|  |
| --- |
| EuropeAid/129522/C/SER/Multi  Contract number 2010/232-231 |
|  |
| Air Quality Governance in the ENPI East Countries |
| Guidelines for designing of National Ambient Air Monitoring Network in compliance with EU requirements |
| Report Date: July 11, 2014 |
|  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Version | Date | Description | Prepared by | Reviewed by |
| 1 | 11 July 2014 | Task 1.2.5. Developed recommendations on location of stationary sampling points | Caucasus Environmental NGO Network (CENN) | Aiga Kāla, Key Expert 2 – Air Quality Assessment and Management |

Summary

Project Title: Air Quality Governance in the ENPI East Countries

Contract Number: 2010/232-231

Country: Armenia, Azerbaijan, Belarus, Georgia, Moldova, Russian federation, Ukraine

**Lead Contractor**

Name MWH

Address Nysdam Office Park

Avenue Reine Astrid, 92

B-1310 La Hulpe

Belgium

Tel. number +32 2 6552230

Fax number +32 2 6552280

Contact person Aïda Yassine, Project Manager

**Signature**

Date of report: 11 July 2014

Report was developed by CENN - Caucasus Environmental NGO Network

NAME OF KE Expert: Aiga Kāla, Key Expert 2 – Air Quality Assessment and Management

**Contents**

[List of Abbreviations and Acronyms 5](#_Toc392598867)

[1. INTRODUCTION 7](#_Toc392598868)

[2. Objectives of Air Quality Directives in EU Member States 8](#_Toc392598869)

[2.1. Exposure to Air Pollution and Health Impacts 8](#_Toc392598870)

[2.2. Main terms within both the Clean Air for Europe Directive (2008/50/EC) and Fourth Air Quality Daughter Directive (2004/107/EC) 8](#_Toc392598871)

[2.3. Limit values for protection of human health, vegetation and eco-systems 10](#_Toc392598872)

[2.4. Upper and lower assessment thresholds 13](#_Toc392598873)

[2.5. Establishment of zones and agglomerations for monitoring and assessment of the air quality 13](#_Toc392598874)

[2.6. Criteria for classifying sampling points for assessments of air quality 14](#_Toc392598875)

[2.7. Macro-scale siting of sampling points 15](#_Toc392598876)

[2.8. Micro-scale siting of sampling points 17](#_Toc392598877)

[2.9. Minimum number of sampling points for each relevant pollutant specified in both Directives 18](#_Toc392598878)

[2.10. Minimum number of point source sampling points 22](#_Toc392598879)

[2.11. Compliance with the PM2.5 Exposure Reduction Target 22](#_Toc392598880)

[2.12. Protection of Vegetation 22](#_Toc392598881)

[2.13. Measurements at Rural Background Locations 22](#_Toc392598882)

[2.14. Data quality objectives for ambient air quality assessment in EU directives 23](#_Toc392598883)

[2.15. Quality assurance for ambient air quality assessment: data validation 25](#_Toc392598884)

[2.16. Reference methods for assessment of concentrations and standardization 26](#_Toc392598885)

[2.17. EU Requirements for Reference Methods 27](#_Toc392598886)

[2.18. Type Approval of Analysers for National Networks 28](#_Toc392598887)

[2.19. Relative Uncertainty of Analyser measurements 29](#_Toc392598888)

[2.20. Reporting and communication 29](#_Toc392598889)

[3. Organisation of air quality monitoring systems in Europe 31](#_Toc392598890)

[3.1. State of air quality monitoring in Europe 31](#_Toc392598891)

[3.2. Temporal Coverage 33](#_Toc392598892)

[3.3. Spatial Coverage 33](#_Toc392598893)

[3.4. Methods Evaluation 37](#_Toc392598894)

[3.5. Data Availability in European Networks 40](#_Toc392598895)

[3.6. Use of Models in the Air Quality Assessment 41](#_Toc392598896)

[3.7. Reporting 41](#_Toc392598897)

# List of Abbreviations and Acronyms

|  |  |
| --- | --- |
| Accumulated Ozone Exposure over a threshold of 40 Parts Per Billion | AOT40 |
| Air quality | AQ |
| Ammonia | NH3 |
| Arsenic | As |
| Automatic Urban and Rural Network | AURN |
| Benzene, toluene, ethylbenzene, xylenes | BTEX |
| Benzo(a)pyrene | B(a)P |
| Cadmium | Cd |
| Calcium ion | Ca2+ |
| Carbon Monoxide | CO |
| Central European Time | CET |
| Clean air for Europe (refers to Directive 2008/50/EC) | CAFE |
| Centre EC Joint Research Centre Air Quality Reference Laboratories | JRC- AQUILA |
| Environmental Protection Agency | EPA |
| European Commission | EC |
| European Committee for Standardization | CEN |
| European Economic Community | EEC |
| European Monitoring and Evaluation Programme / Core Inventory of Air Emissions | EMEP/CORINAIR |
| European Neighbourhood and Partnership Instrument | ENPI |
| European Union | EU |
| Gov Air Quality Governance | Air-Q-GOV |
| Hydrogen sulphide | H2S |
| International Organization for Standardization | ISO |
| Key Expert | KE |
| Lead | Pb |
| Magnesium ion | Mg2+ |
| Mercury | Hg |
| Micrograms per cubic metre | µg/m3 |
| Nanograms per cubic metre | ng/m3 |
| Nickel | Ni |
| Nitrogen dioxide | NO2 |
| Nitrogen oxides | NOx |
| Ozone | O3 |
| Particulate Matters | PM |
| Parts per billion | ppb |
| Polycyclic aromatic hydrocarbons | PAH |
| Quality assurance/Quality control | QA/QC |
| Square kilometre | km2 |
| Square metre | m2 |
| Standard operation procedure | SOP |
| Sulphate ion | SO42– |
| Suspended Particulate Matter | SPM |
| Total Suspended Particulates | TSP |
| Ultra violet | UV |
| United Kingdom | UK |
| Volatile organic compounds | VOC |
| World Health Organization | WHO |

# INTRODUCTION

The purpose of this document is to provide an overview of the current air quality monitoring and assessment systems in Europe. This includes policy, legislative, institutional, instrumental as well as current air quality operations.

The document outlines the essential components within the two principal ambient air quality Directives, 2008 [ambient air quality directive (2008/50/EC)](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF) known as the Clean Air for Europe (CAFE Directive), and the Fourth [Air Quality Daughter Directive (2004/107/EC](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32004L0107:EN:NOT)).

This includes the requirements that EU member states achieve a set of air quality limit values for the protection of human health as well as for the protection of vegetation and ecosystems.

The Directives require member states to assess air quality on a national scale sub-dividing their state into zones and agglomerations. This document outlines the framework behind the establishment of these national monitoring and assessment programmes, where data coverage and assessment method are linked to lower and upper assessment thresholds.

Current resources available in Partner Countries dedicated to ambient air quality monitoring might be insufficient to credibly meet both CAFE Directive and Fourth Daughter Directive requirements. This includes meeting requirements in relation to the number and type of ambient air monitoring stations or data averaging requirements within either the CAFE or Fourth Daughter Directives.

The current document provides guidance for developing a national air quality monitoring system in conformity with the requirements of the EU air quality legislation.

# Objectives of Air Quality Directives in EU Member States

## Exposure to Air Pollution and Health Impacts

Air pollution can have a serious effect on people’s health. Exposure to air pollution can have a long-term effect on health, associated in particular with premature mortality due to cardiopulmonary (heart and lung) effects.

More than 80% of the population in the European Union lives in cities with levels of PM exceeding WHO Air Quality Guidelines.

Long-term exposure to ozone has been recorded as having detrimental effects on the respiratory and cardio respiratory mortality of people with potentially predisposing conditions such as chronic obstructive pulmonary disease, diabetes, congestive heart failure.

Short-term, high pollution episodes can trigger increased admissions to hospital and contribute to the premature death of those people that are more vulnerable to daily changes in levels of air pollutants.

In Europe life expectancy has been estimated to be reduced by almost 9 months through pollution from PM. A strong relationship between long-term ozone exposure and respiratory morbidity has been found where long-term measures of ozone exposure is linked to the onset of asthma in children and increased respiratory symptom effects in asthmatics (EPA, 2012).

Air pollution also has negative impacts on our environment, both in terms of direct effects of pollutants on vegetation, and indirectly through effects on the acid and nutrient status of soils and waters.

Action to manage and improve air quality is largely driven by European (EU) legislation. The 2008 [ambient air quality directive (2008/50/EC)](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF) sets legally binding limits for concentrations in outdoor air of major air pollutants that impact public health such as particulate matter (PM10 and PM2.5) and nitrogen dioxide (NO2) as well as pollutants which have impacts upon sensitive habitats such as ozone and oxides of nitrogen. Having direct effects, these pollutants can combine in the atmosphere to form ground-level (i.e. tropospheric) ozone, a harmful air pollutant (and potent greenhouse gas) which can be transported great distances by weather systems.

The objective of European Air Quality Directives are to ensure that all citizens should have access to outdoor air without significant risk to their health ensuring effective protection against harmful effects on vegetation and ecosystems from exposure to ozone.

## ****Main terms within both the Clean Air for Europe**** [****Directive (2008/50/EC)****](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF) ****and Fourth**** [****Air Quality Daughter Directive (2004/107/EC****](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32004L0107:EN:NOT)****)****

The 2008 directive replaced nearly all the previous EU air quality legislation. The [4th air quality daughter directive (2004/107/EC](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32004L0107:EN:NOT)) set targets for certain toxic heavy metals and polycyclic aromatic hydrocarbons levels in ambient air. Ambient air, according to the directives, is outdoor air at ground or near ground level. Both indoor air and workplace environments are discounted.

Separate legislation exists in Europe for emissions of air pollutants with the main legislation being the U[NECE Gothenburg Protocol](http://www.unece.org/env/lrtap/multi_h1.htm) which sets national emission limits (ceilings) for SO2, NOx, NH3 and volatile organic compounds for countries to meet from 2010 onwards. Similar ceilings have since been set in European legislation under the 2001 [National Emission Ceilings Directive (2001/81/EC)](http://ec.europa.eu/environment/air/pollutants/ceilings.htm).

