Technical Report No. 12

Criteria for EUROAIRNET

The EEA Air Quality Monitoring and Information Network

Prepared by:
Steinar Larssen, Norwegian Institute for Air Research, Kjeller, Norway,
Rob Sluyter, RIVM, Bilthoven, the Netherlands and
Constantin Helmis, National Observatory of Athens, Greece

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European Environment Agency
Kongens Nytorv 6
DK-1050 Copenhagen K
Denmark
Tel: +45 33 36 71 00
Fax: +45 33 36 71 99
E-mail: eea@eea.eu.int

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1. Introduction

1.1. General background

The European Topic Centre on Air Quality (ETC-AQ), under contract to the European Environment Agency (EEA) is required as part of its work programme to develop and maintain a European Air Quality Monitoring Network and a European Air Quality Information System in close collaboration with the European countries. The purpose is to obtain adequate background information for making air quality assessments on the European scale, in order for EEA to provide a firm basis for decisions by the Commission and by member countries on environmental policies regarding air quality.

The role of the EEA in providing information on air quality in Europe, and thus the ETC-AQ task to develop an information system, stems from the main duties of EEA and its information and observation network EIONET[1] as specified in its founding Regulation (1210/90):

- *"...to provide the Community and the Member States with objective, reliable and comparable information at European level enabling them to take the requisite measures to protect the environment, to assess the results of such measures and to ensure that the public is properly informed about the state of the environment;*
- *to provide the Community and the Member States with the objective information necessary for framing and implementing sound and effective environmental policies;*
- *to record, collate and assess data on the state of the environment;*
- *to help ensure that environmental data at European level are comparable and, if necessary, to encourage by appropriate means improved harmonization of methods of measurements;*
- *to ensure the broad dissemination of reliable environmental information. In addition the Agency shall publish a report on the state of the environment every three years;*
- *The Agency shall cooperate actively with other bodies such as ... Unites Nations and its specialized agencies".*

One of ETC-AQ's tasks is to develop a European-wide air quality monitoring network. This network, with acronym EUROAIRNET, will consist of a selection of monitoring stations[2] from networks that are in operation in the European countries today. The existing networks and stations in Europe have been inventoried by the Topic Centre in its EEA Topic Report 26/1996: "Air pollution monitoring in Europe - Problems and trends" (Larssen and Hagen, 1996). Thus, EUROAIRNET will not per se imply the recommendation to establish new monitoring stations. However, if important shortcomings are found, establishment of new stations may be recommended.

A second task of ETC-AQ work programme is to develop an improved data base for air quality data. The data base (acronym AIRBASE) has been established and is being further developed, with modules for data transfer and input, statistics calculations and presentations, and availability on Internet. AIRBASE will be the information system under the EC Exchange of Information Decision, and also the database of EUROAIRNET.

This report describes the objectives of EUROAIRNET, and the criteria behind the design and establishment of the network. The place of EUROAIRNET relative to two other EU-wide networks or reporting processes are described; namely the network and reporting to show compliance with the EU air quality directives (the Regulatory network) and the reporting under the Exchange of Information (EoI) Decision.

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[1] The European Information and Observation Network, the network of EEA together with its partner institutions, e.g. National Focal Points, Main Component Elements, National Reference Centres, European Topic Centres.

[2] In this report, the terms *station* and *site* are used interchangeably. In general, the term *station* is used when referring to the monitoring station including its location, *and* the physical installations (platform, monitors etc.), while the term site is used when referring specifically to the location.

1.2. Air quality monitoring objectives

The strategy for, and design and operation of air quality (AQ) monitoring networks is determined by the objectives of the monitoring activities:

- Compliance monitoring
  - monitoring to support legislation on air quality targets (directives): to *check compliance* with the directives.
- Representative AQ surveillance monitoring
  - monitoring to facilitate a representative description of the AQ in a city/area, state, or in Europe as a whole: to describe *the state and trend* of the air quality.
- Exposure/damage assessment monitoring:
  - monitoring to make a basis for assessing the damage caused by air pollution, to health, vegetation, materials: to *describe the effects* of the air pollution and support the development of *cost-effective abatement strategies*.
- On-line monitoring:
  - monitoring for forecasting episodes of high air pollution: to inform and warn the population, and to carry out short-term abatement actions to reduce episodic high concentrations.
- Operational monitoring:
  - monitoring of air pollution near specific sources: to avoid unacceptable pollution burden of neighbouring areas.
- Monitoring programmes to support scientific research.

