>
<tr><td rowspan="4">Coke Oven Plants</td><td colspan="2">Coal grinding plants: enclosure devices, efficient extraction and dry dedusting systems.</td><td><10 – 20 mg/Nm^3</td><td rowspan="4">ESP: >95% ~99%
FF: >98.5%</td></tr>
<tr><td colspan="2">Charge coke oven chambers: efficient extraction and FFs.</td><td><50 mg/Nm^3</td></tr>
<tr><td colspan="2">Coke dry quenching with heat recovery: FFs.</td><td><20 mg/Nm^3</td></tr>
<tr><td colspan="2">Coke firing:
- Preventing and repairing (new plants) leakage between oven chamber and heating chamber.
- Using desulphurised coke oven gas process gases.</td><td><1 – 20 mg/Nm^3
(the lower range is from one specific plant)</td></tr>
</table>

*Values given in concentrations for high temperature process stages (hot emissions) apply under the following standard conditions (dry gas, temperature of 273.15 K, pressure of 101.3 kPa) and under the following oxygen references: Coke Oven Plants (5% oxygen by volume) and (3% by volume for hot blast stoves by using desulphurised and dedusted surplus coke oven gas, dedusted blast furnace gas, dedusted basic oxygen furnace gas and natural gas, individually or in combination), Blast furnaces (3% oxygen by volume).

Table 9. *(continued from previous page).*

Activities	BATs for reaching associated PM emission levels	BAT-associated PM levels (mg/Nm^3)*	Efficiency (%)
	Coke pushing: - extraction by means of an integrated coke transfer machine equipped with a hood. - using land-based extraction gas treatment with a FFs or other systems, using a one point or a mobile quenching car.	FFs: <10 mg/Nm^3 Other systems: <20 mg/Nm^3	FF: >98.5%
Blast Furnaces	Dry percedusting devices such as: deflectors, dust catchers, CYs and ESPs and subsequent PM abatement such as: hurdle-type scrubbers, Venturi scrubbers, annular gap scrubbers, wet-ESPs and disintegrators.	<10 mg/Nm^3	Not available in BREF Document
Basic oxygen steelmaking and casting	Pre-treatment operations of the melt pig iron (transport, desulfurization, etc.): FFs Recovery of heat gases from the oven after a primary dedusting with ESPs or WSs (existing plants).	Dry systems: 5–30 mg/Nm^3 Wet systems: <50 mg/ Nm^3	Not available in BREF Document
Electric arc furnace steelmaking and casting	Direct gas extraction and doghouse systems (furnaces installed inside buildings) FFs	New plants: <5 mg/Nm^3 Existing plants: <15 mg/Nm^3	>98%

*Values given in concentrations for high temperature process stages (hot emissions) apply under the following standard conditions (dry gas, temperature of 273.15 K, pressure of 101.3 kPa) and under the following oxygen references: Coke Oven Plants (5% oxygen by volume) and (3% by volume for hot blast stoves by using desulphurised and dedusted surplus coke oven gas, dedusted blast furnace gas, dedusted basic oxygen furnace gas and natural gas, individually or in combination), Blast furnaces (3% oxygen by volume).

Manufacture of ceramic products including tiles, bricks, stoneware or porcelain

Table 10. *BATs, Associated Emission Levels (AELs) and efficiency for dedusting off-gases from ceramic installations.*

Stages processes	BATs for reaching associated PM emission levels	BAT-associated PM levels (mg/Nm^3)**	Efficiency %)
Dusty operations	FFs	1–10 mg/Nm^3	Sintered lamellar filters: up to 99.99% FFs: over 98 to 99% depending on the particle size CYs significantly lower efficiency, no efficiency data available Sintered lamellar filters: up to 99.99%
Glazes preparation and glazing	FFs Sintered lamellar filters	1–10 mg/Nm^3	
Spray drying	FF	1–30 mg/Nm^3	
	CYs and high efficiency WSs (existing plants)	1–50 mg/Nm^3	
Drying	Ensure good maintenance	1–20 mg/Nm^3	
Firing	Use of fuels with low ash generation capacity	1–20 mg/Nm^3	
	FF (to treat gaseous pollutants*)		
	Cascade-type packed bed adsorbers[1] (to treat gaseous pollutants*)	<50 mg/Nm^3	

*BATs to reduce acid gaseous emissions are not considered under the scope of the present report.