The EU directives require a ‘Common Approach’ when assessing ambient air.

This relates to:

* Measurement method used
* Location and number of sample points
* Concentration thresholds

### Measurements Used

To maintain the principal of a ‘common approach’, the directives contain a set of prescribed technical and quantitative methods which are required for the operation of a national air quality monitoring and assessment programme to an EU standard. These include use of ‘Reference Method’ detection systems, mandatory sampling at ‘Urban background locations’, incorporation of a ‘margin of tolerance’ into the assessment during the establishment of national network.

* Reference Method – approved internationally established (ISO) and standardised sampling and detection method
* Urban back ground locations shall mean places in urban areas where levels are representative of the exposure of the general urban population
* Margin of tolerance – shall mean the percentage of the limit value by which that value may be exceeded subject to the conditions laid down in this Directive

### Location and number of sampling points

In order to establish a uniform distribution of monitoring sites across member states, the Directives have specified that a series of ‘zones’ and ‘agglomerations’ are determined, which are regional areas within which a specified number of monitoring sites or assessment sites are established.

* Zone - an area of the country defined for the purposes of air quality assessment
* Agglomeration – a zone which has a population in excess of 250,000

Two assessment thresholds are used to determine exactly what intensity and type of ambient air quality sampling will be used in the long-term within each zone or agglomeration. Air pollutants are assessed as to whether their concentration falls below the ‘lower assessment threshold’, between ‘upper’ and ‘lower assessment thresholds’, or above the ‘upper assessment threshold’.

* Upper Assessment Threshold –a pollution level above which long-term ‘fixed measurements’ are required;
* Lower Assessment Threshold – a pollution level below which only air quality modelling and /or ‘indicative measurements’ are required;
* Fixed measurements – samples collected from fixed monitoring sites, either continuously or by random sampling;
* Indicative measurements – samples collected which meet data quality objectives, though are less strict than those required for fixed measurements.

### Concentration thresholds

From subsequent ambient air quality data collected, both the ‘average exposure indicator’ and ‘national exposure reduction targets’ can be evaluated.

* Average exposure indicator – the average level from measurements made at urban background locations which reflects population exposure;
* National exposure reduction target – shall mean a percentage reduction of the average exposure of the population of a member state set for the reference year with the aim of reducing harmful effects on human health, to be attained where possible over a given period.

In the long-term air quality is then assessed against both ‘target values’, ‘limit values’ for human health and ‘critical levels’ for ecosystem protection.

* Target values – a concentration which should not be exceeded where possible;
* Limit Values – a statutory concentration not to be exceeded across a set time;
* Critical levels – a level above which direct adverse effects may occur on some receptors, such as trees, other plants or natural eco-systems but not on humans.

## ****Limit values for protection of human health, vegetation and eco-systems****

EU limit values (Table 2‑1) are legally binding EU parameters that must not be exceeded. Limit values are set for individual pollutants and are made up of a concentration value, an averaging time over which it is to be measured, the number of exceedences allowed per year, if any, and a date by which it must be achieved. Some pollutants have more than one limit value covering different endpoints or averaging times.

Target values, which are air quality objectives, and which are not yet legally binding, are used in some EU Directives and are set out in the same way as limit values. They are to be attained where possible by taking all necessary measures not entailing disproportionate costs.

Averaging times for limit values reflect their health impacts across varying time periods. Where a particularly chemical species is known at high concentrations to have an acute health impact, then a very short averaging time (typically hourly) is used to reflect that particular impact. Where a chronic health impact is known to occur then a much longer averaging time (typically annually) is applied to the limit values. Chemical species may have more than one averaging time, as both acute and chronic health impacts may occur.

Table 2‑1 European Air Quality Directive limit and target values for the protection of human health

| **Pollutant** | **Limit Value** | **Concentration measured as** | **Date to be achieved by and thereafter** | **Margin of Tolerance 1** |
| --- | --- | --- | --- | --- |
| **PM10** | 50 g/m3 not more than 35 times a year | 24 hour mean | 31 December 2004 | 50% before 31 December 2004 |
| 40 g/m3 | Annual Mean | 31 December 2004 | 20% before 31 December 2004 |
| **PM2.5** | 25 g/m3 | Annual Mean (Calendar year) | 1 January 2015 | 20% on 11 June 2008, decreasing on the next 1 January and every 12 months thereafter by equal annual percentages to reach 0% by 1 January 2015 |
| 20g/m3 | Annual Mean (Calendar year) | 31 December 2019 | None |
| **Nitrogen Dioxide** | 200 g/m3not to be exceeded more than 18 times a year | 1 hour mean | 31 December 2009 | 50 % on 19 July 1999, decreasing on 1 January 2001 and every 12months thereafter by equal annual percentages to reach 0 %by 1 January 2010 |
| 40 g/m3 | Annual Mean (Calendar year) | 31 December 2009 | 50% on 19 July 1999, decreasing on 1 January 2001 and every 12 months thereafter by equal annual percentages to reach 0% by 1 January 2010 |
| **Ozone** | Target of 120 g/m3 not to be exceeded on more than 25 days per year per calendar averaged over 3 years | Maximum 8 hour mean | 31 December 2009 | None |
| **Sulphur Dioxide** | 350 g/m3 not to more exceeded more than 24 times a year | 1 hour mean | 31 December 2004 | 150 g/m3 (43%) before 31 December 2004 |
| 125 g/m3not to more exceeded more than 3 times a year | 24 hour mean | 31 December 2004 | None |
| **Polycyclic aromatic hydrocarbons** | 1 ng/m3 B(a)P | PM10 Fraction over a calendar year | 31 December 2010 | None |
| **Benzene** | 5 g/m3 | As annual average | 31 December 2009 | 5 µg/m3 (100 %) on 13 December 2000, decreasing on 1 January 2006 and every 12 months thereafter by 1 µg/m3 to reach 0 % by 1 January 2010 |
| **Arsenic** | ng/m3 | PM10 Fraction over a calendar year | 1 January 2008 | 0% |
| **Cadmium** | ng/m3 | PM10 Fraction over a calendar year | 1 January 2008 | 0% |
| **Nickel** | ng/m3 | PM10 Fraction over a calendar year | 1 January 2008 | 0% |
| **Carbon Monoxide** | 10 mg/m3 | Maximum daily running 8 hour mean | 31 December 2004 | 60% before 31 December 2004 |
| **Lead** | g/m3 | Annual mean (Calendar year) | 31 December 2004  (31 December 2004 for Industrial contaminated sites) | 100% before 31 December 2004 |

‘Margin of Tolerance’ is the percentage of the limit value by which that value may be exceeded subject to the conditions laid down in this Directive

Limit and target value averaging times for the protection of vegetation and ecosystems (Table 2-2) are annual averages for Oxides of Nitrogen and Sulphur Dioxide, due to the chronic impact both of these chemical species have upon habitats and species over an extended period at low concentration levels. Though due to the historically high concentrations of Sulphur Dioxide in ambient air over the winter periods in Northern Europe, and due to increased fossil fuel use during that period, an additional Sulphur Dioxide winter average averaging period (1 October to 31 March) has been identified for the purposes of protection of vegetation.

Both Sulphur Dioxide and Ozone can have significant short-term or acute impacts at elevated concentrations on vegetation and ecosystems.

The limit value for ozone is expressed as an accumulated ozone exposure over a threshold of 40 ppb (80 g/m3) during hours of sunlight between spring and summer. This sum is known as AOT40 and takes into account that a high concentration of ozone over a long-period has the potential of damaging habitats.

Table 2‑2 European Directive Limit and target values for the protection of vegetation and ecosystems

| **Pollutant** | **Limit Value** | **Concentration measured as** | **Date to be achieved by and thereafter** | **Margin of Tolerance** |
| --- | --- | --- | --- | --- |
| **Oxides of Nitrogen** | 30 g/m3 | Annual Mean (Calendar year) | 19 July 2001 | None |
| **Sulphur Dioxide** | 20 g/m3 | Annual Mean (Calendar year) & Winter (1 Oct to 31 March) | 19 July 2001 | None |
| **Ozone: protection of vegetation & ecosystems** | Target of 18,000 g/m3 based on AOT401 to be calculated from 1 hour values from May to July and to be achieved, so far as possible, by 2010 | Average over 5 years | 31 December 2009 |  |

1 AOT40 (expressed in (g/m3) • hours) means the sum of the difference between hourly concentrations greater than 80 g/m3 (= 40ppb) and 80 g/m3 over a given period using only the one-hour values measures between 8:00hr and 20:00hr Central European Time (CET) each day

## ****Upper and lower assessment thresholds****

The degree of assessment is dependent upon whether average air quality is above or below the upper threshold or below the lower assessment threshold, as set out within the CAFE Directive (Part A, Annex II). Should it be found to be above both at the preliminary assessment stage, then that pollutant must be routinely assessed using a fixed measurement technique s (typically 12 months in duration) using a reference method.

In addition a lower boundary or lower assessment threshold has been set out within the CAFE Directive (Part A, Annex II). Should a pollutant concentration consistently fall below lower assessment threshold at the preliminary assessment stage, then the assessment of the pollutant must be undertaken using a combination of fixed measurements and modelling techniques and/or indicative measurements.

## ****Establishment of zones and agglomerations for monitoring and assessment of the air quality****

Under the CAFE and Air Quality directives, EU member states are obliged to carry out national air quality assessment within areas termed zones and agglomerations of large population (greater than 250,000). Zones are primarily units for air quality assessment and management, but the directives specify assessment requirements per zone[[1]](#footnote-1).

Once the level of assessment has been determined member states are obliged to assess ambient air quality within their territory; the territory can be divided into zones which reflect their population, population density and land area, and agglomerations. Ambient air can be assessed within a zone using:

* continuous measurement at a fixed location sampling;
* a combination of continuous measurement at a fixed location sampling and modelling techniques and or indicative measurement;
* modelling techniques or objective-estimation techniques or both.