Monitoring of air pollution is only one of the activities needed in the full assessment of air pollution and its effects, and in the work to abate the pollution effectively. Table 1-1 puts the air quality monitoring activities into this context. It shows how the monitoring activities relate to the other activities of emission inventory, dispersion modelling, damage assessment and cost analysis in the analytical work of cost-effective air pollution abatement.

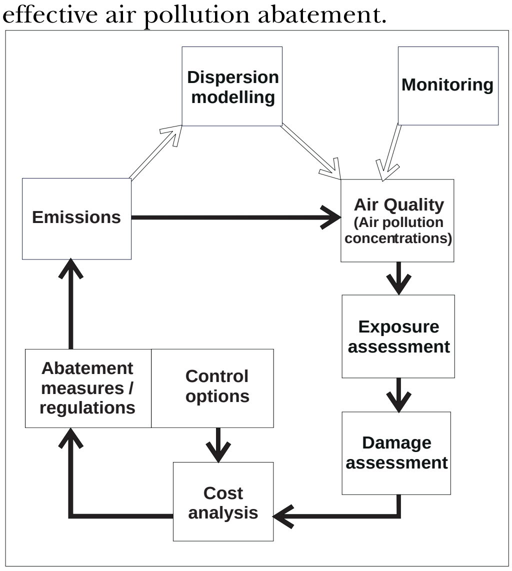

Table 1-1: Model concept for air pollution abatement based upon cost-benefit analysis.

1.3. Relationship between EU Regulatory Network and EUROAIRNET

In the context of the European Union, compliance monitoring is related to the requirements set in the Air Quality "Framework Directive" and the Daughter Directives on how to detect non-compliance or to show compliance with the directives. To answer these requirements, Member States (MS) must develop a compliance monitoring or Regulatory Network.

Representative AQ monitoring is related to the main information requirement of the European Environment Agency (EEA): to provide to the European Community and its Member States "objective, reliable and comparable information at a European level enabling the MS to take the requisite measures to protect the environment, to assess the results of such measures and to ensure that the public is properly informed about the State of the environment". To be able to fulfil this requirement to provide information, EEA must ensure that it receives air quality information, which gives a representative picture of European air quality. To fulfil the information requirements on a reasonably timely basis, EEA has also indicated that one year's data should be available within the first 6 months of the next year. To meet these two requirements the EUROAIRNET (European air quality monitoring and information network) needs to be established.

Because of the different objectives for the two networks, they will be somewhat different in a number of respects.

The main differences are:

- The Regulatory Network is set up to detect exceedances (or near exceedances). EUROAIRNET shall give representative air quality information, and thus also requires monitoring in less polluted areas.
- The compounds in the Regulatory Network are those for which the EC has set limit or targets values. EUROAIRNET will also report other compounds of interest.
- The Regulatory Network covers the EU area. Norway, Iceland and Liechtenstein are also obliged to follow the same directives, as part of the "European Economic Area" Agreement. Accession countries will eventually be required to follow the directives. EUROAIRNET is intended to cover all of Europe.

To show compliance, Member States may have to put up new monitoring stations, or relocate existing ones. The EUROAIRNET, on the other hand, will in general not require establishment or relocation of stations. EUROAIRNET will be a selection of already existing stations (of which there are more than 6,000 in Europe, see Larssen and Hagen, 1996). In some areas EUROAIRNET may be more extensive than the Regulatory Network. Nevertheless, in the process of establishing EUROAIRNET, new station locations might be proposed, if important gaps in coverage are detected.

1.4. Relationship between EoI network and EUROAIRNET

EU Member States, in the framework of so-called "Exchange of Information Decisions" (EoI), already have over 20 years experience with the reciprocal exchange of air quality data.

The objectives for establishing EUROAIRNET more or less coincide with the goals for the EoI as far as air quality reporting is concerned and it is to be expected that there will be a large overlap (in EU Member States) between stations and data transmitted in the framework of the EoI and those of EUROAIRNET in the first years.

There are, however, some marked differences between EoI and EUROAIRNET data reporting which, once EUROAIRNET is fully implemented, will differentiate the two programmes significantly:

- EUROAIRNET shall cover all of Europe, while EoI concerns the EU plus Iceland, Liechtenstein and Norway (and eventually Accession countries).
- EUROAIRNET will also provide/require data on meteorological parameters to the extent they are available to the network operators, to assist in interpretation of trends, and as input to modelling.
- Under the EoI Decision, EU Member States will have to transmit data for the calendar year by 1 October of the following year at the latest. In the framework of EUROAIRNET, EEA has indicated that data should be transmitted for the calendar year as soon as possible and within 6 months.