**Values given in concentrations for high temperature process stages (hot emissions) apply under the following standard conditions (dry gas, temperature of 273.15 K, pressure of 101.3 kPa) and 18% oxygen by volume.

[1] **Cascade-type packed bed adsorbers**: In a cascade-type packed bed adsorber, the reaction between the adsorbent, usually calcium carbonate ($CaCO_3$, limestone) and the pollutants (mainly HF, SO_X and HCl) in the flue-gas takes place in a chamber, in which the adsorbent sinks by gravity and through which the flue gases are passed in counter or crossflow. Increased dust emissions as result of the increase in the dust load arising from the calcium carbonate granules are possible, especially if peeling drums are used.

Refining of mineral oil and gas

Table 11. *BATs, Associated Emission Levels (AELs) and efficiency for dedusting off-gases from mineral oil and gas refineries.*

Processes stages	BATs for reaching associated PM emission levels	BAT-associated PM levels (mg/Nm^3)*	Efficiency (%)
Combustion units	I. Primary or process-related techniques, such as: - Selection or treatment of fuel - Combustion modifications: Optimisation of combustion	Existing units: 5–50 mg/Nm^3 New units< 50 MW: 5–25 mg/Nm^3	ESP: >95% CYs: 80% WSs: 85–95% Combination: >99%
Catalytic cracking process	I. Primary or process-related techniques, such as: - Use of an attrition-resistant catalyst - Use of low sulphur feedstock II. Secondary or end-of-pipe techniques, such as: - ESPs - Multistage CYs - Third stage blowback filter - WSs	Existing units: 10–50 mg/Nm^3 (the lowest end of the range can be achieved with a 4-field ESP) New units: 10–25 mg/Nm^3	3rd stage blowback filter: 30 - >90% Multistage CYs: 80% WSs: 85–95% Combination: >99%
Green coke process	- ESPs - Multistage CYs	10–50 mg/Nm^3 (the lower end of the range can be achieved with a 4-field ESP; when an ESP is not applicable, values of up to 150 mg/Nm^3 may occur)	ESP: <95% Multistage CYs: 80%

*Values given in concentrations for high temperature process stages (hot emissions) apply under the following standard conditions (dry gas, temperature of 273.15 K, pressure of 101.3 kPa) and under the following oxygen references: Combustion units using liquid or gaseous fuels with the exception of gas turbines and engines (3% oxygen by volume), combustion unit using solid fuels (6% oxygen by volume) and catalytic cracking process (regenerator) (3% oxygen by volume).

Production of cement lime and magnesium oxide

Table 12. *BATs, Associated Emission Levels (AELs) and efficiency for dedusting off-gases from cement and lime industry.*

Activities	Processes stages	BATs for reaching associated PM emission levels	BAT-associated PM levels (mg/Nm^3)*	Efficiencies (%)
Cement Industry	All kiln systems	ESPs	<10 – <20 mg/Nm^3	ESPs and FFs: 99% (both depend on particle size) WSs significantly lower efficiency, no efficiency data available HYFs, no efficiency data available
	Clinker coolers		<10 – <20 mg/Nm^3	
	Cement mills		<10 mg/Nm^3	
	All kiln systems	FFs	<5 mg/Nm^3	
	Clinker coolers		<5 mg/Nm^3	
	Mills (raw material, cement, coal mills)		<10 mg/Nm^3	
	All kiln systems, clinker coolers, cement mills	HYFs	<10 – 20 mg/Nm^3	
Lime Industry	All kiln systems, milling plants, subsidiary processes	ESPs	< 10 – < 20 mg/Nm^3	
	All kiln systems milling plants, subsidiary processes	FFs	< 10 – < 20 mg/Nm^3	
	All kiln systems, hydrating plants	WSs	10 – 30 mg/Nm^3	

*Values given in concentrations for high temperature process stages (hot emissions) apply under the following standard conditions (dry gas, temperature of 273.15 K, pressure of 101.3 kPa) and under the following oxygen references: Cement industry (10% oxygen by volume) and lime industry (11% oxygen by volume). In the case of lime industry, for sintered dolime produced by the 'double-pass process', the correction for oxygen does not apply.