Where a particular pollutant concentration has been identified as being below the lower assessment threshold at the preliminary assessment stage, then modelling or objective estimation techniques may be used to assess ambient air quality for that pollutant.

## ****Criteria for classifying sampling points for assessments of air quality****

Monitoring sites are classified according to the type of environment in which they are to be located, which permits a greater understanding of the monitoring data they will generate. Site should reflect the influence of a particular pollutant source or of overall land use[[2]](#footnote-2).

There are a limited number of classifications for air quality monitoring site identities within the wider EU network, these include urban, surburban, rural and rural background.

Monitoring site classifications used within the UK Automatic Urban and Rural Network (AURN) have been outlined in Table 2-3 and Table 2-4 below, and are recommended as they are comprehensive, and include a definition of urban background, roadside, kerbside, industrial as well as the category ‘other’.

Table 2‑3 Monitoring site classifications used within the UK Automatic Urban and Rural Network (AURN)

|  |  |
| --- | --- |
| **Monitoring Site Classification** | **Category** |
| **Site Type** | **Description** |
| Urban centre | An urban location representative of typical population exposure in towns or city centres, for example, pedestrian precincts and shopping areas. |
| Urban background | An urban location distanced from sources and therefore broadly representative of city-wide background conditions, e.g. urban residential areas. |
| Suburban | A location type situated in a residential area on the outskirts of a town or city |
| Roadside | A site sampling typically within one to five metres of the kerb of a busy road (although distance can be up to 15 m from the kerb in some cases). |
| Kerbside | A site sampling within one metre of the kerb of a busy road. |
| Industrial | An area where industrial sources make an important contribution to the total pollution burden. |
| Rural | An open countryside location, in an area of low population density distanced as far as possible from roads, populated and industrial areas. |
| Other | Any special source-orientated or location category covering monitoring undertaken in relation to specific emission sources such as power stations, car-parks, airports or tunnels |

## Macro-scale siting of sampling points

### CAFE-Directive 2008/50/EC

Site criteria for ozone sampling differ for the criteria for sulphur dioxide, nitrogen dioxide, particulate matter (PM10 and PM2.5), lead, benzene and carbon dioxide sampling. Sample site criteria for the measurement of sulphur dioxide, nitrogen dioxide, particulate matter (PM10 and PM2.5), lead, benzene and carbon monoxide require samples to be collected within zones and agglomerations where concentrations are at their highest, or where the population are likely to be exposed.

Whereas ozone sampling points are to be sited where ozone concentrations, in a zone or agglomeration, have exceeded their long-term objectives (Table 2-1) at any time of the previous five years of measurement, fixed measurements shall be taken. The number of sampling points for fixed measurements of ozone in each zone or agglomeration within which measurement is the sole source of information for assessing air quality shall not be less than the minimum number of sampling points specified in table 2-6 below.

The exposure period needs to represent a significant proportion of the averaging period of the limit values. Additional sampling sites need to be established within zones and agglomerations which reflect the pollution exposure of the general population. All sample sites should where possible be representative of similar locations which are not in the immediate locality, i.e. a particular roadside sample site could be considered representative of other roadside locations in the area which have similar layout and traffic levels, speeds etc.

Sampling sites where either high or low ambient air pollution exists over a very small area (micro-environments) are to be avoided. Where feasible sample sites must reflect a wide area, e.g. either a length of 100m street segment at a traffic-oriented site or an industrial site of minimum area of 250 m X 250 m.

Urban background sample locations need to be sited at a location where they can be influenced by the cumulative effects of all sources upwind of the sample site. These sample sites are expected to be representative of several square kilometres. Sampling close to dominant single sources should be avoided, unless such a source is typical for a large urban area.

Rural background sample sites should not be influenced by agglomerations or industrial sites and are expected to be located greater than five kilometres from such sources.

The CAFE Directive contains specific guidelines (section 2, part B of ANNEX III) for the location of sample sites specifically allocated to the assessment of air pollution impacts upon vegetation and ecosystems, which state that, ideally, these sites should be more than 20 km away from agglomerations and 5 km away from major roads or industrial locations or built-up areas.

When assessing air pollution contributions from industrial sources, at least one downwind sample site is required, and if background concentrations are unknown an additional sample site must be established upwind.

Measurements of PM2.5, including total mass concentration and chemical speciation concentrations, should be taken at one rural background sampling location per 100,000 km2. These sites should be located away from significant sources of air pollution. A minimum of one rural background site per member state should be established, though several common sites may be established with adjoining member states.

### Fourth Daughter Directive

The location of sampling points for the measurement of arsenic, cadmium, nickel and benzo(a)pyrene should be selected in such a way as to provide data on the areas within zones and agglomerations where the population are likely to be exposed to the highest concentration over averaged over a calendar year. It should also provide data on levels in other areas within zones and agglomerations which are representative of the exposure of the general population as well as on deposition rates representing the indirect exposure of the population through the food chain.

Sampling sites should be located to avoid measuring very small micro-environments. Sampling points should be representative of air quality in surrounding area of no less than 200m2 at traffic orientated sites and at least 250 m x 250 m at industrial sites, and several square kilometres at urban-background sites.

If the background levels are being sampled, then the sampling site should be located several kilometres away from agglomerations or industrial sites to minimise being influenced by them.

Where contributions from industrial sources are assessed, at least one downwind sampling point should be installed, ideally within the nearest residential area. If the background concentration is unknown, an additional sampling site should be installed upwind of the industrial source.

Sample sites should be representative of similar locations which are not in the immediate locality, and where appropriate they should be co-located with sampling points for PM10. This provides an opportunity for co-locating PM10 gravimetric samplers, and therefore comparable PM10 samples, allowing the level of PM10 sampling uncertainty to be assessed. In addition the efficiency savings of using one sample site for staff resources, security and infrastructure costs.

Table 2‑4 Monitoring site classifications for Ozone used within the UK Automatic Urban and Rural Network (AURN)

|  |  |  |
| --- | --- | --- |
| **Monitoring Site Classification**  **Category** | |  |
| Site Type | Macro-scale siting criteria | Representativeness1 |
| Urban | Away from the influence of local emissions such as traffic, petrol stations, etc.; Vented locations where well mixed levels can be measured; locations such as residential and commercial areas of cities, parks (away from the trees), big streets or squares with very little or no traffic, open areas as characteristic of educational, sports or recreation facilities. | A few km2 |
| Suburban | At a certain distance from the area of maximum emissions, downwind following the main wind direction/directions during conditions favourable to ozone formation; where population, sensitive crops or natural eco-systems located in the outer fringe of an agglomeration are exposed to high ozone levels; where appropriate, some suburban stations also upwind of the area of maximum emissions, in order to determine the regional background levels of ozone | Some tens of km2 |
| Rural | Stations can be located in small settlements and/or areas with natural ecosystems, forests or crops; representative for ozone away from the influence of immediate local emissions such as industrial installations and roads; at open area sites, but not on summits of higher mountains. | Sub-regional levels (some hundreds of km2) |
| Rural background | Station located in areas with lower population density, e.g. with natural ecosystems, forests, at a distance of at least 20 km from urban and industrial areas and away from local emissions; avoid locations which are subject to locally enhanced formation of ground-near inversion conditions, also summits of higher mountains; coastal sites with pronounced diurnal wind cycles of local character are not recommended | Regional/ national/ continental levels (1,000 to 10,000 km2) |

1 Sampling points should, where possible be representative of similar locations not in their immediate vicinity.

## ****Micro-scale siting of sampling points****

Identification of the specific suitability of a sample site locations are a matter for the individual member state and are typically nominated at the Preliminary Assessment stage.

Guidelines on the position of sample sites with respect to sources and their installation are given in both section C Annex III of CAFE-Directive 2008/50/EC and section II Annex III of 4th Daughter Directive 2004/107/EC.

Both the Fourth Daughter Directive (2004/107/EC) and CAFE Directive (2008/50/EC) provide prescriptive guidelines on the microscale siting of the air quality sampling points. With exception to two variations, the guidelines were identical and should be followed in so far as is practicable.

Box 2‑1 Microscale siting sampling points

|  |
| --- |
| **Microscale siting sampling points** |
| The flow around the inlet sampling probe should be unrestricted, without any obstructions affecting the airflow in the vicinity of the sampler (normally some metres away from buildings, balconies, trees and other obstacles and at least 0.5 m from the nearest building in the case of sampling points representing air quality at the building line); |
| In general, the inlet sampling point should be between 1.5 m (the breathing zone) and 4 m above the ground. Higher positions (up to 8 m) may be necessary in some circumstances. Higher siting may also be appropriate if the station is representative of a large area; |
| The inlet probe should not be positioned in the immediate vicinity of sources in order to avoid direct intake of emissions unmixed with ambient air; |
| The sampler’s exhaust outlet should be positioned so that recirculation of exhaust air to the sample inlet is avoided; |
| Traffic-orientated sampling points should be at least 25 metres from the edge of major junctions and at least 4 m from the centre of the nearest traffic lane; inlets should be sited so as to be representative of air quality near the building line; |
| The following additional factors may also be taken into account:   * + - interfering sources     - security     - access     - availability of electrical power and telephone communications     - visibility of the site in relation to its surroundings     - safety of the public and operators     - the desirability of co-locating sampling points for different pollutants     - planning requirements. |
| Variation in the Fourth Daughter Directive (2004/107/EC) microscale siting guideline |
| For the deposition measurements in rural background areas, the EMEP guidelines and criteria should be applied as far as practicable and therefore have not been specified in the Annexes of the fourth daughter directive. |
| Variation in the CAFE Directive (2008/50/EC) microscale siting guideline |
| For all pollutants, traffic-orientated sampling probes shall be at least 25m from the edge of major junctions and no more than 10m from the kerbside. |

## ****Minimum number of sampling points for each relevant pollutant specified in both Directives****

### Minimum number of sampling points per zone / agglomeration

The minimum number of sampling points within a zone or agglomeration is specified in Annex V and IX of CAFE-Directive 2008/50/EC and section IV Annex III of 4th Daughter Directive 2004/107/EC Directives (Tables 3-5 and 3-6). Minimum numbers of sampling points per zone / agglomeration are:

* 1 for pollutants NO2, SO2, CO, Pb, Benzene
* 2 for PM10 and PM2.5
* 1 for Cd, Ni, and As, and
* 1 for B(a)P

All of the above are dependent upon whether pollutants concentrations are above or below upper assessment threshold or above or below lower assessment thresholds. In addition the number of monitoring sites is indirectly proportional to the population size of the zone / agglomeration.