EoI is an air quality data reporting and public information procedure. EUROAIRNET once established will also facilitate air quality assessments, produced for EEA, on the basis of monitoring and modelling and quantitative assessment of exposure. However, initially, use will be made of the data supplied under the EoI Decision to analyse how representative these data are prior to making decisions on adding stations within EUROAIRNET to fill gaps and provide more representative coverage.

For EU Member States EUROAIRNET will build upon the station selection and reporting requirements of EoI and the Regulatory Network. Based upon the criteria developed for EUROAIRNET the representativeness of those networks will be enhanced in terms of exposure assessment. Also the data quality will improve with application of EUROAIRNET QA/QC criteria.

2. Monitoring and exchange of information in the context of the EU Directives

2.1. Compliance monitoring under EU Directives

The existing EU Directives define the strategy for air quality monitoring for the Member States to demonstrate compliance, or to show non-compliance, with the limit values of the directives. The new Directive on air quality assessment and management, the Framework Directive (FWD) (EU Directive 96/62/EC) and the new proposed Daughter Directives (DD) (CEC, 1997) likewise define such strategies on which to base the design and operation of the compliance networks of the Member States.

This chapter summarises these strategy formulations, as well as the requirements and the implications for items such as network design, QA/QC and data availability that can be derived from them.

Framework Directive and Daughter Directives

The Framework Directive sets a general framework for air quality measurement and assessment in the European Union. The FWD requires Air Quality Limit Values (AQLV) to be set in so called "Daughter Directives".

According to the FWD, measurement will be mandatory in the following cases:

- Agglomerations with more than 250,000 inhabitants, or where the population concentration is 250,000 inhabitants or less, a population density per km^2 which for the Member States justifies the need for ambient air quality to be assessed and managed.
- In zones with concentrations >x% of the AQLV (x dependent on component and specified in Daughter Directive).
- In other areas with concentrations above the AQLV.

The measurements should be taken at fixed sites, continuously or by random sampling, and the number is to be sufficiently large to determine pollution levels.

For air pollution approaching the AQLV (<x% of AQLV), combinations of measurements and other assessment techniques (modelling, objective estimation) are accepted. At low concentrations (<y% of AQLV), assessment techniques (modelling, objective estimation) may be used solely.

Position Papers (PPs) are produced by working groups, which give a recommendation for the AQLV as well as the component specific monitoring strategy. Criteria will be specified for the location of sampling points, the minimum number of sampling points and the reference measurement and sampling techniques. QA/QC recommendations are given.

Taking note of these PPs, the Commission submits to the Council proposals for Daughter Directives, for the setting of limit values (and where appropriate alert thresholds) and measurement strategies, according to the following time table:

- SO_2, NO_2, fine particulates including PM_{10} and $PM_{2.5}$, TSP, Pb: 1998
- O_3: in accordance with Directive 92/72/EEC: 1998
- Benzene, CO: 1998
- PAH's, Cd, As, Ni, Hg: 1999

The PPs and DD proposals from the Commission have been completed for SO_2, NO_2, particulates and Pb.

EEA and JRC (Joint Research Centre, Ispra) were requested by the Commission to help develop a "guidance report on preliminary assessment" in support of the assessment requirements set in the FWD.

The guidance report (van Aalst et al., 1998) provides guidance for preliminary assessments as defined under article 5 of the FWD in case no representative measurements are available.

Three assessment methods or tools should be used in combination:

- indicative air quality measurements;
- air emission inventories;
- air pollution modelling.

Member States will have to inform the Commission on all observed exceedances of limit values, including the reasons that led to an exceedance, within 9 months after the end of each year. Member States will also annually forward a list of zones and agglomerations in which levels of pollutants are higher than the limit value. Every three year a sectoral report should be forwarded to the Commission in accordance with the Framework Directive.

2.2. Exchange of information under the EoI Decision

The new Exchange of Information (EoI) Decision (Council Decision 97/101/EC) deals with establishing a reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution.

The Decision *only sets reporting requirements*, not monitoring requirements. In the considerations mentioned in the preamble, it is stated that the information collected needs to be sufficiently representative to enable pollution levels to be mapped throughout the Community. The reciprocal exchange covers only existing stations:

- which are (will be) used in the framework of the implementation of Daughter Directive adopted in accordance with the Council Directive on Ambient Air Quality Assessment and Management (“Framework Directive”);
- which, without being covered by the Directives referred to in the first indent, will be selected for this purpose amongst existing stations at national level by countries in order to estimate local air pollution levels for pollutants which are not listed in Annex 1 to the Framework Directive, and regional (so called “background” pollution) levels for all pollutants listed in the EoI Decision;
- to the extent possible, which took part in the reciprocal exchange of information established by Decision 82/459/EEC, provided that they are not covered by the previous indent.

