IAQM

Guidance on Air Quality Monitoring in the Vicinity of Demolition and Construction Sites

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Contents

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About the Institute of Air Quality Management (IAQM): The mission of the Institute of Air Quality Management is to be an authoritative voice by maintaining, enhancing and promoting the highest standards of working practices in the field of air quality and for the professional development of those who undertake this work.

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1. Introduction

1.1 The Institute of Air Quality Management (IAQM) is committed to enhancing the understanding and development of the science behind air quality by promoting knowledge and understanding of best working practices. Membership of IAQM is mainly drawn from practicing air quality professionals working within the fields of air quality science, air quality assessment and air quality management.

1.2 Constructing buildings, roads and other infrastructure can have a substantial, temporary impact on local air quality. The most common impacts are increased particulate matter (PM) concentrations and dust soiling. Depending on the risk of dust effects occurring, monitoring may need to be carried out during both demolition and construction activities to ensure that the applied mitigation measures are effective in controlling dust emissions, and that there are no significant impacts on the surrounding environment.

1.3 This guidance on air quality monitoring in the vicinity of demolition and construction sites has been produced as a result of the voluntary contribution of the members of a Working Group, for which IAQM is very grateful. The Working Group members were:

Chair

Stephen Moorcroft (Air Quality Consultants)

Drafting Sub Group

Hugh Datson, DustScan Ltd

Peter Fleming, TRL

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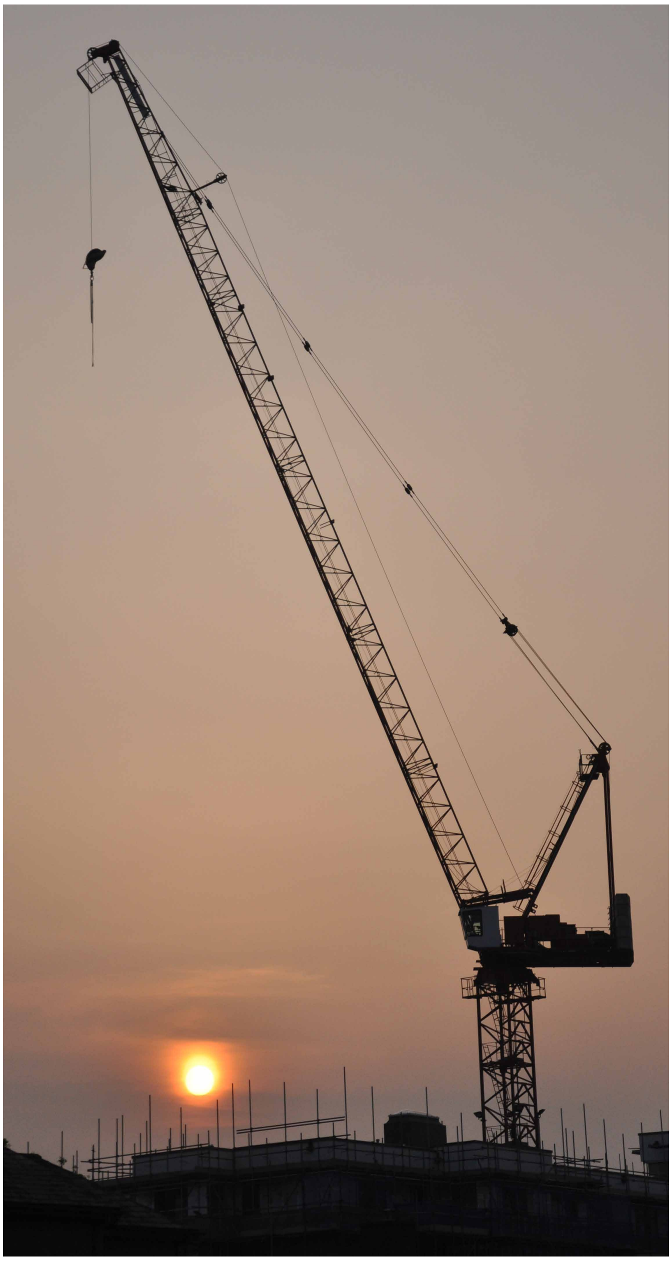
Useful comments were also received from:

Duncan Laxen, Air Quality Consultants

1.4 IAQM is also grateful for the co-operation of the Greater London Authority in developing this guidance.



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2. Background

2.1 Environmental Impact Assessment (EIA) requires the consideration of any impacts associated with the demolition/construction phase of a proposed development. Such considerations are also frequently incorporated into a variety of other air quality assessments. These assessments often need to consider the role of air quality monitoring within the package of mitigation measures that is proposed, and such monitoring proposals are frequently incorporated into s106 legal agreements.

2.2 In 2006, the Greater London Authority (GLA) with the London Councils produced The Control of Dust and Emissions from Construction and Demolition: Best Practice Guidance, with the assistance of BRE and others. This guidance has been widely used to develop measures to be applied to control dust at construction sites, even outside London. The guidance includes information on site monitoring protocols and air quality monitoring techniques, and when these should be applied. The Mayor of London committed to updating this guidance in his 2010 Air Quality Strategy.

2.3 Since the GLA Best Practice Guidance was published, there have been changes to monitoring techniques and considerable experience has been gained in the field from construction monitoring programmes. IAQM has therefore identified the need for new guidance on monitoring protocols and techniques.

2.4 This document provides updated guidance on air quality monitoring in the vicinity of demolition and construction sites. It should be read and applied in conjunction with the Guidance on the Assessment of the Impacts of Construction on Air Quality and the Determination of their Significance that was published by the IAQM in January 2012, and with updated guidance on site evaluation guidelines and mitigation measures that is to be published by the GLA within a Supplementary Planning Guidance.

2.5 This guidance is based on the most up-to-date information available, and draws upon the practical experience of the Working Group members, and other contributors, over many years. The evidence related to the development of site action levels applied to both concentrations of particulate matter and dust deposition rates is, however, very limited. Although substantial monitoring around construction sites has occurred since the GLA Best Practice Guidance was first published, there has been little or no attempt to pull this information together, and the data are not readily accessible within the public domain. The IAQM encourages local planning authorities to make these data public via the s106 legal agreements that are established, so that appropriate future site action levels can be founded on more robust information.

2.6 This guidance is not intended to be prescriptive with regard to the various monitoring techniques that can be used, and instead aims to highlight the advantages and disadvantages of each, in order to assist in the selection of the most appropriate method. Where reference has been made to commercially-available samplers, this is intended to provide additional guidance on the method and represents no endorsement or recommendation by IAQM.

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3. Methodology

3.1 This IAQM guidance has been developed through an on-going dialogue within the IAQM and a Working Group established to develop draft guidance. Suggestions on what should be in the guidance have been solicited from the Working Group.