Strategic mitigation measures for channelled emissions

In view of the results from the ambient air source apportionment study (action B2) and the technological scenario regarding the degree of BATs implementation (action B5), which were identified for each AIRUSE city, the potential degree of improvement with regard to primary PM channelled emissions is relatively limited. Nevertheless, a potential improvement has been detected, which would only be applicable in certain cases, through the application of the following strategies: updating the PM emission limit values (ELVs) based on the current generic ELVs adopted in the BREFs, and increasing emission control frequency to ensure proper operation of the implemented BATs.

In contrast, the study suggests that there is greater potential for reducing the emissions of gaseous pollutants considered precursors of secondary PM (NOx, SO_2, NH_3, and NMVOCs) and heavy metals, focusing in the latter case on those with higher volatility, because their emission is mainly associated with high-temperature industrial processes. In this sense, a relevant mitigation strategy would be to study in detail the possibility of regulating, as far as possible, emitted exhaust gas temperatures and/or the running temperatures of the cleaning systems.

2.2. WORKS

PM fugitive emissions are relevant at construction sites, a source recognized as of main concern for urban air quality. Currently, it is possible to find several examples of published guidance for the prevention and control of PM emissions at construction sites:

- Guide to air quality assessment in Sacramento County, Sacramento metropolitan Air Quality management District. 2009. CEQA Guide to Air Quality Assessment (www.airquality.org)
- Best practices for the reduction of air emissions from construction and demolition activities. Environment Canada, Transboundary Issues Branco. 2005. (www.bieapfremp.org)
- Regional Government of Styria, Austria. www.feinstaub.steiermark.at. 2006.
- Stäubli, A., Kropf, R. 2004. Air pollution control at construction sites – construction guideline air. Environment in practice. Swiss Agency for the Environment, Forests and Landscape BUWAL, Bern. Download PDF at: www.buwalshop.ch. Code:VU-5024-E
- The control of dust and emissions during construction and demolition. Supplementary planning guidance. Greater London Authority. July 2014. (www.london.gov.uk)
- Air Quality Management's (IAQM) - 2014 Guidance on the Assessment of dust from demolition and construction is a good example to develop a site evaluation. 2014. (www.iaqm.co.uk)

Dust and emissions control measurement

One of the first actions would be to perform a site evaluation in order to develop an appropriate plan for reducing PM. The site evaluation process set out in the Institute of Air Quality Management's (IAQM) - 2014 Guidance on the Assessment of dust from demolition and construction (IAQM Guidance) (Figure 11) - is a good example. In this guidance, a specific method is developed with a special classification of the potential dust emission magnitude that is used as a basis for the required plan. The risk assessment should consider the potential effects of each development phase on the nearest receptors including: the risk of health effects from an increase in exposure to PM10 and PM2.5, annoyance due to the deposition of dust; and harm to the natural environment. The level of risk is based on the scale and nature of the works and the sensitivity of the area, for example, a site would be classified as low, medium or large risk (see Table 13).

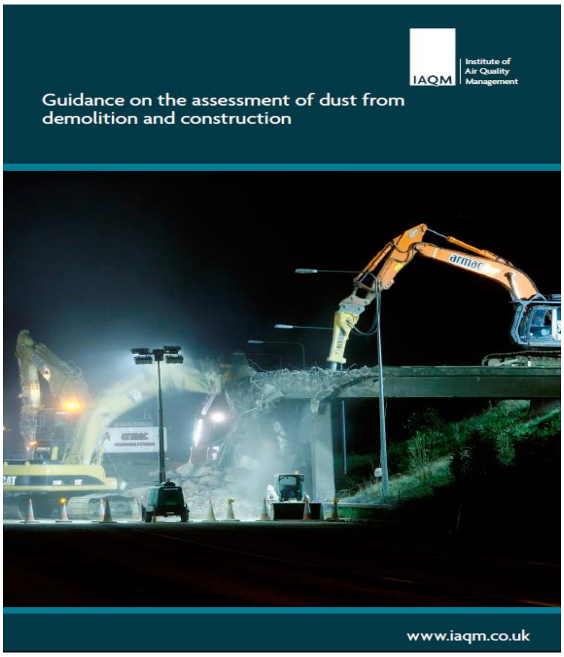


Figure 11. *IAQ Guidance, 2014. Source: www.iaqm.co.uk*

The activities on construction sites identified in the IAQM-Guidance have been divided into four types to reflect their different potential impacts. These are: demolition; earthworks; construction; and trackout. A brief explanation of the activities considered and their potential dust emissions are shown in Table 13.