However the minimum number of ozone sample points is:

* 1 for zones which have a population greater than 250,000 and are deemed to be either suburban or rural areas;
* 1 for an agglomerations which have a population greater than 500,000 and are deemed to be either urban or suburban;
* 1 rural background station per 50,000 km2 of member state land area;
* 1 rural background station per 25,000 km2 of complex terrain in member state land area;
* 1 rural background station per 100,000 km2 of member state land area, where long-term objective is met.

Where the long-term objective is met within a zone or agglomeration the minimum number of sampling points for fixed measurements can be reduced to one a third of that stated above.

### Minimum number of diffuse source sampling points

Both the CAFE and 4th Daughter Directives have specific criteria for a minimum number of diffuse sources sampling points in zones and agglomerations, where fixed measurements are the sole source of information, in order to assess compliance with the following:

* Limit values for NO2, CO, PM10, Pb, SO2, Benzene
* PM2.5 exposure
* Target values for As, Cd, Ni & B(a)P
* Target values for Ozone

When monitoring for nitrogen dioxide, particulate matter, benzene and carbon monoxide where upper assessment threshold have been exceeded, it is a requirement that at least one urban background monitoring station and one traffic-orientated station are in place. Though this is only a requirement when there are two or more fixed sampling points.

In any member state when monitoring nitrogen dioxide, particulate matter, benzene and carbon monoxide, the total number of urban-background stations sampling diffuse sources and the total number of traffic oriented stations shall not differ by more than a factor of 2.

Sampling points must be maintained if the limit value for PM10 has been exceeded within the last three years, unless location is necessary owing to special circumstances, in particular spatial development.

Where PM2.5 and PM10 are being measured at the same rural background locations these measurements shall count as two separate sampling points.

The total number of PM2.5 and PM10 sampling points in a member state required under Section A (1) shall not differ by more than a factor of 2.

When monitoring for As, Cd, Ni and B(a)P at least one urban-background station should be included. When monitoring for B(a)P at two or more sample sites then one traffic-oriented station should be included.

Table 2‑5 Minimum Number of Sample Points for Diffuse Sources within an agglomeration or zone required under both 2008/50/EC (Annex V) and 2004/107/EC (Annex V)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Minimum Number of Sample Points for Diffuse Sources within an agglomeration or zone** | | | | | | | | |
| **Population of agglomeration or zone (thousands)** | **If maximum concentrations exceed the upper assessment threshold** | | | | **If maximum concentrations are between the upper and lower assessment thresholds** | | | |
| **Pollutants except PM** | **PM (2) (sum of PM10 and PM2.5)** | **As, Cd, Ni** | **B(a)P** | **Pollutants except PM** | **PM (2) (sum of PM10 and PM2.5)** | **As, Cd, Ni** | **B(a)P** |
| 0 – 249 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 |
| 250 – 499 | 2 | 3 | 1 | 2 |
| 500 – 749 | 2 | 3 | 1 | 2 |
| 750 – 999 | 3 | 4 | 2 | 2 | 1 | 2 | 1 | 1 |
| 1,000 – 4,499 | 4 | 6 | 2 | 3 |
| 1,500 – 1,999 | 5 | 7 | 2 | 3 |
| 2,000 – 2,749 | 6 | 8 | 2 | 3 | 3 | 4 | 1 | 1 |
| 2,750 – 3,749 | 7 | 10 | 3 | 4 |
| 3,750 – 4,749 | 8 | 11 | 3 | 4 | 3 | 6 | 2 | 2 |
| 4,750 – 5,999 | 9 | 13 | 4 | 5 | 4 | 6 | 2 | 2 |
| > 6,000 | 10 | 15 | 5 | 5 | 4 | 7 | 2 | 2 |

### Minimum number of sampling points for fixed measurements of concentrations of ozone

The number of sampling points for fixed measurements of ozone in each zone or agglomeration within which measurement is the sole source of information for assessing air quality shall not be less than the minimum number of sampling points specified in table 2-6 below.

Table 2‑6 Minimum Number of Sample Points for fixed measurements for zones and agglomeration attaining the long-term objectives required under 2008/50/EC (Annex V)

| **Minimum Number of Sample Points for fixed measurements for zones and agglomeration attaining the long-term objectives** | | | |
| --- | --- | --- | --- |
| Population of agglomeration or zone (thousands) | Agglomerations (urban and suburban) or zone (thousands) | Other zones (suburban and rural) | Rural background |
| < 250 |  | 1 | 1 station/ 50,000 km2 as an average density overall zones per country |
| < 500 | 1 | 2 |
| < 1,000 | 2 | 2 |
| < 1,500 | 3 | 3 |
| < 2,000 | 3 | 4 |
| < 2,750 | 4 | 5 |
| < 3,750 | 5 | 6 |
| > 3,750 | One additional station per 2 million inhabitants | One additional station per 2 million inhabitants |

When sampling in agglomerations at least 50% of the stations shall be located in suburban areas, and within suburban areas at least one station should be located where highest exposure of the population was likely to occur.

When sampling at a rural background with complex terrain, at least one monitoring site per 25,000 km2 is recommended.

In zones and agglomeration where the long-term objectives are attained, then the number of stations located in agglomerations and other zones may be reduced to one-third of the number specified in Table 2-6 above. The residual number of sampling points for ozone shall be combined with supplementary assessment information (e.g. air quality modelling and collocated nitrogen dioxide measurements) in order to sufficiently examine the trend of ozone pollution and check compliance with the long-term objectives.

In cases where the sole source of information is from fixed measurement stations, then at least one monitoring station shall be kept. In zones with no remaining O3 monitoring station, though supplementary assessment information is available, coordination with the number of stations in neighbouring zones should be made to ensure that adequate assessment of ozone concentrations against long-term objectives is undertaken.

The minimum number of rural background stations shall be one per 100,000 km2 of land area.

## ****Minimum number of point source sampling points****

When determining the number of fixed measurement sampling points for assessing the contribution of pollution in the vicinity of point sources, the following should be taken into account:

**Emission densities** - where is the pollution coming from and which are the areas with the greatest pollution emissions?

**Likely distribution patterns of ambient air pollution** - how dispersed is the pollution, where is it most and least concentrated?

**Potential exposure of the population** - where are members of the public at greatest risk of being exposed to poor air quality?

## ****Compliance with the PM2.5 Exposure Reduction Target****

In order to assess compliance with the PM2.5 exposure reduction target for the protection of human health a minimum number of sampling points for fixed measurement has been set. This has a maximum ceiling of one sampling point per million inhabitants. These can be summed over agglomerations, and additional urban areas in excess of 100,000 inhabitants shall be operated for this purpose. Those sampling points may coincide with sampling points required to assess impact upon human health.

## ****Protection of Vegetation****

Specific criteria have been provided within Section C of Annex V of the CAFE Directive for a minimum number of sampling points for the Protection of Vegetation in zones other than agglomerations. Where maximum concentrations exceed the upper assessment threshold, then there should be a minimum of 1 station every 20,000 km2, whereas if maximum concentrations are between upper and lower assessment threshold there need only be a minimum of 1 station every 40,000 km2.

## ****Measurements at Rural Background Locations****

In addition to the assessment of pollutants for purposes of protection of both human health and ecosystems, fixed measurements shall be made at rural background locations away from significant sources of air pollution. These are required for the purposes of assessing possible contribution from long-range transport of air pollutants, and should, as a minimum, include information on the total mass concentration and the chemical speciation concentrations of fine particulate matter (PM2.5) on an annual average basis.

Measurements at rural locations are required to meet the following criteria:

* That there is one sampling point every 100,000 km2.
* Member States may set up one or in agreement with adjoining Member States, several common measuring stations, covering the relevant neighbouring zones, to achieve the necessary spatial resolution.
* Where feasible, monitoring should be coordinated with the monitoring strategy and measurement programme of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP).
* Measurement of PM2.5 must include at least the total mass concentration and concentrations of appropriate compounds to characterise its chemical composition. As a minimum, the following shall be included: SO42–, Na+, NH4+ Ca2+ NO3-, K+ Cl–, Mg2+, organic carbon, elemental carbon.

## ****Data quality objectives for ambient air quality assessment in EU directives****

Minimum requirements for the quality of data acceptable to Directive 2008/50/EC are termed Data Quality Objectives. These include uncertainty, minimal data capture and minimal time coverage.

Fixed measurements of monitoring ambient air quality are required where a pollutant species has been identified as exceeding the upper assessment threshold (as set out in part A Annex II of the CAFE Directive). Where a pollutant concentration is well below the lower assessment threshold (as set out in part A, Annex II of the CAFE Directive) then it is acceptable to use indicative measurement method.

Data Quality Objectives for fixed measurements (long-term), such as a permanently located continuous monitor are set out in Table 2-7, and data quality objectives for indicative measurements (short-term) are set-out in Table 2-8.

Random measurements may be applied instead of continuous measurements for benzene, lead and particulate matter to the Commission if they can demonstrate that:

* the combined uncertainty of random sampling and measurements for benzene, lead and particulate matter, meets the quality objective of 25%;
* the time coverage is still larger than the minimum time coverage for indicative measurements; and
* Random sampling is evenly distributed over the year in order to avoid skewing of results.