3.2 Once consensus within the Working Group had been achieved on the major issues, the guidance was circulated to IAQM members for their comments, and these comments have been taken into consideration, and incorporated as far as was reasonably possible. As such, this document represents a recommended approach to monitoring in the vicinity of construction sites. It was developed through a collaborative process involving the Institute of Air Quality Management's professional membership.

Photo credit: Matt Stoaling (SLR Consulting)

4. Glossary of Terms

AAC% Absolute Area Coverage The "total" dust coverage on the sample surface, determined as pixels having a lower greyscale value than a reference value in a computer-scanned image of a "sticky pad" sample as a % of total area.

Dust Refers to all airborne particulate matter (and is synonymous with the definition of TSP). Within this Guidance the term "dust" is used to define the particles that may give rise to both human health effects and soiling. NB: this is different to the definition of "dust" given in BS 6069 Part 2, which refers to particles <75 µm diameter.

Dust Deposition Rate of dust fallout to a nominally horizontal surface, most usually quantified in terms of mg/m2/day in the nominally vertical plane. Normally associated with measurements conducted using non-directional (deposition) samplers. Dust deposition may also be measured in terms of "dust soiling" (see EAC% and Soiling Units)

Dust Flux The rate of passage of dust on the pathway from emission source to receptor i.e. the horizontal component of wind-blown dust. Normally associated with directional (flux) samplers. Although dust flux may be expressed by the same metric as dust deposition (mg/m^2/day), the two are not directly comparable or interchangeable.

EAC% Effective Area Coverage "Dust soiling " determined by the loss of reflectance using a smoke stain reflectometer, or as a relative difference in greyscale of pixels in a computer-scanned image of a "sticky pad" sample.

PM_{10} Particulate matter suspended in ambient air which passes through a size-selective inlet with a 50% efficiency cut-off at 10 µm aerodynamic diameter.

$PM_{2.5}$ Particulate matter suspended in ambient air which passes through a size-selective inlet with a 50% efficiency cut-off at 2.5 µm aerodynamic diameter.

Receptor Location Locations at which dust emissions from construction activities may have an impact. "Sensitive receptors" are those receptor locations which may be particularly sensitive to dust impacts (e.g. residential properties etc.). "Proxy receptors" are monitoring locations identified to represent sensitive receptors (for reasons of security, access to power etc.).

Site Action Levels Threshold above which further investigation or action is instigated. This may involve a more detailed assessment of the monitoring data to determine the likely contribution of the construction site activities to the threshold exceedence, investigation of site activities and mitigation, or if appropriate cessation of the works.

Soiling Units (su) Determined using a gloss meter as the loss of reflectance at 45° to the surface of a glass microscope slide. It is normal to express this as a "soiling rate", e.g. su/week.

TSP Total Suspended Particulate matter. A term describing the mass of airborne particles in ambient air that is measured without a size-selective inlet. Includes particles across a wide range of sizes.

Photo credit: Matt Stoaling (SLR Consulting)

5. Approaches to Monitoring Dust

5.1 The approach used to devise an air quality monitoring strategy for a specific construction site should be commensurate with the risk category ("negligible", "low risk", "medium risk" or "high risk") assigned to each of the four potential activities (demolition, earthworks, construction and trackout) identified within "STEP 2" of the IAQM Guidance on the Assessment of the Impacts of Construction on Air Quality.

5.2 It is possible that different risk categories may be assigned to different site activities (e.g. "high" risk during demolition, and "low" risk during construction). In addition, on large construction projects, where the work is carried out in distinct phases, different risk categories may also be assigned to these different phases. In such circumstances it may be appropriate to apply different air quality monitoring strategies as the works proceed in each phase or stage of the works, but considerable care will need to be taken to ensure that the appropriate monitoring is carried out at the correct time. For this reason, in many cases, it may be deemed more practical, and precautionary, to assign the highest risk category to the entire period of site works.

Purpose of Air Quality Monitoring

5.3 It is essential to give full and proper consideration to the purpose of monitoring during the construction works before any strategy is finalised. Monitoring may be carried out in order to fulfil a number of objectives :

• To ensure that the construction activities do not give rise to any exceedences of the air quality objectives/limit values for PM_{10} and/or $PM_{2.5}$, or any exceedences of recognised threshold criteria for dust deposition/soiling ;

• To ensure that the agreed mitigation measures to control dust emissions are being applied and are effective;

• To provide an "alert" system with regard to increased emissions of dust, and a trigger for cessation of site works or application of additional abatement controls;

• To provide a body of evidence to support the likely contribution of the site works in the event of complaints; and

• To help to attribute any high levels of dust to specific activities on site in order that appropriate action may be taken.

5.4 These objectives are not mutually exclusive, and in some cases they are complementary; however, it may not be necessary to fulfil all of these objectives, in all situations. Careful consideration of the objectives will assist in devising the appropriate monitoring strategy, including the choice of monitoring method, the number and location of monitoring sites, the duration of monitoring, the requirements for a baseline survey, and whether the monitoring sites should remain in a static position throughout the construction works. In all cases, there should be a "nominated representative" responsible for the dust monitoring surveys, who is a member of the Principal Contractors team.

Qualitative Monitoring Surveys

5.5 At all sites, an inspection for visible dust emissions in the vicinity of the site boundary (internal and external) should be conducted at least once on each working day. The results of this inspection should be clearly recorded.

5.6 Visual monitoring is likely to involve observation of dust deposition onto a surface and dispersion on and off-site. Whilst such observations are necessarily influenced by subjective opinion, the approach is simple to implement, and can be used effectively to minimise problems occurring. The monitoring involves observing both the conditions likely to lead to dust release (weather and nature of construction activity) in addition to the observation of any effects. Visual monitoring for dust will therefore also include perception of the potential for dust release and be associated with procedures likely to be described in a Dust Management Plan (DMP) or Construction Environmental Management Plan (CEMP) for the site. Observations should always be recorded in a site log.

Monitoring for conditions likely to increase the risk of dust release

5.7 There are obvious visual signs that a site will be operating at an increased risk of dust release. These signs will be related to:

• Weather (i.e. dry periods with higher wind speeds); and
• Site operations (i.e. activities with increased potential for dust release).

5.8 When it is clear that these conditions are occurring, the nominated representative should increase the frequency of visual assessments of dust release and monitoring of any visible surface soiling (see below). This is particularly the case if the prevailing wind is in a direction towards sensitive receptors.

Visual assessment of any dust release

5.9 In its most basic form, this assessment will simply involve the nominated representative surveying the site for evidence of dust release. This may include, for example, observing the movement of vehicles, stockpiling and demolition. It should

Box 1: Directional or deposited dust monitoring – which approach to take?