***Table 13**. Potential dust emission magnitude. Source: IAQM, 2014.*

PHASE	LEVEL OF RISK		
	LOW	MEDIUM	LARGE
Demolition phase	• total volume of building to be demolished <20,000m^3, or • construction material with low potential for dust release (e.g. metal cladding or timber), or • demolition activities <10m above ground demolition during wetter months.	• total volume of building to be demolished 20,000m^3 – 50,000m3, or • potentially dusty construction material, or • demolition activities 10-20m above ground level;	• total volume of building to be demolished >50,000m^3, or • potentially dusty construction material (e.g. concrete), or • on-site crushing and screening, or • demolition activities >20m above ground level;
Earthworks phase	• total site area <2,500m^2, or • soil type with large grain size (e.g. sand), or • <5 heavy earth moving vehicles active at any one time, formation of stockpile enclosures <4m in height, or • total material moved <10,000 tonnes (where known), or earthworks during wetter months.	• total site area 2,500m^2 – 10,000m^2, • moderately dusty soil type (e.g. silt), or • 5–10 heavy earth moving vehicles active at any one time, or • formation of stockpile enclosures 4m – 8m in height, or • total material moved 20,000 tonnes – 100,000 tonnes (where known).	• total site area >10,000m^2, • potentially dusty soil type (e.g. clay, which will be prone to suspension when dry to due small particle size), or • >10 heavy earth moving vehicles active at any one time on site, or • formation of stockpile enclosures >8m in height; • total material moved >100,000 tonnes (where known).
Construction phase	• total building volume <25,000m^3, or • construction material with low potential for dust release (e.g. metal cladding or timber).	• total building volume 25,000m^3 – 100,000m^3, or • potentially dusty construction material (e.g. concrete), or • on-site concrete batching;	• total building volume >100,000m^3, or • piling, or • on site concrete batching; or • sandblasting
Track out phase	• <10 HDV (>3.5t) trips in any one day, • surface material with low potential for dust release, • unpaved road length <50 m.	• 10-50 HDV (>3.5t) outward movements in any one day, • moderately dusty surface material (e.g. high clay content), • unpaved road length 50 m – 100 m (high clay content);	• >50 HDV (>3.5t) outward movements in any one day, • potentially dusty surface material (e.g. high clay/silt content), • unpaved road length >100 m;

The present technical guide identifies the activities most likely to produce PM emissions and outlines best practices to prevent or minimise these. To do so, the IAQM Guidance (2014) has been used as reference document. These measures are summarised in Tables 13 to 17, and they are divided according to key construction and demolition stages, site risk and whether they are either highly recommended or desirable

The mitigation measures have also been divided into general measures applicable to all sites (Table 14) and measures specifically applicable to demolition (Table 15), earthworks (Table 16), construction (Table 17) and trackout (Table 18), for consistency with the assessment methodology.

In general, these measures are intended to be effective and deliverable and in-line with best practice to deal with the specific air quality problems facing agglomerations. It should be noted that it is difficult to provide generic guidance, as each site and its location will be different and professional judgement is required.

Table 14. *Mitigation measures for demolition, earthworks, construction and trackout. Source: IAQM Guidance.*

MITIGATION MEASURES	LOW RISK	MEDIUM RISK	HIGH RISK
Site management			
Develop and implement a stakeholder communications plan that includes community engagement before work commences on site.		XX	XX
Develop a Dust Management Plan.		XX	XX
Display the name and contact details of person(s) accountable for air quality pollutant emissions and dust issues on the site boundary.	XX	XX	XX
Display the head or regional office contact information.	XX	XX	XX
Record and respond to all dust and air quality pollutant emissions complaints.	XX	XX	XX
Make a complaints log available to the local authority when asked.	XX	XX	XX
Carry out regular site inspections to monitor compliance with air quality and dust control procedures, record inspection results	XX	XX	XX
Increase the frequency of site inspections by those accountable for dust and air quality pollutant emissions issues when activities with a high potential to produce dust and emissions and dust are being carried out, and during prolonged dry or windy conditions.	XX	XX	XX
Record any exceptional incidents that cause dust and air quality pollutant emissions, either on or off the site, and the action taken to resolve the situation is recorded in the log book.	XX	XX	XX
Hold regular liaison meetings with other high risk construction sites within 500m of the site boundary, to ensure plans are co-ordinated and dust and particulate matter emissions are minimised.			XX
Preparing and maintaining the site			
Plan site layout: machinery and dust causing activities should be located away from receptors.	XX	XX	XX
Erect solid screens or barriers around dust activities or the site boundary that are, at least, as high as any stockpiles on site.	XX	XX	XX
Fully enclosure site or specific operations where there is a high potential for dust production and the site is active for an extensive period.	X	XX	XX
Install green walls, screens or other green infrastructure to minimise the impact of dust and pollution.		X	X
Avoid site runoff of water or mud.	XX	XX	XX
Keep site fencing, barriers and scaffolding clean using wet methods.	X	XX	XX
Remove materials from site as soon as possible.	X	XX	XX
Cover, seed or fence stockpiles to prevent wind whipping.		XX	XX