When using indicative measurements for benzene, data quality objectives are less stringent, and only a one day random measurement a week must be taken, which must be evenly distributed over the year, or eight weeks evenly distributed over the year. Though when using a fixed measurement, the minimal time coverage must be distributed across the year to be representative of various conditions for climate and traffic.

When using indicative measurements for SO2, NO2 and NOx and CO and particulates then a one day random measurement a week must be taken, evenly distributed over the year, or eight weeks evenly distributed over the year.

The uncertainty due to random sampling should be determined by the standard ISO 11222 (2002) ‘Air Quality — Determination of the Uncertainty of the Time Average of Air Quality Measurements’.

Where random measurements are used to assess compliance of the PM10 limit value, then compliance with the daily limit of 50 µg/m3 PM10 (which is highly influenced by data coverage) should be assessed from the 90.4 percentile (to be lower than or equal to 50µg/m3), instead of the number of exceedances.

Minimum data capture as well as time coverage are not calculated using any losses of data which are due to the regular calibration or the normal maintenance of the instrumentation. Though any losses of data due to instrument failure, repair or baseline drift are included within the minimum data capture and time coverage calculation.

Table 2‑7 Data quality objectives for the fixed measurement of ambient air quality assessment in National Networks

| **Objective Criteria** | **SO2, NO2 and NOx and CO** | **Benzene** | **PM10, PM2.5 and Pb** | **Ozone and related NO and NO2** | **B(a)P** | **As, Cd, & Ni** | **PAH’s other than B(a)P, total gaseous Hg** | **Total Deposition** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Fixed Measurements | | | | | | | |
| Uncertainty | 15 % | 25 % | 25 % | 15 % | 50 % | 40 % | 50 % | 70 % |
| Minimum data capture | 90 % | 90 % | 90 % | 90 % during summer | 90 % | 90 % | 90 % | 90 % |
|  |  |  |  | 75 % during winter |  |  |  |  |
| Minimum time coverage |  |  |  |  | 33 % | 50 % |  |  |
| Urban Background and traffic | - | 35 % | - | - |  |  |  |  |
| Industrial sites | - | 90 % | - | - |  |  |  |  |

Table 2‑8 Data quality objectives for indicative measurement of air quality assessment in National Networks

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Objective Criteria** | **SO2, NO2 and NOx and CO** | **Benzene** | **PM10, PM2.5 and Pb** | **Ozone and related NO and NO2** | **B(a)P** | **As, Cd, & Ni** | **PAH’s other than B(a)P, total gaseous Hg** | **Total Deposition** |
|  | Indicative Measurements | | | | | | | |
| Uncertainty | 25 % | 30 % | 50 % | 30 % |  |  |  |  |
| Minimum data capture | 90 % | 90 % | 90 % | 90 % |  |  |  |  |
| Minimum time coverage | 14 % | 14 % | 14 % | > 10 % during summer | 14 % | 14 % | 14 % | 33 % |
| Objective estimation Uncertainty | 75 % | 100 % | 100 % | 75 % |  |  |  |  |

## ****Quality assurance for ambient air quality assessment: data validation****

Monitoring data collected from EU national networks are required to be collected from frequently calibrated devices, fully validated and ratified, and subject to scrutiny against data from monitoring stations nearby.

All networks are required to operate to minimal quality standards which allow data to meet data quality objectives. In order to meet minimum quality assurance and quality control criteria, air quality networks operate within parameters set out in their respective national quality plans. These form the foundation upon which acceptable precision, accuracy, completeness, comparability, and representativeness can be determined if not assured (Table 2-9). National quality plans require the following criteria to be determined:

Table 2‑9 Foundation of a National Air Quality Monitor Plan

|  |  |
| --- | --- |
| Foundation of a national air quality monitoring plan | |
| Quality control procedure | Data scrutiny and instrument performance checks & maintenance procedures, including calibrations & flow-checks |
| Quality assurance | Audit procedures involving external review and internal personnel.  Requires assesses effectiveness of the QC program   * Data quality, * Data completeness, * Data accuracy, * Data precision, and * Representativeness of data. |
| Analyser zero and span verifications | Fort-nightly rapid checks of monitoring device responses using ‘zero-air’ and analytical standards |
| Calibrations | Routine multi-point calibrations of monitoring devices against suitable analytical standards |
| System audits | Third party checks on written procedures, data recording, data storage, handling, calculation methods and reporting |
| Equipment service and repairs | Routine (6-monthly) servicing of all instruments and monitoring station infrastructure. Establishment of service contracts with specialist supply companies, with set response times to repair all instrument failures or replace instruments |
| Future network intercalibration and site audits | Check network conformity by calibrating all devices against a universal reference, i.e. National reference standard. Devices must conform within the maximum margin of deviation. Check operation and condition of all monitoring sites through annual audits |
| Inter-calibration procedures | Clear written SOP for all intercalibrations, use of reference standards and criteria with which to reject a device on poor performance |
| Data ratification | Screening data against minimum criteria, scaling against long-term drift, removal of suspect or invalid data, verification against other relevant data |

All monitoring data are required to be traceable to a national primary reference standard, where calibration standards certify standards with a known minimal standard preparation tolerance. Measurements need to be collected and calculated in such a way as to be of a known and documented quality.

All data shall be comparable, meaning that the data shall be produced in a similar and scientific manner using standard methodologies for sampling, calibration, auditing, and collection of data. In order to assure that measurements are comparable designated reference or equivalent methods compliant to CEN Standard requirements are required to be used.

All data shall be representative of the parameters being measured with respect to time, location, and the conditions from which the data are obtained. The use of standard methodologies contained in this manual should insure that the data generated is representative.

## ****Reference methods for assessment of concentrations and standardization****

Ambient air reference methods provide concentration data which is of known (or traceable) accuracy, precision, repeatability and uncertainty. As they are universally applied, they therefore provide a standardised approach to obtaining ambient air quality data. The CAFE and Fourth Daughter Directive has stated strict data quality objectives which are easily achievable using reference methods. In addition both the CAFE and Fourth Daughter Directives require measurement to be made using a reference (or equivalent) detection method.

When designing an ambient air quality monitoring network which meets the requirements of both the CAFE and Fourth Daughter Directive careful selection of monitoring equipment is essential. A reference measurement method for each pollutant species is available from CEN, or is in the process of being completed by CEN (e.g. EN 12341 for the measurement of PM10).

A primary requirement in both the CAFE and Fourth Daughter Directive is the principle that a sampling operation should be able to demonstrate compliance with the limit and guide values as stated in the Directives. This means that detection limits and averaging times must be suitable. Non-reference methods may not allow sample averaging times to comply with the limit and guide values.

Likely future needs for monitoring, in terms of shorter averaging periods and/or lower detection limits, should also be borne in mind. The need to use data for purposes other than the estimation of compliance, e.g. the assessment of air quality in relation to health effects, the dispersion of pollutants and the validation/calibration of models, should also be borne in mind. Other important factors to be considered in the selection of monitoring equipment are outlined in Table 2-10 below.

Table 2‑10 Important Factors to be considered when Selecting Monitoring equipment

|  |
| --- |
| Important factors to be considered in the selection of monitoring equipment |
| Ease of use |
| Expandability (mainly for data processing equipment) |
| Reliability |
| Durability |
| Compatibility with any existing hardware or software |
| Availability of training and documentation (including circuit diagrams) |
| Availability of spares, warranties and after-sales services (maintenance and possibly calibration) |

## ****EU Requirements for Reference Methods****

The required reference methods of measurement for air quality pollutants (specified in Annex VI of Directive 2008/50/EC) are based upon Standard Methods developed by CEN and are outlined in Table 2-11 below:

Table 2‑11CEN Air Quality Standard Method

|  |  |  |  |
| --- | --- | --- | --- |
| Pollutants | Reference standard | Method Description | Year |
| (NOx) | EN14211: | Chemiluminescence Detection | 2005 |
| (SO2) | EN14212: | Fluoresence Detection | 2005 |
| (O3) | EN14625: | UV Photoionisation | 2005 |
| (CO) | EN14626: | Infra Red Detection | 2005 |
| (PM10) | EN12341: | Gravimetric determination by weight difference | 1999 |
| (PM2.5) | EN14907: | Gravimetric determination by weight difference | 2005 |
| (Benzene) | EN14662 | Gas chromatography and photo ionisation Detection | 2005 |
| PAH’s and B(a)P | EN12884 | High Volume Sampling and detection using Gas Chromatography / Mass Spectrometry | 2005 |
| Pb, As, Cd & Ni | EN14902 | Pumped samples onto a filter and determination by Inductively Coupled Plasma Atomic Absorption/ Atomic Absorption | 2005 |
| Gaseous Mercury | EN 15852 | Fluorescence Detection |  |

Member state may also use any other methods which it can demonstrate give results equivalent to the above methods.

These standards describe in detail how analysers are to be tested, approved for use, calibrated and their ongoing performance determined. These harmonised procedures allow member states to reliably and consistently quantify the uncertainties associated with their measurements of air pollution. CEN, through the various Working Groups, continue to revise and improve the Standards as new information becomes available.

For the gaseous analysers, the relevant Standard Methods include a requirement for type testing and approval.

For particle monitoring (PM10 and PM2.5) compliance is achieved by either using a reference method device or ensuring that all analysers used in the network have been demonstrated as satisfying the compliance criteria whilst operating within the member state and proven to be equivalent to the reference methods. The details of the compatibility test with a reference procedure are contained in both the method document EN 12341.1:1998 and EN 14907:2005.

## ****Type Approval of Analysers for National Networks****

All analysers and samplers used in the national networks are required to be Type approved devices.

For an analytical method to comply with a CEN standard it must undergo a ‘type-approval test’ in order to meet the minimum requirement within a set of performance characteristics.

Individual gas analyser type approval compliance tests carried out are contained in table 2-12 below.