In theory, passive (unpowered) dust monitoring is quite straightforward. The common methods are used to sample directional dust (i.e. dust flux) or deposited dust (i.e. dust fall). The instruments are generally quite simple to install and operate. The samplers don't usually require a power source and can generally be left unattended for days, or even weeks, between servicing. But their apparent simplicity can disguise an important consideration: what method to use, where and why?

There is a range of passive directional and deposited dust sampling methods. No method is perfect and all have advantages and disadvantages. It is important to appreciate some of the key differences between them and their suitability for the task when recommending compliance values, designing dust management and monitoring schemes, or evaluating data.

Essentially, dust flux represents the horizontal passage of dust past a point (e.g. between source and receptor) while dust in deposition represents the vertical passage of dust to a surface (e.g. dust fall at a receptor). Accordingly, a directional (flux) gauge cannot automatically be used to show what the impact could be at an off-site receptor, whilst a deposition gauge cannot automatically be used to show where the dust at a receptor originated from. A directional gauge can be used to indicate the potential source, or sources, of dust (i.e. whose dust is it?), whilst a depositional gauge can be used to indicate its accumulation (i.e. how much is there?).

Many operators recognise the importance of measuring dust emissions from construction and demolition sites. Where appropriate, the site operator will pay for (or contribute to the cost of) a dust monitoring programme. However, it can be difficult to justify provision of passive dust monitoring equipment beyond the site boundary especially if there is a risk that it cannot realistically be used to discriminate between dust from the site in question and from other sources (e.g. roads, arable farmland, industrial premises or other construction and demolition sites) or where there is a risk of tampering or interference with it. Consequently, there is a potential paradox in developing effective dust monitoring programmes for construction and demolition sites: how to measure, and properly attribute, dust impacts from a site upon the community beyond?

At some sites, the boundary is so close to adjacent receptors that, for all intents and purposes, any dust monitoring method on it can be effective. In such cases, the site boundary can be considered a receptor in its own right – a proxy for an off-site receptor. But at other sites, the choice of sampling equipment, and the setting of appropriate compliance values, is much more critical and requires careful consideration.

be immediately obvious if such operations are leading to the release of dust emissions and the size and frequency of such releases. Under such circumstances the nominated representative may need to undertake further mitigation as defined in the DMP or CEMP for the site. This approach is well-suited for identifying the occurrence of short-lived (acute) dust events and allowing immediate action to prevent further releases.

Monitoring of any visible surface soiling

5.10 There are likely to be many surfaces on (and around) the boundary of a construction or demolition site where it should be obvious whether dust is being generated at a level where it is leading to visible surface soiling. These may include, but are not limited to:

- Car bonnets and roofs;
- Windowsills; and
- Street 'furniture' (such as lampposts and traffic bollards).

5.11 Where such visual inspections are carried out, consideration will need to be given to the periods of time over which dust can accumulate, and whether the surfaces were likely to have been clean before the construction activities started.

Air Quality Monitoring and Risk Assessment

5.12 For negligible and low risk category sites, it should not normally be necessary to undertake any air quality monitoring, although in some circumstances it may be applicable to undertake occasional surveys (e.g. for TSP or for PM_{10} concentrations) using hand-held monitors during the Qualitative Monitoring Surveys as a means of demonstrating the efficacy of site controls.

Box 2: Which PM Concentration Metric Should be Measured?

Some monitoring techniques can only measure one metric (e.g. PM_{10} or $PM_{2.5}$) while others can simultaneously measure several. It is recommended that priority be assigned to the measurement of PM_{10}, as emissions of dust from construction sites are predominantly in the coarser fractions, but where TSP concentrations are also recorded, these may be useful in identifying source contributions.

Monitoring of $PM_{2.5}$ concentrations should not normally be required (but should be reported where available) unless measurements for comparison with the air quality objectives/limit values are required. It is recommended that $PM_{2.5}$ should not be the primary metric.

Photo credit: Matt Stoaling (SLR Consulting)

For medium risk sites, it should normally be adequate to undertake surveys of dust flux over the site boundary, and/or dust deposition/soiling rates around the site at nearby receptors. For high risk sites, it will normally be necessary to supplement the monitoring for medium risk sites with monitoring of ambient particulate matter concentrations (see **Box 1** and **Box 2**).

Air Quality Monitoring Techniques

5.13 There are a wide variety monitoring techniques available to measure both concentrations of airborne particulate matter and dust flux, deposition and soiling rates. These range from "active" (powered) samplers to measure specific dust fractions (e.g. PM_{10}) to simpler "passive" (unpowered) samplers that measure dust flux, dust deposition and soiling. Active dust samplers include sophisticated, automatic analysers that provide real-time, high-resolution measurements of airborne particulate matter concentrations that can be directly compared to the objectives/limit values, and other automatic analysers that measure real-time concentrations of airborne particulate matter that are only indicative in comparison to the objectives/limit values; there are also non-automatic samplers that measure concentrations of airborne particulate matter (see **Box 3**). Passive samplers include a variety of techniques that can be used to quantify dust flux and deposition rates, or provide an indication of dust soiling rates. Some of the most commonly-used techniques are described in more detail in **Appendix 1**. The various advantages and disadvantages of each technique, and the general applicability to construction dust monitoring, is shown in **Table 1**, p15.

5.14 For those monitoring techniques that require laboratory analysis of samples, this should be conducted by a laboratory that has appropriate (e.g. UKAS) accreditation for the tests (assuming such accredited tests are available).

Selection of Monitoring Techniques

5.15 It is not the purpose of this guidance to be prescriptive in the selection of specific samplers or analysers, rather to provide guidance on the factors that should be taken into account in choosing an appropriate technique that will meet the defined objectives.

5.16 The important questions that need to be asked in selecting the appropriate monitoring technique are:

• Is there a requirement to carry out measurements that can be directly compared with the objectives/limit values? If so, a technique that provides "reference equivalent" concentrations will usually be needed (see **Box 3** and **Table 1**, p15). Indicative instruments (as described in **Box 3** and **Table 1**, p15) may be suitable for demonstrating that the objectives/limit values are not being exceeded, where measured levels are well below the criteria, but it is not possible to determine a threshold for this;

• Is there a requirement to carry out real-time monitoring of PM concentrations? If so, an automatic analyser will be required;

• Is there access to electrical power and secure sites? Suitable arrangements to provide additional power and security may be required; and

• Are there reliable meteorological (wind speed and direction) data available that are characteristic of the site? It may be necessary to set up a local meteorological station at the site.