Table 14. *(continued from previous page)*

MITIGATION MEASURES	LOW RISK	MEDIUM RISK	HIGH RISK
Carry out regular dust soiling checks of buildings within 100m of site boundary and cleaning to be provided if necessary.		X	XX
Provide showers and ensure a change of shoes and clothes are required before going off-site to reduce transport of dust.			X
Agree monitoring locations with the Local Authority.		XX	XX
Preparing and maintaining the site			
Where possible, commence baseline monitoring at least three months before phase begins.		XX	XX
Put in place real-time dust and air quality pollutant monitors across the site and ensure they are checked regularly.		XX	XX
Operating vehicle/machinery and sustainable travel			
Ensure all on-road vehicles comply with the requirements of the London Low Emission Zone.	XX	XX	XX
Ensure all non-road mobile machinery (NRMM) comply with the standards set within this guidance.	XX	XX	XX
Ensure all vehicles switch off engines when stationary – no idling vehicles.	XX	XX	XX
Avoid the use of diesel or petrol powered generators and use mains electricity or battery powered equipment where possible.	XX	XX	XX
Impose and signpost a maximum-speed-limit of 10mph on surfaced haul routes and work areas (if long haul routes are required these speeds may be increased with suitable additional control measures provided, subject to the approval of the nominated undertaker and with the agreement of the local authority, where appropriate).	X		
Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials.		XX	XX
Implement a Travel Plan that supports and encourages sustainable travel (public transport, cycling, walking, and car-sharing).	XX	XX	XX
Operations			
Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems.	XX	XX	XX
Ensure an adequate water supply on the site for effective dust/particulate matter mitigation (using recycled water where possible).	XX	XX	XX
Use enclosed chutes, conveyors and covered skips.	XX	XX	XX
Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.	XX	XX	XX
Ensure equipment is readily available on site to clean any dry spillages, and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods.		XX	XX
Waste management			
Reuse and recycle waste to reduce dust from waste materials	XX	XX	XX
Avoid bonfires and burning of waste materials.	XX	XX	XX

XX: Highly recommended; X: Desirable

Table 15. *Measures specific to demolition. Source: IAQM Guidance, 2014.*

MITIGATION MEASURE	LOW RISK	MEDIUM RISK	HIGH RISK
Soft strip inside buildings before demolition (retaining walls and windows in the rest of the building where possible, to provide a screen against dust)	X	X	XX
Ensure water suppression is used during demolition operations	XX	XX	XX
Avoid explosive blasting, using appropriate manual or mechanical alternatives	XX	XX	XX
Bag and remove any biological debris or damp down such material before demolition	XX	XX	XX

XX: Highly recommended; X: Desirable

Table 16. *Measures specific to earthworks. Source: IAQM Guidance, 2014.*

MITIGATION MEASURE	LOW RISK	MEDIUM RISK	HIGH RISK
Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces		X	XX
Use Hessian, mulches or trackifiers where it is not possible to re-vegetate or cover with topsoil		X	XX
Only remove secure covers in small areas during work and not all at once		X	XX

XX: Highly recommended; X: Desirable

Table 17. *Measures specific to construction. Source: IAQM Guidance, 2014.*

MITIGATION MEASURE	LOW RISK	MEDIUM RISK	HIGH RISK
Avoid scabbling (roughening of concrete surfaces) if possible	X	X	XX
Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place	X	XX	XX
Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery		X	XX
For smaller supplies of fine powder materials ensure bags are sealed after use and stored appropriately to prevent dust		X	X