Table 2‑12 Individual Gas Analysers Laboratory and Field Compliance Tests

|  |  |
| --- | --- |
| Laboratory tests: | Field tests: |
| Short-term drift of instrument  Response times to Concentration change | Reproducibility between two analysers in over 3 months |
| Repeatability at zero concentrations and limit value | Long-term drifts of instrument |
| Lack of fit | Period of unattended operation. |
| Sample gas pressure sensitivity  Sample temperature sensitivity | Percentage time the analyser is available for measurements |
| Sensitivity to electrical voltage |  |
| Analyser temperature sensitivity to the surrounding temperature |  |
| Sensitivity to interfering substances |  |
| Averaging Tests |  |
| Molybdenum converter efficiency (NOx) |  |
| Sample and span inputs differences. |  |

In addition to achieve compliance an overall expanded uncertainty of the measurement result is required, this is based on the output from the relevant performance characteristics. Expanded uncertainties are assessed against the maximum uncertainty in the Directive’s Data Quality Objective (Table 2-7).

## ****Relative Uncertainty of Analyser measurements****

Instrument uncertainty is calculated using a combination of laboratory instrument performance characteristics and field test data. Uncertainty (expressed at a 95% confidence level) of the assessment methods will be evaluated in accordance with the principles of the CEN Guide to the Expression of Uncertainty in Measurement (ENV 13005-1999), the methodology of ISO 5725:1994 and the guidance provided in the CEN report ‘Air Quality—Approach to Uncertainty Estimation for Ambient Air Reference Measurement Methods’ (CR14377:2002E).

Measurement uncertainty given in Table 2-7 and Table 2-8 above are given for both fixed and indicative individual measurements averaged over the period considered by the limit value (or target value in the case of ozone), for a 95% confidence interval.

The uncertainty for the fixed measurements shall be interpreted as being applicable when measuring at a concentration close to the appropriate limit value (or target value in the case of ozone). Expanded uncertainties for measurements are assessed against Data Quality Objectives (Table 2-7) which for fixed measurements are typically 15% for gas analysers and 25% for particulate monitors and benzene analyser, 50% for the determination of B(a)P and gaseous Hg, 40% for heavy metals (As, Cd & Ni) and 70% for total deposition.

## ****Reporting and communication****

Among the principal obligations of member states are information and reporting requirements. These include the requirement to inform the public of:

* cases where the air quality alert thresholds are exceeded;
* the identity of competent authorities and bodies responsible for implementing the directive; and
* the plans and programmes for attaining limit value in zones where prescribed limit values have been exceeded.

Where there is a risk of air quality limit values being exceeded following significant pollution originating in another member state, then the state must communicate this risk to that neighbouring state with a view to finding a solution.

Member states are also required to submit annual reports. Table 2-13 below contains an outline of the Air Quality annual report required by the European Commission from each member state.

Table 2‑13 Required to be Reported to the European Commission by Member States

|  |
| --- |
| Member states are required to report to the Commission on |
| Competent authorities and bodies responsible for implementing the directive; |
| National standards, criteria and techniques that are more stringent than Community standards or that relate to pollutants not covered by Community legislation; |
| Lists of zones and agglomerations drawn up pursuant to Articles 8 and 9; |
| Methods used for the preliminary assessment of air quality; |
| Cases where limit values and alert thresholds are exceeded, and reasons for the occurrence; |
| Plans and programmes adopted pursuant to Article 8, and (every three years) progress in implementing the plans or programmes; |
| Measures taken to attain target value for zone that exceeds that set by the Commission; |
| Transposition, with texts of the main provisions of national law adopted in the field covered by the directive (Art. 13); and |
| Every three years, information on reviews of the levels in zones and agglomerations referred to in Articles 8 and 9 of the Directive |

Complete and efficient data collection and reporting are essential components of air quality management. Air Quality Directives requiring air quality monitoring to be undertaken impose a duty to report to the Commission on their implementation and to report the results and the degree of compliance to both the Commission and the public. The format of this reporting is specified by Directive 91/692/EEC on standardising and rationalising reports on the implementation of certain directives relating to the environment, which amends the reporting requirements in original directives.

Competent authorities are required to ensure that reporting is undertaken in accordance with the requirements of this directive.

Data should be subject to quality control before it can be accepted as part of an archive of data, which can then be used for the analysis of high pollution episodes or the detection of trends in air quality over time. Where data needs to be supplied rapidly (for example, to warn the public regarding ozone levels) it may be impossible to complete all the quality assurance procedures. Where this occurs, the data should be accompanied by a statement to this effect.

Data on emission rates from sources (and surrogate data such as traffic flows) are also of value, for example in building up a picture at the national and regional level of the causes of high pollution episodes.

# Organisation of air quality monitoring systems in Europe

The EU Air Quality Directives are precise and distinct in what monitoring they require Member States to conduct. These requirement have been outlined in chapters 2-7 and 2-8 above, and include a minimum number of monitoring stations per population/ land mass, that a discrete set of chemical species are measured for minimal averaging period, and that measurements systems to be used are required to meet the reference criteria or its equivalence.

Existing European air quality monitoring networks and sites included in routine long-term operations and reported within national reports to the EU have been analysed for their performance and quality in order to assess their suitability to be used as a template for the proposed air quality network in Partner Countries.

## ****State of air quality monitoring in Europe****

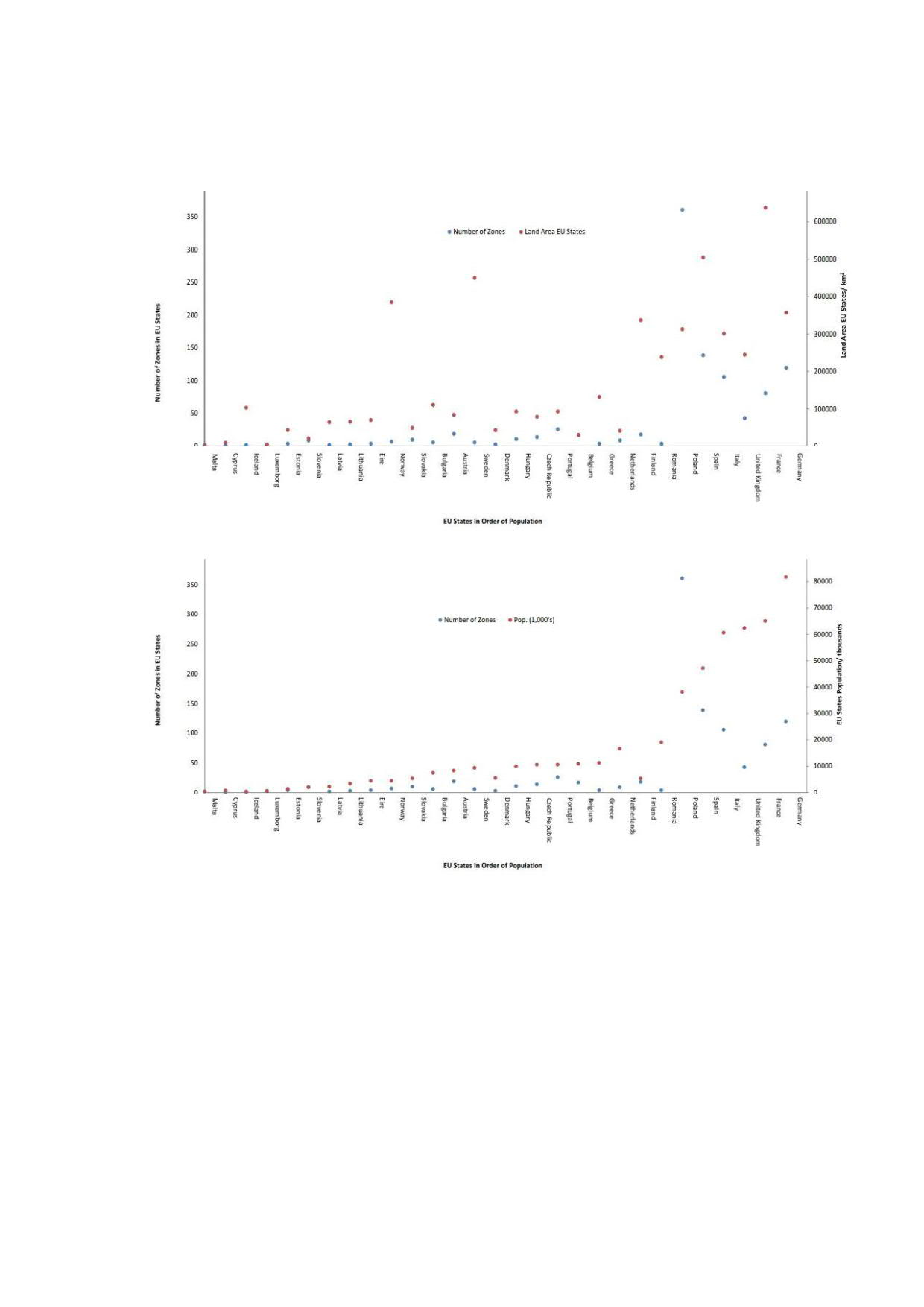
This chapter is a summary comparison of practices in existing EU member states, countries of the European Economic Area (Iceland & Norway), where each state performance against the following criteria have been examined:

* Network Description
* Methods
* Coverage
* Data availability
* Reporting
* Trends

### Zones Per Population

EU Members States are obliged (under CAFE Directive 2005/50/EC) required to separate their land mass into a minimum number of designated monitoring zones. Minimum criteria for this process have been outlined in Table 2-5 and 2-6 above. As a guide the number of zones within EU states has been assessed across the populations of those states[[3]](#footnote-3) (Figure 3-1).