Box 3: Certification of Analysers and Samplers for the Measurement of Ambient PM Concentrations

A number of analysers and samplers (both automatic and non-automatic) for the measurement of suspended Particulate Matter (PM_{10} and $PM_{2.5}$) have been tested for equivalence to the European reference samplers defined in EN12341 and EN14907 (specified as the reference methods in EC Directive 2008/50/EC).

Instruments that are able to comply with the Data Quality Objectives as defined in the Directive are often described as being "reference equivalent". Such instruments are capable of reporting concentrations that can be directly compared with the objectives/limit values. A list of such reference-equivalent instruments that have been tested by Defra can be found at http://uk-air.defra.gov.uk/networks/monitoring-methods?view=pm-equivalence. Type approval of PM instruments has also been carried out under the Environment Agency's MCERTS scheme for Continuous Ambient Air Monitoring Systems (CAMS) This mirrors the equivalence testing carried out by Defra, and for the purpose of this Guidance can be considered identical. A list of MCERTS type-approved PM instruments can be found at http://www.siraenvironmental.com/UserDocs/mcerts/MCERTSCertifiedProductsCAMS.pdf.

"Indicative Instruments" are also defined under the Agency's MCERTS scheme. These instruments carry a higher level of uncertainty than reference-equivalent analysers, and they cannot report concentrations for strict comparison with the objectives/limit values. A list of indicative instruments can be found at the above SIRA website.

Baseline Monitoring

5.17 A period of baseline monitoring prior to the start of construction activities (including any demolition or site clearance works) can often be beneficial. This allows existing conditions to be defined more accurately, and can assist with the setting or interpretation of "trigger thresholds". The longer the period of baseline monitoring, the more robust the data will be. Where baseline monitoring is deemed necessary, it will normally be necessary to undertake baseline monitoring for a minimum period of three months, but careful consideration should be given to seasonal variations; for example, a period of baseline monitoring carried out for three months during a wet, winter period, is unlikely to provide a robust baseline for construction activities carried out during a subsequent hot, dry summer. Under such circumstances, the applicability of baseline monitoring will need to be carefully considered and justified. Where baseline monitoring is conducted, it should be carried out using the same techniques and same site locations as identified for the main study.

5.18 In some situations, baseline monitoring may not be required, e.g. in some urban areas where there is a large existing body of monitoring data (and where these sites are expected to continue to operate throughout the duration of the construction works). In other situations it may not be practicable to carry out baseline monitoring, e.g. if the risk assessment determines that monitoring need only be carried out during a short-duration activity of the works (such as demolition, which may only extend over several weeks).

5.19 In circumstances where monitoring is only required for the later stages of the construction works (e.g. the demolition and earthworks activities are classified as "low risk", while the construction activities are classified as "high risk") the baseline monitoring will need to be undertaken before any site works commence.

Selection of Monitoring Locations

5.20 In the selection of monitoring locations, a number of issues need to be taken into account, including a decision on the number of sites that are to be established, whether they are to remain in a permanent position throughout the entire construction works, and whether monitoring is required for direct comparison with the objectives/limit values. There are a number of practical issues that also must be considered, such as the availability of electrical power, access to the monitoring sites, and security.

5.21 Care needs to be taken with regard to the microenvironment in positioning of samplers. For example, sampler inlets should be located in a clear, unobstructed position, and some metres away from any large structures (such as walls of buildings) that might interrupt airflow; immediately above should be open to the sky (free in an arc of at least 270°), with no overhanging trees or other structures. To measure airborne dust concentrations, the sampler head should ideally be located between 1.5 to 4m above ground level as suggested in the 2008 Ambient Air Quality Directive (2008/50/EC).

5.22 In most circumstances, the principal aim of monitoring will be to ensure that the agreed mitigation measures are being effectively applied, and that impacts upon the local community are minimised. In such circumstances, monitoring at, or close to, the site boundary is recommended as this will record the highest dust emissions. It is also usually more convenient (for reasons of power supply, security and access) to locate the sampling equipment at the construction site boundary.

5.23 Where monitoring is required to measure compliance with the air quality objectives, it is essential that a "reference equivalent" method be used (see **Box 3**, p11; **Table 1,** p15; and **para 5.17**). Under such circumstances, it will also be more appropriate to site the monitoring station(s) close to the sensitive receptors (where the air quality objectives/limit values apply) rather than directly at the site fenceline. Potential contributions from other (non-site) dust sources (such as roads or other dusty activities in the area) should be taken into account as it is important that responsibility for the exceedence of trigger values (or objective/limit values) is allocated appropriately.

5.24 The number of monitoring sites that can be practically established will normally be influenced by the technique that is to be used. Where monitoring of PM concentrations is to be carried out, a minimum of two sampling sites, one upwind and one downwind of the construction site, in relation to the prevailing wind, should be established; this allows analyses of source contributions to be carried out if necessary (e.g. when trigger thresholds are exceeded) particularly if wind speed and direction data are available, and also allows for coverage during variable weather conditions. Other considerations include the proximity of the closest sensitive receptors to the site boundary, and additional sites may be required to ensure there is adequate coverage over all meteorological conditions. In some circumstances it can also be useful to establish additional sites in the downwind direction from the construction site, along a transect. Data from these additional sites are useful in assigning source contributions (as the contribution of site dust emissions will fall off with increasing distance from the site boundary).

5.25 Where local meteorological data are not readily available, consideration should be given to installing appropriate wind speed and direction sensors at the site. Care should be taken to ensure that the sensors have a clear and unobstructed air flow around them.

5.26 Where monitoring for dust deposition or dust soiling rates is conducted, a minimum of two sites (upwind and downwind of the site, in relation to the prevailing wind) should be established, but it is always useful to establish additional sites around the site boundary (and, as described above along a downwind transect), and (where applicable) to collocate PM analysers and dust deposition gauges. For measurement of dust flux across a site, three samplers may be required in order to enclose the site boundary. As above, the location of the closest sensitive receptors may dictate that additional monitoring sites are included to ensure there is adequate coverage.

5.27 For construction works that extend over a long period, the work may be carried out in different phases (and as discussed above, different risk categories may be assigned). In this case, the monitoring locations may remain unchanged throughout the duration of the works, or may be relocated as the phasing progresses. There are potential advantages and disadvantages with both approaches:

• If the sampling locations are relocated, there may be substantial "downtimes" when the equipment is moved and re-commissioned (particularly when power supply is required), and equipment may potentially be damaged;

• If the sampling locations are not relocated:

1. monitoring during some stages of the works may be some considerable distance from the dust-raising activities and may not provide adequate information on maximum levels at the site boundary, or risks of exceedences at off-site receptors;

2. as phases of the works proceed, new sensitive receptor locations may introduced within close proximity to the revised site boundary.