XX: Highly recommended; X: Desirable

Table 18. *Measures specific to trackout. Source: IAQM Guidance, 2014.*

MITIGATION MEASURE	LOW RISK	MEDIUM RISK	HIGH RISK
Regularly use a water-assisted dust sweeper on the access and local roads, as necessary, to remove any material tracked out of the site	X	XX	XX
Avoid dry sweeping of large areas	X	XX	XX
Ensure vehicles entering and leaving sites are securely covered to prevent escape of materials during transport	X	XX	XX
Record all inspections of haul routes and any subsequent action in a site log book		XX	XX
Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems and regularly cleaned		XX	XX
Inspect haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable		XX	XX
Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable)	X	XX	XX
Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits		XX	XX
Access gates to be located at least 10m from receptors where possible		XX	XX
Apply dust suppressants to locations where a large volume of vehicles enter and exit the construction site		X	XX

XX: Highly recommended; X: Desirable

2.3. SHIPPING ACTIVITIES

Over 90% of global trade is carried by sea. So in terms of air quality, the emissions generated from shipping activities are of great concern, especially in coastal cities, increasing the pressure on the shipping industry from stakeholders in general, and regulators in particular, to tackle their emissions and improve their energy efficiency.

The document "*Emission Reduction in the Shipping Industry: Regulations, Exposure and Solutions*" (Helfre and Couto, 2013) is a good reference on the main environmental impacts and technologies for complying with the more stringent regulations.

In general, the environmental impact from emissions generated by the shipping industry is due to the combustion of fossil fuel used by a vessel's engines, which produces greenhouse gases (GHGs) as well as non-GHG emissions, such as sulphur oxides (SOx), nitrogen oxides (NOx) and PM.

Of these pollutant emissions it may be noted that the shipping industry is among the top emitters of SOx, accounting for between 5% and 8% of the world's total SOx emissions, especially due to the use of low-quality residual fuels containing high amounts of sulphur and heavy metals. Shipping also accounts for 15% of the world's NOx emissions. It should be noted that the emissions of gaseous pollutants, such as SOx and NOx, are considered important precursors of secondary PM, as evidenced from the results obtained in Action B.2. - PM speciation and source apportionment. Consequently, reducing these pollutant emissions will contribute directly to decreasing PM levels in ambient air, especially in coastal cities with an important shipping activity.

In this sense, with regard to SOx emissions, regulations governing shipping pollutants remain lax and are primarily concerned with the sulphur content of bunker fuel (2005/33EC Directive for EU ports). Such regulations may not always be met, given the general absence of inspections. The most prominent regulators in the shipping industry are the International Maritime Organization (IMO) and the European Union (EU). The regulatory IMO framework sets new and more stringent targets for reducing air emissions from the marine industry. With the 0.1% sulphur target in 2015 for emission control areas, Monitoring of Air Emissions on Ships will play an important role to prove compliance. Some voluntary initiatives have emerged in countries such as Singapore (CNN, 2012) and Hong Kong (Government of Hong Kong, 2013).

In order to comply with the SOx regulations, companies will need to opt for either of the corrective measures shown in Table 18. Low-sulphur fuel is currently considered the best short-term solution for mitigation, with scrubbers being a solution in the medium term, and dual-fuel/ LNG being considered longer-term solutions.

Table 19. *Solutions for reducing non-GHG emissions. Source: Helfre and Couto, 2013.*

Emissions	Solution Type
Non-GHG emissions	Low-sulphur fuel
	Fuel mix (dual-fuel) usually made of natural gas and diesel
	Scrubbers
	Liquefied natural gas (LNG)


Figure 12. *Examples of shipping emissions.*
Source: www.morguefile.com

2.4. PORTS: STORAGE AND HANDLING BULK CARGO ACTIVITIES

Dry bulk cargo is a commodity cargo that is transported unpackaged in large quantities. It refers to granular material, in particulate form, as a mass of relatively small solids, such as grain, coal, or gravel. This cargo is usually dropped or poured, with a spout or shovel bucket, into a bulk carrier ships hold, railroad car, or tanker truck/trailer/semi-trailer body and sometimes stored in specific areas of the port until the upload.