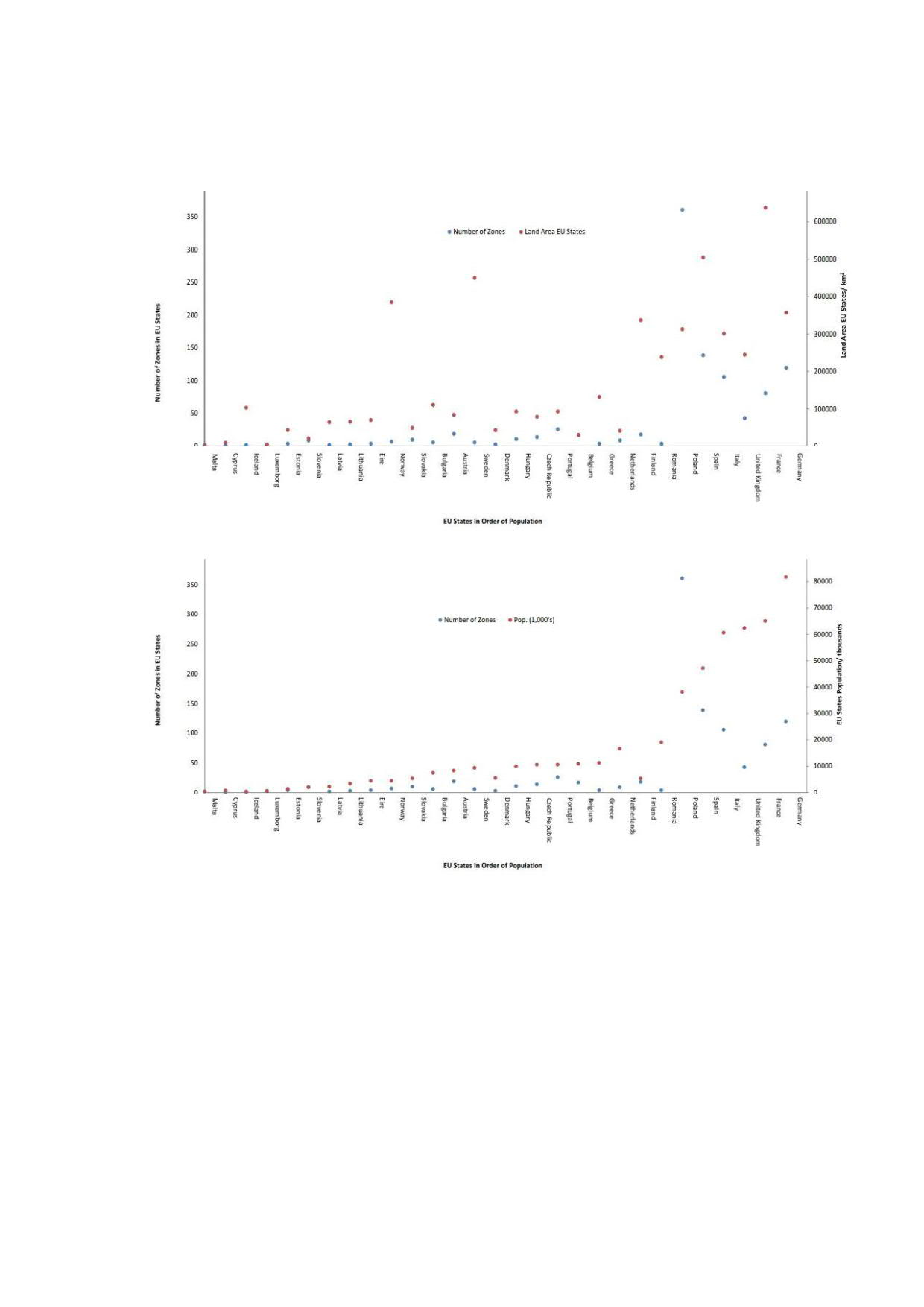
Figure 3‑1 Number of Air Quality Monitoring Zones in EU Countries against population size



### Zones Per Land Area

An additional set of criteria for the purpose of designated number of air quality monitoring zones is the land area for a particulate member state (as outlined in Table 2-5 and 2-6). Once again, the number of zones within EU states has been assessed across the land area of those states (Figure 3-2).

Figure 3‑2 Number of Air Quality Monitoring Zones in EU Countries against Land Area



### Network description

Detailed site descriptions are an important background for evaluating representatively of networks and for judging the air quality information from the network correctly. Dedicated reports with detailed site descriptions are available from Austria, the Netherlands and Spain. For some other countries, brief descriptions were available within the AQ reports, such as for Sweden, the UK.

## ****Temporal Coverage****

Most countries operate their networks the entire year. Exceptions are Norway and Sweden, where the monitoring is concentrated to the six winter months, which have the highest concentrations. For regional sites in Sweden, O3 and NO2 are monitored only in the six summer months, except for the 6 EMEP stations, which are monitored all the year.

With a few exceptions, especially some East European countries, monitoring and/or sampling cover all days/hours.

## ****Spatial Coverage****

Most member states have a substantial number of monitoring sites in operation. The monitoring networks in each state may be national, regional or local in area coverage, and the organisation of monitoring responsibilities between national, regional or local authorities (municipalities) differs between states.

The largest states in EU have the most sites. For example (Table 3-1), France has close to 900 sites, Germany has more than 500 sites, Spain about 1000 sites and the UK has about 80 active sampling and over 1100 passive sampling sites.

European countries, which have fewer monitoring stations deployed, include:

* Albania which has 23 urban sites, Greece has 32 sites (31 are urban), Croatia has 41 sites (40 are urban), Norway has 45 sites (6 are urban), Denmark 35 sites (18 are urban), Hungary 39 urban sites, Estonia 18 sites (16 urban/local).
* The total number of air pollution monitoring sites across the whole European network is very large. For the 29 countries who supply data, there are close to 5,000 urban/local sites, and more than 800 regional sites.

Table 3‑1 Spatial coverage of AQ monitoring Sites Across European States[[4]](#footnote-4)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | LOCAL | | | | | | | REGIONAL | | | |
| No. of sites | No. of cities/towns | | Site class distribution | | | | No. of sites | SO2+ | Deposi-tion | O3 |
| Urban | | | Regional |
| General | Traffic hot-spot | Industrial/ hot spot |
| Austria | 165 | 10 | 100 | | 30 | 20 | 15 | 55 | 55 | 35 | 55 |
| Belgium | 168 | 60 | 125 | | | 30 | 13 | 25 |  |  |  |
| Denmark | 18 | 3 | 7 | | 8 | 3 | 0 | 17 | 6 | 17 | 3 |
| Finland | 120 | 30 | 71 | | 18 | 28 | 3 | 22 | 8 | 7 | 9 |
| France | 875 |  | 875 | | | | | 21 | 17 |  | 21 |
| Germany | 467 |  | 232 | | 156 | 79 | | 74 | 658 |  | 578 |
| Greece | 31 | 11 | 22 | | 2 | 7 | 0 | 1 | 1 | 1 | 0 |
| Ireland | 81 | 15 | 45 | | 25 | 10 | 1 | 12 | 7 |  | 5 |
| Italy | 1293 | 41 | 129 | | | | | 34 | 3 | 3 | 2 |
| Luxembourg | 4 | 1 | 1 | | 2 | 1 | 0 | 2 | 1 | 0 | 1 |
| The Netherlands | 20 | 9 | 7 | | 13 | 0 | 0 | 36 | 30 | 14 | 26 |
| Portugal | 80 | 5 | 6 | | 15 | 6 | 53 | 13 | 12 | 3 | 3 |
| Spain | 893 |  | 288 | | 438 | 167 | | 190 |  |  | >7 |
| Sweden | 66 | 45 | 63 | | 3 |  |  | 49 | 12 | 36 | 5 |
| U.K. | 515 | 34 | 45 | | 2 |  | 4 | >38 | 38 | 32 | 15 |
| Iceland | 3 | 2 | 1 | | 1 | 0 | 1 | 1 | 1 |  |  |
| Liechtenstein | 1 | 1 | 1 | | 0 | 0 | 0 |  |  |  |  |
| Norway | 6 | 6 | 6 | | 0 | 0 | 0 | 39 | 12 | 34 | 15 |
| Albania | 23 | 11 | 23 | | | | |  |  |  |  |
| Bulgaria | 100 |  | 100 | | | | |  |  |  |  |
| Croatia | 62 | 8 | 62 | | | | | 1 | 1 | 0 | 0 |
| Cyprus | 2 | 1 | 0 | | 2 | 0 | 0 | 1 | 1 | 1 | 1 |
| Czech Republic | 6501 |  |  | |  |  |  |  |  |  |  |
| Estonia | 16 | 9 | 8 | | 2 | 6 |  | 2 | 2 | 2 | 2 |
| Hungary | 39 |  | 39 | | | | | 2 | 2 | 2 |  |
| Poland7 | >540 |  | >500 | |  |  | 33 | 11 |  |  |  |
| Romania | 152 |  | 152 | | | | | 138 | 4 | 1372 | 4 |
| Slovakia | 37 | 17 | 14 | | 6 | 10 |  | 7 | 7 | 7 | 4 |
| Slovenia | 86 |  | 86 | |  |  |  | 4 |  |  |  |
| Switzerland | 986 |  | 55 | | 31 | 12 |  | 54 |  |  |  |