5.28 It is important that the phasing of the work be adequately considered, and appropriate monitoring strategies be implemented to address the above issues.

Table 1: Summary of advantages and disadvantages of principal dust monitoring techniques

Technique	Advantages	Disadvantages	Applicability for Construction Site Monitoring
Airborne Particulate Matter			
FDMS Analyser	Provides continuous real-time data with 1-hour time resolution. Demonstrated to be equivalent to the reference method (certain versions only) and concentrations can be directly compared with the objectives/limit values.	Very high capital and operational cost. Requires electrical power and site security, careful servicing and maintenance. Experience has demonstrated that considerable care needs to be taken with instrument operation and subsequent data ratification. Individual analysers can only measure PM_{10} or $PM_{2.5}$ depending on size selective inlet.	Unlikely to be applicable in most situations due to cost and stringent operational requirements. May be appropriate for very sensitive sites where demonstration of compliance with the objectives/limit values is critical.
TEOM Analyser	Provides continuous real-time data with ‹1-hour (or even shorter) time resolution. Data (15-min or 1-hr) can be corrected for loss of semi-volatile material using the VCM approach to provide concentrations that can be compared with the objectives/limit values.	Relatively high capital and operational cost. Requires electrical power and site security, careful servicing and maintenance. Individual analysers can only measure PM_{10} or $PM_{2.5}$ depending on size selective inlet.	Unlikely to be applicable in most situations due to cost and operational requirements. May be appropriate for very sensitive sites where demonstration of compliance with the objectives/limit values is desirable. They can be used to identify any periods of unexpectedly high levels of dust.
Beta-attenuation Analysers	Provides continuous real-time data with 1-hour time resolution. Demonstrated to be equivalent to the reference method (some instruments only – see **Box 3**) and concentrations can be directly compared with the objectives/limit values.	Relatively high capital and operational cost. Requires electrical power and site security, careful servicing and maintenance. Individual analysers can only measure PM_{10} or $PM_{2.5}$ depending on size selective inlet.	Unlikely to be applicable in most situations due to cost and operational requirements. May be appropriate for very sensitive sites where demonstration of compliance with the objectives/limit values is critical.

Table 1 Continuation: Summary of advantages and disadvantages of principal dust monitoring techniques.

Technique	Advantages	Disadvantages	Applicability for Construction Site Monitoring
Optical Analysers	Some analysers have the ability to measure several size fractions simultaneously (TSP, PM_{10} and $PM_{2.5}$) and continuously. Relatively lightweight, portable and may be battery operated. Easily attached at site boundary. Relatively low cost (compared to other automatic analysers). Requires little routine servicing and maintenance.	Calculation of PM concentrations is based upon assumptions about particle characteristics which may vary from place to place and from time to time, and may be subject to "artefacts" e.g. interference during foggy conditions. Concentrations only indicative with regard to the objectives/limit values. Requires power and site security.	Analysers can be easily deployed at the site boundary. Real-time monitoring provides information on effectiveness of mitigation measures. Minimal requirement for routine servicing and maintenance beneficial to construction site environments. They can be used to identify any periods of unexpectedly high levels of dust.
Filter-based gravimetric samplers	One sampler has been demonstrated to be equivalent to the reference method (Partisol 2025) and concentrations can be directly compared with the objectives/limit values. Other samplers (e.g. MiniVol) are relatively small and battery powered, and can be easily deployed, but are not reference equivalent.	Considerable care needs to be taken with filter selection, storage and handling, and with QA/QC procedures for filter weighing. High operating costs and intensive resource requirements. Time resolution of measurement limited to 24h, and results not available in real-time.	Unlikely to be applicable in most situations. Although some sampler types are small and battery powered, they do not provide real-time information, and are resource-intensive to operate.
Hand-held samplers	Provide real-time information for several size fractions simultaneously. Can be easily deployed for walk-over surveys to check effectiveness of mitigation measures.	There may be problems with the detection limit of some sampler types. Concentrations only indicative.	Information from hand held samplers useful for application at some low-risk sites, and at other sites to supplement information gathered from permanent monitoring.
Dust Deposition and Soiling			
Deposit gauges (e.g. Frisbee Gauge)	Relatively low cost. Can be easily deployed on site. Requires no electrical power. Can be deployed with other gauges (e.g. sticky pads).	Requires subsequent laboratory analysis of particle mass. Time resolution limited to several weeks or longer, and cannot provide information on short-term events. "Custom and practice" trigger thresholds based on relatively historic data, and no account taken of particle colour. There is no directional component to the measurements.	Provides useful information to supplement monitoring of PM concentrations (at high risk sites). At other sites, provides an indication of potential loss of amenity and effectiveness of mitigation measures, although time resolution of monitoring is a significant disadvantage.

Table 1 Continuation: Summary of advantages and disadvantages of principal dust monitoring techniques.

Technique	Advantages	Disadvantages	Applicability for Construction Site Monitoring
Sticky Pads (horizontal)	Relatively low cost. Can be easily deployed on site. Requires no electrical power. Measurement of EAC takes account of particle colour.	Require subsequent laboratory analysis of EAC% and or AAC%. Time resolution limited to one week (or longer), and cannot provide information on short-term events. There is no directional component to the measurements.	Provides useful information to supplement monitoring of PM concentrations (at high risk sites). At other sites, provides an indication of potential loss of amenity and effectiveness of mitigation measures, although time resolution of monitoring is a disadvantage.
Dust Soiling Gauges (e,g, glass slides)	Relatively low cost. Can be easily deployed at large number of sites. Requires no electrical power.	Require subsequent laboratory analysis of dust soiling rates. Time resolution limited to one week (or longer), and cannot provide information on short-term events. There is no directional component to the measurements.	Provides useful information to supplement monitoring of PM concentrations (at high risk sites). At other sites, provides an indication of potential loss of amenity and effectiveness of mitigation measures, although time resolution of monitoring is a disadvantage.
Dust Flux			
Sticky pads (vertically-orientated)	Relatively low cost. Can be easily deployed on site. Requires no electrical power. Measurement of EAC takes account of particle colour. Can be used to identify intensities of dust flux from different directions and relative source contributions.	Require subsequent laboratory analysis of EAC% and or AAC%. Time resolution limited to one week (or longer), and cannot provide information on short-term events.	Provides very useful information on the likely contributions of dust emissions from different sources and can assist in confirming the effectiveness of mitigation measures.

Operation, Data management and QA/QC Procedures

5.29 It is essential that suitable and adequately documented procedures are applied to all construction site monitoring that is conducted. This should cover the operation of the sampling equipment, data management, and Quality Assurance/Quality Control (QA/QC). These procedures should be undertaken by appropriately qualified and experienced personnel.