The following activities can generate PM emissions in ports:

- Exhaust emissions (combustion products) from cargo handling equipment, road transport (trucks), rail transport (trains) and ships; and
- PM emissions from storage and handling of bulk cargo, and from truck movements and windblown dust on unpaved roads (Figure 13).

Currently, there is no specific legislation on these activities, although numerous initiatives have been developed by port authorities to improve dry bulk cargo activities and reduce the environmental impact associated with PM emissions. Some of these are as follows:

- Guía de Buenas Prácticas en la Manipulación y Almacenamiento de Graneles Sólidos en Instalaciones Portuaria. Obdulio Serrano. División de Sostenibilidad Subdirección de Innovación. Puertos del Estado. 2015.
- Handling of dry bulk cargoes at facilities in the port of Geelong. GeelongPort.2009.
- Technical pollution prevention guide for dry bulk terminals in the lower Fraser basin. Environment Canada. 1996.
- Green Guide. Towards excellence in port environmental management. ESPO. 2012.

The present section focuses on PM emissions generated from dry bulk solids management. In this sense, from a general point of view and in order to ensure greater PM emissions prevention and efficiency, it is highly recommended to apply the mitigation measures adopted in accordance with a defined protocol previously that should consider different operational measures in the order proposed in Table 20.

Table 20. *Operational measures to be considered in bulk cargo activities management.*

Operational measures	Objective
1 Good operational practices	Defining the best activity management to prevent and avoid PM emissions
2 Good maintenance practices	Ensuring that the equipment works properly and will not adversely affect PM emissions
3 Technical preventive measures	These measures apply to all direct and indirect equipment involved in dry bulk cargo activities, mainly aimed at avoiding spillage
4 Technical complementary measures	These are extra-measures, required when the preventive measures do not provide high PM emissions reduction efficiency
5 Operational functioning with regard to wind	Dry bulk cargo activities are influenced by wind conditions (direction and velocity). Under severe PM emissions conditions such as high wind speed and/or wind directions towards vulnerable areas (residential area), all bulk cargo activities should be ceased

Figure 13. *Examples of handling of dry bulk cargoes. Source: ITC-AICE*

Table 21 shows some real examples of mitigation measures applied in a specific port (Geelong Port, 2009).

Table 21. *Examples of operational measures in Geelong Port.*

Operational activities		Examples
Operating principles		When handling dry bulk cargoes at any shipping facility in the port, users must ensure that discharges of particulate from the facility, including fine dust, are managed in a way that might reasonably be expected not to be detrimental to: a) the life, health and well being of humans; b) life, health and wellbeing of other forms of life, including marine fauna and flora; c) visibility; d) useful life and aesthetic appearance of buildings, structures, property and materials; and e) aesthetic enjoyment and local amenity.
Cargo planning		To prepare an Environmental Management Plan (EMP) prior to the arrival of a particular vessel or in respect of a particular commodity generally. The EMP must include, amongst other things, the intended handling procedures and the environmental management measures that will be adopted by the stevedore
Handling of cargo	Loading and unloading	Cargoes should be released from a grab at a height and a speed that minimises escape of PM from the hopper.
		No cargo may be placed on the wharf deck unless its properties are such that wind blown dust emissions can be managed and any residues can be cleaned off the wharf deck without staining
		The tipping of cargo onto the wharf by trucks should be kept to a minimum
		Grabs should be of a fully closing type to minimise spillage. Grabs that spill excessive quantities of cargo must not be used
		Grabs should be of a fully closing type to minimise spillage. Grabs that spill excessive quantities of cargo must not be used
		The loading / unloading of light cargoes subject to wind blown dust emission (e.g. soybean meal, fish meal, etc.) must cease in the event of winds causing PM to disperse past the facility boundary
Facility cleaning		All spilt cargo must be continually swept up to minimise cargo build up on the wharf and to ensure no offsite emission of particulates occurs during the loading or unloading of dry bulk cargo as well as at the end of the cargo transfer.
Vessel cleaning		All spilt cargo on a vessel must be swept up to minimise cargo build up on the vessel deck and to ensure that no offsite emission of PM occurs during the loading or unloading of dry bulk cargo as well as at the end of the cargo transfer.
Cleaning of local roads		All spillage on local roads arising from the carriage of dry bulk cargo must be cleaned up on a regular basis
Inspections		To carry out random inspections of operations at the facility. An environmental controller will carry out these inspections

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