1 Total for urban and regional. Site classification not known

2 All stations measure pH, conductivity and acidity/alkalinity. 14 sites measure major ions.

3 Not complete.

4 Only EMEP sites

5 Plus 1100 passive NO2 sampling sites

6 Plus 12 passive SO2 and 102 passive NO2 sites.

7 All cities with >20,000 inhabitants.

8 The number of sites may not be quite correct.

Table 3‑2 Compound coverage of AQ monitoring Networks across European States

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | LOCAL | | | REGIONAL | | | |
| SO2, NO2, Black Smoke/  PM10, TSP, Pb, O3 | CO, Heavy Metals | Benzene, VOC, H2S | SO2 + | Deposition | O3 | O3 Precusors |
| Austria | x | CO | VOC, H2S | x | x | x | x |
| Belgium | x | CO | VOC | x | x | x |  |
| Denmark | x | CO, Heavy Metals |  | x | x | x |  |
| Finland | x | CO, Metals |  | x | x | x |  |
| France | x | CO | VOC | x | x | x | x |
| Germany | x | CO | VOC | x | x | x | x |
| Greece | x | CO |  | x | x |  |  |
| Ireland | x |  |  | x | x | x |  |
| Italy | x |  |  | x | x | x |  |
| Luxembourg | x | CO, Heavy Metals | VOC | x | x | x | x |
| The Netherlands | x | CO, Heavy Metals | PAH | x | x | x | x |
| Portugal | x (-Pb) | CO |  | x | x | x |  |
| Spain | x | CO, Heavy Metals | VOC, H2S | x | x | x |  |
| Sweden | x | Heavy Metals | VOC | x | x | x | x |
| U.K. | x | CO, Heavy Metals | VOC, PAH | x | x | x | x |
| Iceland | x | CO |  | x | x |  |  |
| Liechtenstein | x (-Pb) | CO |  |  | x |  |  |
| Norway | x (-SO2, Pb) |  | BTX | x | x | x |  |
| Albania | x (-O3, Pb) |  |  | x | x |  |  |
| Bulgaria | x | CO, As | H2S | x | x |  |  |
| Croatia | x (-O3, Pb) |  | H2S, PAH | x | x |  |  |
| Cyprus | x | CO |  | x | x | x |  |
| Czech Republic | x | AD, Heavy Metals |  | x | x | x |  |
| Estonia | x (-Pb) | CO | H2S, BTX | x | x |  |  |
| Hungary | x (-Pb) | CO | VOC | x | x |  |  |
| Poland | x | CO, Heavy Metals |  | x | x |  |  |
| Romania | x (-Pb, SPM) | CO | VOC | x | x | x |  |
| Slovakia | x | CO |  | x | x | x |  |
| Slovenia | x | CO |  | x | x | x |  |
| Switzerland | x (-Pb) | CO | VOC | x | x | x | x |

## ****Methods Evaluation****

Methods of ambient air measurements employed throughout European ambient air quality networks vary widely, with a residue of manual methods remaining from prior practices. The majority of network methods employ reference methods conforming to the requirements set in EU directives, or considered equivalent to them. For the purpose of this analysis several states have been roughly classified according to the following scheme:

### Standard techniques

Conforms to the requirements set in EU directives, or considered equivalent to those.

### State-of-the-art, or advanced techniques

These include e.g. the DOAS technique, light scattering and beta attenuation PM detection, Gas Chromatography for Benzene/ BTEX detection as well as diffusion tubes for NO2, BTX etc.

### Non-standard techniques

Techniques not conforming to the requirements of the directives, or not considered equivalent, in terms of required accuracy and specificity.

### Methods

Standard methods, samplers and monitors are used almost exclusively in most of the EU states networks, as described in EU directives. Though a number of Eastern Europe states (e.g. Albania, Bulgaria, Croatia, Estonia, Romania) have deployed non-standard methods for some of the compounds.

All countries utilise standard or advanced/state-of-the-art methods for some or all of the compounds measured. In addition a limited number of EU states have deployed advanced monitoring methods routinely at some sites, such as DOAS in Finland, Norway and Sweden, and on-line compound-specific VOC analysis in the UK.

Among the new techniques are candidates which are being introduced soon into air quality directives or as reference methods. These include new PM10 equivalence methods, Benzene/BTX analysis either manually or by DOAS, or other (UK, see below), passive samplers for SO2, NO2 , BTX etc.

Table 3-3 below Indicates which European States have succeeded in adopting all required monitoring methods required by EU Air Quality Directives, including state of the art techniques such as DOAS and light scattering techniques.

Table 3-4 indicates which EU member states have employed new parameters and techniques.

Table 3-3 European States which have succeeded in adopting relevant EU Air Quality Directive Monitoring Methods

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **European Country** | **Species** | | | | | | | | | | |  |
| **SO2** | **PM10** | **O3** | **NO2** | **CO** | **PM2.5** | **Ben-zene** | **Lead** | **Ni** | **Cd** | **As** | **B(a)P** |
| **Andorra** | √ | √ | √ |  | √ | √ |  |  |  |  |  |  |
| **Albania** | √ | √ | √ | √ | √ | √ | √ |  |  |  |  |  |
| **Austria** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Cyprus** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |  |
| **Bosnia** | √ | √ | √ | √ | √ | √ |  |  |  |  |  |  |
| **Belgium** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Bulgaria** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Switzerland** | √ | √ | √ | √ | √ | √ | √ | √ |  | √ |  |  |
| **Czech** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Germany** | √ | √ | √ | √ | √ | √ | √ | √ |  | √ | √ |  |
| **Denmark** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |  |
| **Estonia** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |  |
| **Spain** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |  |
| **Finland** | √ | √ | √ | √ | √ | √ | √ | √ |  |  |  | √ |
| **France** | √ | √ | √ | √ | √ | √ | √ |  |  |  |  |  |
| **UK** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Greece** | √ | √ | √ | √ | √ | √ | √ |  |  |  |  |  |
| **Croatia** | √ | √ | √ | √ | √ |  | √ |  |  |  |  |  |
| **Hungary** | √ | √ | √ | √ | √ | √ | √ |  | √ | √ | √ |  |
| **Ireland** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Italy** | √ | √ | √ | √ | √ | √ | √ |  |  |  |  |  |
| **Liechtenstein** |  | √ | √ | √ |  |  |  |  |  |  |  |  |
| **Lithuania** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Luxembourg** | √ | √ | √ | √ | √ | √ | √ |  |  |  |  |  |
| **Latvia** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Montenegro** | √ | √ | √ | √ | √ |  |  |  |  |  |  |  |
| **Macedonia** | √ | √ | √ | √ | √ |  | √ |  |  |  |  |  |
| **Malta** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |  |
| **Netherlands** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |  |
| **Poland** | √ | √ | √ | √ | √ | √ | √ | √ |  |  |  |  |
| **Portugal** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |  |
| **Romania** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |  |
| **Serbia** | √ | √ | √ | √ | √ |  | √ |  |  |  |  |  |
| **Sweden** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Slovenia** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |  |
| **Slovakia** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **Turkey** | √ | √ | √ |  |  |  |  |  |  |  |  |  |

Table 3‑4 Countries where New Air Quality Monitoring techniques have been introduced

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | PM10 | | Benzene/BTX | | Passive samplers | |
| Hourly | Integrated | Hourly | Integrated | NO2 | BTX |
| Austria |  |  | xa |  | x1 | x1 |
| Belgium | x |  |  |  |  |  |
| Finland | x | x | x |  |  |  |
| France | x |  |  |  |  |  |
| Germany | x |  |  |  |  |  |
| Greece | x |  |  |  |  |  |
| The Netherlands | x |  |  |  |  |  |
| Portugal |  |  |  |  |  |  |
| Spain | x |  |  |  |  |  |
| Sweden | x |  | x |  |  | x |
| U.K. | x |  | x2 |  | x |  |
| Iceland | x | x |  |  |  |  |
| Norway | x | x | x |  |  | x |
| Cyprus | x |  |  |  |  |  |
| Czech Republic | x |  |  |  |  |  |
| Estonia |  |  | x |  |  |  |
| Poland |  |  |  |  |  |  |
| Slovakia | x |  |  |  |  |  |
| Slovenia | x |  |  |  |  |  |
| Switzerland | x |  |  |  |  |  |

a: half-hourly from 1995.

1 Passive sampling during limited monitoring campaigns.

2 UK has on-line, compound-specific VOC monitoring at 9 sites.

## ****Data Availability in European Networks****

One of the main features of modern monitoring networks is the ability to make the data available to users and the public soon after the measurement has taken place. Where a manual monitoring method is used, analysis is required after sampling, resulting in a significant delay (1-2 months) before data becomes available.

With widespread use of automated monitors, there has been an increase in the ability of networks to provide daily (or hourly, or near-real-time) data.

The following countries are able to make data from monitors available externally, in near-real-time (one to a few hours delay): Austria, Denmark, the Netherlands, UK, Norway, Cyprus. Typically, in these states validated data are available 1-6 months after measurement, varying between countries and annual reports are available after 2-12 months delay.

Specific information is missing for many countries, as shown in the Tables 3-2 and 3-3, specifically with regard to the sampling and analysis of PM2.5, benzene, heavy metals (PB, Ni, Cd, As) and B(a)P. With only 10 of the 37 countries listed providing information on all pollutants species.

Up to date non-validated monitor data is available at a central data base for one or more networks in the following countries: Austria, Denmark, the Netherlands, UK, Norway, Cyprus.

Validated data are in general available after 1-3 months after measurement for gas pollutants such as NO2, SO2, CO and O3, but some countries require more time to validate sample data, especially for data from manual samplers and for precipitation data.

The UK has made the data from the automatic monitor programme available on-line on the internet. The preliminary data are updated with quality controlled data regularly, after a delay of 2-3 months.

## ****Use of Models in the Air Quality Assessment****

The following countries provided information about their use of dispersion and/or other models as part of their routine surveillance and assessment of air quality: Finland, the Netherlands, Norway, Sweden, UK.

## ****Reporting****

The time delay before network reports are available varies substantially. Ozone represents a special case. For EU countries, the CAFE directive requires that ozone is reported in principle to the public every day.

For local air quality, annual reports are available 4 - 12 months after the year, depending upon country.

Some countries or networks issue monthly reports after a much shorter time delay. The reports are written in the national language, but some countries issue summary reports in English as well (e.g. Czech Republic, Slovakia, Slovenia).

1. EC, Guidance on Assessment under the EU Air Quality Directives [↑](#footnote-ref-1)
2. JRC- AQUILA, Position Paper Assessment on sitting criteria, classification and representativeness of air quality monitoring stations. [↑](#footnote-ref-2)
3. http://rod.eionet.europa.eu/obligations [↑](#footnote-ref-3)
4. List of zones in EU Member States in relation to air quality thresholds laid down in Council Directives 96/62/EC, 1999/30/EC, 2000/69/EC and 2002/3/EC Year 2006 ETC/ACC Technical paper 2008 [↑](#footnote-ref-4)