5.30 Guidance on the general principles for operation, data management and QA/QC has been provided by Defra, and is not reproduced in full within this document. Specific regard will need to be given to the following:

- Equipment maintenance and servicing should be carried out according to manufacturer's recommendations;
- All site servicing should be carried out by appropriately trained staff, and records should be kept of all service visits;
- Data verification and ratification for PM concentration data should be carried out by appropriately trained and experienced personnel;
- Arrangements for sample handling, storage and transport should be documented and suitable to avoid sample contamination or loss.

Photo credit: Matt Stoaling (SLR Consulting)

Site Action Levels

5.31 It is common practice to set Site Action levels for PM concentrations and/or dust deposition/flux/soiling rates, as a mechanism to ensure that dust mitigation measures are both adequate and are being applied correctly. Unfortunately, whilst there is a large body of monitoring data that has been collected in the vicinity of construction sites, these data are not readily available for analysis, and it is not possible to assess the extent to which the application of existing Site Action Levels have been successful. IAQM strongly encourages local planning authorities to make these data public via the s106 legal agreements that are established, so that appropriate future Site Action Levels can be founded on more robust information.

5.32 In the absence of other information, the Site Action Levels set out below are recommended. These will be reviewed in the future as additional information becomes available.

- PM_{10} Concentrations: 250 $\mu g/m^3$ averaged over a 15-minute period
- Dust Deposition
- Frisbee-type Deposition Gauges: 200 mg/m^2/day, averaged over a 4-week period
- Glass Slide Deposit Gauges: 25 soiling units (su) per week, measured as a running 4-week average
- Sticky Pads: 2-5% EAC/day, measured over a 1-week period
- Dust flux
- Sticky pads where both EAC and AAC are measured over a 1-week period as shown in **Table 2**, p17. This provides an informal prediction of the potential risk of dust nuisance as measured with directional sticky pad samplers. It is suggested that a Site Action Level is set at "High" or "Very High".

Table 2: Site Action Levels for Sticky Pads With Combined EAC/AAC

		AAC: Dust Coverage				
EAC: Dust Soiling		**Level 0** **<80% / interval**	**Level 1** **80-95% / interval**	**Level 2** **95-99% / interval**	**Level 3** **99-100% / interval**	**Level 4** **100% over 45° / interval**
	Level 0 **<0.5%/day**	Very Low	Very Low	Very Low	Low	Medium
	Level 1 **0.5-0.7%/ day**	Low	Low	Low	Medium	High
	Level 2 **0.7-2.0%/ day**	Medium	Medium	Medium	High	High
	Level 3 **2.0-5.0%/ day**	High	High	High	High	Very High
	Level 4 **>5.0%/day**	Very High	Very High	Very High	Very High	Very High

As proposed by Datson (2010) and included in AEA (2011)

Photo credit: Matt Stoaling (SLR Consulting)

Further Reading

AEA (2011). Management, mitigation and monitoring of nuisance dust and PM10 emissions arising from the extractive industries: an overview. Didcott: AEA Technology plc (AEAT/ENV/R3141 Issue 1).

BRE (2003). Controlling particles, vapour and noise pollution from construction sites - set of five Pollution Control Guides. Available to purchase from: http://www.brebookshop.com/details.jsp?id=144548.

Environment Agency (2004). Monitoring of particulate matter in ambient air around waste facilities: Technical Guidance Document (Monitoring) M17 [online]. Available from: http://publications.environment-agency.gov.uk/PDF/GEHO1105BJXU-E-E.pdf.

Environment Agency (2011). Technical Guidance Note (Monitoring) M8: Monitoring Ambient Air [online]. Available from: http://publications.environment-agency.gov.uk/PDF/GEHO0611BTYA-E-E.pdf.

IAQM (2012). Guidance on the Assessment of the Impacts of Construction on Air Quality and the Determination of their Significance [online]. Available from: http://www.iaqm.co.uk/text/guidance/construction_guidance_2012.pdf.

Case study: Barts and London NHS Trust

Background

Barts and the London NHS Trust sought to upgrade their estate through the demolition of existing buildings and subsequent provision of state of the art facilities as provided through a Public Finance Initiative (PFI). The Trust was required to continue operating as normal through the entire duration of the demolition and re-build programme, which was anticipated to take place over 10 years'.

The challenge

Concern was expressed by the Trust in relation to patient care and health during the occurrence of demolition and construction where the propensity for uncontrolled dust releases was high, particular where works were in close proximity to the hospital wards. The aged brick work of some of the estates had additionally highlighted the potential for Aspergillus spore release.

The Solution

Mitigation measures were deployed at the sites which sought to reduce the occurrence of uncontrolled emission releases associated with demolition and construction activities. A monitoring programme was implemented which sought to provide the necessary evidence to the contractor – SKANSKA – that mitigation measures were being effective in their suppressing ability.

The main features of the monitoring protocol are:

It recognises that there is a need to provide evidence throughout the period of demolition and construction work to ensure that levels of dust at the site are no worse than currently exists. This approach acknowledges the urban setting of the Royal London in an existing Air Quality Management Area, where problems in the attainment of air quality objectives are known to exist;

It recognises the need to monitor the likely occurrence of annoyance in and around the site, in respect of larger particles that may be deposited to sensitive locations during the course of construction work;

It recognises the need to monitoring the potential impact on health of the patients located on wards that are maintaining full operation during the course of the re-development of the site;

It recognises the concerns expressed by The Trust in respect of 'other contaminants' likely to be present at site. Notably, the occurrence of Aspergillus spores arising from demolition activity, which forms part of the PM_{10} fraction;

It recognises the need for (almost) real-time information on PM_{10} occurrence at the site;

It recognises the need to undertake simultaneous measurements on wind speed and wind direction to facilitate interpretation of data at the site;

It recognises the need to separate the impacts of secondary formation of particles arising from transportation of wider emissions (such as transboundary European episodes) from those related to the impact of primary emissions (i.e. construction activities) at the site;

It provides a basis on which The Trust can further react to determine any possible danger to patients on operational wards resulting from the possible occurrence of Aspergillus spores arising during periods of demolition.

Stringent Criteria

The adoption of site-specific criteria was based on frequency of occurrence of 15-minute average concentrations derived from 4 months on-site baseline data and the application deviations from the maximum value of 15-minute average data (at 100 µg/m^3) in steps of 10 units for single occurrence and two consecutive occurrences. This was found to be far more stringent that default adopted thresholds of 200 – 250 µg/m^3, and aligned well with the need for additional vigilance in the hospital environs. Analysis sought to identify the potential for thresholds to lead to a cessation of works and subsequent investigations into the reasons for the alert, which would heavily influence the overall programme of works relative to the need for environmental diligence. That is, too many interruptions to the programme arising from alerts and the financial penalties would be too great set against the need to ensure that air quality remained within safe thresholds for assurance to the NHS Trust the patient health was not compromised.

On the basis of the frequency of the following threshold alert values were adopted (inclusive of gravimetric correction):

Early Warning / Lower Threshold: a single occurrence of 15-minute average › 80 µg/m^3

Upper Threshold: two consecutive 15-minute averages ›80 µg/m^3

Further procedures were implemented to identify the separation between locally derived alerts – those directly attributed to the programme – and those that were attributed to regional episodes of PM_{10}, or transboundary European events. In the case of the latter, the programme identified successfully the impacts of forest fires in Russia and also the impacts associated with Saharan dust episodes, both of which were beyond the influence of the contractor and enabled works to continue without interruption, despite alert thresholds being exceeded.

Success

The monitoring provided a successful means of reducing interruptions to works for SKANSKA whilst ensuring concerns of the NHS Trust were addressed. Cessation of works and subsequent investigations identified where mitigation measures had temporarily failed and were able to be corrected. Triggered alerts were additionally used in respect of Aspergillus surveys undertaken when localised dust releases arose.

SKANSKA were successful in winning a number of awards for management of the programme, of which the dust monitoring programme contributed. These included:

City of London Considerate Contractor award 2007

UK Quality in Construction Awards – Corporate Social Responsibility award 2008

The UK Sustainable City Awards – Sustainable Procurement award 2009

The Constructing Excellence UK Awards – Innovation award 2009

City of London Considerate Contractor Environmental Award 2010

The following table provided an analysis of the frequency of occurrence for single events and for two consecutive events:

	Month 1	Month 2	Month 3	Month 4
Number of 15-minute averages above				
›100	0	2	0	8
›90	4	6	1	19
›80	12	9	6	40
›70	23	21	25	71
Number of 2 consecutive 15-minute averages above				
›100	0	1	0	1
›90	1	1	0	3
›80	1	1	1	5
›70	3	4	2	7

Case study: East Parkside, Greenwich

Photo credit: Hugh Datson (DustScan)

Nuisance dust emissions from construction and demolition works are common, with fine particles from these sources capable of being carried long distances from sites, polluting the local environment and affecting the health of local residents, as well as those working on the site.

In addition to legal health and safety requirements, further regulations now require local authorities to work towards achieving national air quality objectives and construction site operators will therefore need to demonstrate that both nuisance dust and fine particle emissions from their sites are adequately controlled and are within acceptable limits.

With this in mind, DustScan Ltd was commissioned by VolkerFitzpatrick Ltd to prepare a dust management and monitoring strategy (DMS) for site redevelopment works at East Parkside, Greenwich. The works were being undertaken for Meridian Delta Ltd (the overall site developer) and comprised reconstruction and provision of infrastructure prior to development of individual plots on a brownfield site on Greenwich Peninsula.

The DMS was prepared after consultation with Greenwich Council's Environmental Protection team and follows construction industry best practice and guidance and Greenwich Council's own Noise and Dust Protocols.

Photo credit: Hugh Datson (DustScan)

Fugitive 'nuisance' dust emissions were monitored at five locations on the site boundary using DustScan DS-100 directional dust gauges. The DS-100 is a passive (i.e. unpowered) dust sampler, featuring a 'sticky cylinder' to sample dust in flux for subsequent quantification. The directional dust monitoring head collects fugitive dust from 360° around the gauge to indicate potential dust sources and pathways.

As recommended by DustScan Ltd, directional dust samples were taken over seven day intervals. At the end of the monitoring intervals, each sampling cylinder is removed and placed in a protective carrying flask and a replacement head fitted. Used sampling heads are sent to DustScan Ltd for computer analysis.

Directional dust was reported at 15° resolution as Absolute Area Coverage (AAC%, the presence of dust irrespective of colour) and Effective Area Coverage (EAC%, the darkness or potential soiling of dust). The dust monitoring results were tabulated and shown as 'directional dust roses' to show the magnitude of AAC% at each monitoring location for each sampling interval.

The directional dust monitoring data can be reviewed in accordance with the London BPG for 'sticky pad' dust monitoring and are summarised in relation to the DustScan AAC% and EAC% 'dust nuisance risk matrix'.

To assess the risk of fugitive dust from the site affecting nearby residents, directional 'arcs of significance' were determined for the site as 'any direction where dust propagation might cross the site boundary'. For this, the dust data was summarised as a 'risk factor' of potential dust nuisance across the site boundary in five levels ranging from 'very low' to 'very high'.

Ongoing dust suppression measures are revised and updated according to site conditions and operations.

Appendix

Summary of Air Quality Monitoring Methods

There is a wide variety of monitoring techniques available to measure both concentrations of airborne particulate matter and dust deposition/soiling rates. Further guidance on monitoring methods and the appropriate QA/QC procedures that should be applied, can be found in Defra Technical Guidance LAQM. TG(09). Some of the most commonly-used techniques are described below:

Airborne Particulate Matter

Concentrations of airborne particulate matter can be carried out using automatic analysers, that provide high-resolution measurements in real-time, or by filter-based gravimetric samplers that normally only provide 24-hour mean concentrations, and require laboratory determination of the particle mass.

Some types of analyser are capable of simultaneously measuring different size fractions of particulate matter; other analysers use a specific, size-selective inlet, and can normally only measure one fraction (although there are dichotomous samplers available) – and, of course, more than one analyser can be deployed. For monitoring around construction sites, consideration should normally be given to measurements of the PM_{10} fraction. Measurements of the Total Suspended Particulate (TSP) fraction may also be useful in identifying source contributions (as dust emissions from demolition and construction activities are predominantly in the coarser fractions).

Automatic samplers: These are capable of providing high-resolution measurements (typically for 15-min or 1-hr averages, although shorter period measurements can be made, and may be useful in source identification). The instruments are based on a number of widely-differing measurement principles. Some instruments have been accredited as equivalent to the European reference sampler, and the concentrations can be compared directly with the air quality objectives/limit values for PM_{10} and $PM_{2.5}$. Other instruments have no such “equivalence status”, and the recorded concentrations can only provide an indication as to whether the objectives/limit values are likely to be exceeded; this is only important where it is necessary to compare the measured concentrations directly against the objectives/limit values. Commonly-available automatic samplers include:

Filter Dynamic Measurement System (FDMS): Based on the TEOM analyser (see below) the FDMS independently measures the volatile component of the air sample. The sample stream passes through the size selective inlet (PM_{10} or $PM_{2.5}$) and then through a drier (to remove water) before entering the TEOM sensor unit where the PM is collected onto a filter and weighed. The analyser samples in this “base cycle” for 6 minutes, during which time there will be losses of semi-volatile particles from the filter. The sample flow then switches so that it passes through a cooled chamber and then through a filter to remove PM from the sample stream; this cooled, scrubbed air is returned to the sensor unit. During the purge cycle (which also runs for 6 minutes), volatile particles continue to evaporate from the sensor unit filter, such that the average PM concentration measured will normally be negative. The FDMS then adjusts the final mass concentration by reference to any mass change recorded in the purge cycle e.g. if a decrease in mass was measured during the purge cycle (which is normally the case) this would be added back to the base cycle measurement recorded. The analyser has been declared as equivalent to the European reference sampler for both PM_{10} and $PM_{2.5}$ measurements.

Tapered Element Oscillating Microbalance (TEOM): The TEOM analyser is based on the principle that the frequency of oscillation of a glass, tapered tube changes by an amount that is directly proportional to the mass of the tube. Thus, any change in mass, due to deposition of particles onto a small filter affixed to one end, will result in a change in the resonant frequency which is proportional to the additional mass. Due to the need to eliminate the effect of changing humidity on the mass measurement, the sample filter is held at 50°C. This results in losses of semi-volatile particles, and the TEOM systematically under-reads PM concentrations when compared with the European reference sampler, and it is necessary to apply a “correction” to the data. A new approach to correcting TEOM data has been introduced involving the Volatile Correction Model (VCM) developed by King’s College. A VCM web portal (http://laqm1.defra.gov.uk/review/tools/vcm.php) is available which allows users to download geographically-specific correction factors to apply to TEOM PM_{10} measurements on either a 1-hour or 24-hour basis. VCM-corrected PM_{10} data can be considered to be “reference equivalent”. It should be noted that $PM_{2.5}$ concentrations measured using the TEOM cannot be corrected in this way.

Beta-attenuation analysers: These devices sample air onto a paper tape, and the reduction in the transmission of beta particles from the start to the end of the sampling period is recorded to determine the PM concentration. These instruments can have both heated or unheated inlets, which perform very differently. The Met-One BAM (unheated) is used by a number of local authorities. For more information on equivalent instruments follow the link in **Box 3** on page 11 of this guidance document.

Optical analysers: There are a number of optical particle monitors that rely on the interaction between airborne particles and visible or infrared laser light. The instruments that utilise light scattering often have the advantage that they can report concentrations for a range of particle sizes (total particles, PM_{10}, $PM_{2.5}$ and PM_1) and they are often portable (or semi-portable) and can be battery-operated; they are also relatively small and lightweight and can be attached to lampposts, fences, etc. The principal disadvantage is that they rely on a range of assumptions to calculate the PM mass concentration, the validity of which may vary both spatially and temporally, and they can only provide measurements that are indicative of exceedences of the objectives/limit values. These optical monitors are often used to identify potential issues surrounding construction works. There are a number of analysers available, such as the Osiris and Topaz, Grimm, and the AQM DM11.

Non-automatic samplers: These samplers, often referred to as "gravimetric samplers" are based on drawing air through a filter for a known length of time, and at a known flow rate; the filter is then weighed in the laboratory to determine the particle mass. Although simple in theory, weighing of filters is fraught with difficulties and particular care needs to be taken to the handling and transport of the filters, and the pre- and post-sampling conditioning. The European reference sampler is a filter-based gravimetric sampler; the Partisol 2025 has also been demonstrated to be "reference equivalent". There are a variety of other samplers that are used, including the MiniVol portable air sampler. These samplers are only able to report PM concentrations averaged over a 24-hour period, and there is a delay between the sampling period and the availability of the result. For these reasons, they are not commonly used for monitoring in the vicinity of construction sites.

Hand-held monitors: A wide variety of portable hand-held monitors is available for measuring concentrations of ambient particulate matter. Many of these are designed for sampling in industrial environments, and are often aimed at measuring compliance with the much higher Workplace Exposure Limits set by HSE. Nonetheless, if they have sufficient sensitivity they can be usefully applied in "walk-over" surveys at demolition or construction sites, and used to identify whether mitigation measures are being adequately implemented.

Dust Deposition and Soiling: Measurements of dust deposition, dust flux or dust soiling rates can be used to assess the potential for loss of amenity in the local community. Such measurements can also be used to determine whether the dust mitigation measures are being applied effectively. It is important to note that dust deposition and dust flux are different. A deposit gauge is used to measure dust deposition; a directional gauge is used to measure dust flux. Whilst dust deposition and dust flux may be expressed by the same metric (e.g. mg/m^2/day), it is not possible to covert measurements of dust flux to dust deposition (e.g. by adding the directional components together).

Dust deposition: This can be measured using a variety of techniques that collect the deposited dust into containers or onto "sticky pads". The "Frisbee gauge" is one of the most widely used deposit gauges, and its use has superseded that of the original "British Standard" gauge. Dust is collected onto a "Frisbee-type" collector; the dust is then washed into a bottle. The mass of the collected material is then determined by subsequent laboratory analysis and the results expressed in terms of mg/m^2/day. Sampling is normally carried out over a period of several weeks to a month. The Frisbee Gauge can also be adapted to include a vertically-mounted cylindrical sticky pad to permit directional sampling (see below).

Sticky pad gauges are founded on the principle that the deposited dust becomes trapped onto the surface. Instead of weighing the mass of the collected dust, the analysis is carried out optically to determine the Effective Area Coverage (EAC%), which takes account of the "darkness" of the particles and the discoloration caused, or the Absolute Area Coverage (AAC%) which records the percentage dust coverage of the surface, regardless of the colour.

Dust flux: Sticky pads configured in the form of a cylinder provide a directional component of both EAC and AAC. Some samplers allow configurations of both horizontal (dust deposition) and cylindrical (dust flux) to be used, and in conjunction with a PM10 sampler if required. Samples are normally collected over a one-week period. The BS 1747 Part 5 "CERL" directional gauge is no longer recommended due to its recognised limitations.

Dust soiling: Measurements of dust soiling rates can be carried out using the "glass slide deposit gauge". Glass slide deposit gauges consist of cleaned glass microscope slides that are left exposed for one week at a time. The reduction in surface gloss when measured by a gloss-meter (Rendel Dust Meter) is proportional to the amount of dust soiling on the slide after exposure. The intention is that the slides act as surrogates for surfaces where soiling may cause a nuisance, such as windowsills and car paintwork . The results are presented as a soiling rate, expressed in soiling units averaged over one week (su/week), rounded to the nearest whole number. One soiling unit is equivalent to a one percent reduction in reflectance.

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