Both raw air quality data and statistics will be exchanged for stations referred to in indent 1 and 3. For stations referred to in indent 2, at least statistics will be exchanged. Next to the air quality information, Member States will also transmit meta information on their individual stations and networks. Box 1 presents an overview of components, averaging times and statistics covered by the EoI.

The EoI Decision is complementary to the Framework Directive (96/62/EC) as it requests for additional information (raw air quality data) on top of the information Member States are obliged to transmit in the framework of the so-called compound specific Daughter Directives.

Decision 97/101/EC sets a limit of *9 months* after the end of a calendar year for data to arrive at the Commission. Up till 1995, all data transmitted in the framework of subsequent EoI Decisions were stored in APIS (air quality data) and GIRAFE (meta information on networks and stations). Since 1996 data are stored in AIRBASE, which combines APIS and GIRAFE and is being maintained and developed by EEA/ETC-AQ.

According to Article 5.6 of the new EoI Decision data transmitted in the framework of the EoI shall be made available to the public via an information system set up by EEA (AIRBASE Web-application) and data can be supplied by EEA upon request. For more information on the development of AIRBASE, refer to Sluyter et al. (1997).

Box 1: Components listed in Dec. 97/101/EC, their averaging times and requested statistics

Pollutant		Average over	Expressed as
1	**SO_2 (sulphur dioxide)**	24 h	
2	Acid deposition	1 month	
3	**Strong acidity**	24 h	SO_2 equivalent
4	**TSP (Total suspended particulates)**	24 h	
5	**PM_{10} (Suspended particulates <10 μm)**	24 h	
6	**Black smoke**	24 h	
7	**O_3 (Ozone)**	1 h	
8	**NO_2 (Nitrogen dioxide)**	1 h	
9	**NO_x (Nitrogen oxides)**	1 h	NO_2 equivalent
10	**CO (Carbon monoxide)**	1 h	
11	H_2S (Hydrogen sulphide)	24 h	
12	**Pb (Lead)**	24 h	
13	**Hg (Mercury)**	24 h	
14	**Cd (Cadmium)**	24 h	
15	**Ni (Nickel)**	24 h	
16	Cr (Chromium)	24 h	
17	Mn (Manganese)	24 h	
18	**As (Arsenic)**	24 h	
19	CS_2 (Carbon disulphide)	1 h	
20	**C_6H_6 (Benzene)**	24 h	
21	C_6H_5-CH_3 (Toluene)	24 h	
22	C_6H_5 -CH=CH_2 (Styrene)	24 h	
23	CH_2 =CH-CN (Acrylonitrile)	24 h	
24	CH_2=CH-CH=CH_2 (1,3 Butadiene)	1 h	
25	HCHO (Formaldehyde)	1 h	
26	C_2HCl_3 (Trichloroethylene)	24 h	
27	C_2Cl_4 (Tetrachloroethylene)	24 h	
28	CH_2Cl_2 (Dichloromethane)	24 h	
29	BaP (Benzo(a)pyrene)	24 h	
30	**PAH (Polyaromatic hydrocarbons)**	24 h	
31	VC (Vinyl chloride)	24 h	
32	NM-VOC (Total non-methane volatile organic 33	24 h	
33	T-VOC (Total non-methane volatile organic compounds)	24 h	
34	PAN (Peroxyacetyl nitrate)	1 h	
35	NH_3 (Ammoniac)	24 h	
36	N-DEP (Wet nitrogen deposition)	1 month	N equivalent
37	S-DEP (Wet sulphur deposition	1 month	S equivalent

Statistics pollutant 1-35:
The arithmetic mean, median, 98 percentile (99.9 percentile for pollutants for which the mean is calculated over 1 hour), and the maximum calculated from raw data corresponding to the recommended averaging times. For ozone the statistical parameters will also be registered from mean values over 8 hours.
pollutant 2, 36 and 37:
The arithmetic mean calculated from raw data corresponding to the recommended averaging times.

Pollutants printed in bold: listed in Annex 1 to the Directive on Ambient Air Quality Assessment and Management.

3. Monitoring for European-wide assessment of air quality and its effects: EUROAIRNET

3.1. Background

The recent inventory of existing monitoring networks and stations, which covered 30 European countries (Larssen and Hagen, 1996) showed that there are about 5,000 monitoring stations in urban or industrial areas and about 800 regional air pollution/precipitation monitoring stations in operation (including the EMEP stations). Annex 1 shows the summarising Tables and Figures from the above report, showing number of stations by country, compounds measured, types of sites, data availability, etc.

At present, the availability of data from those networks and stations does not fully satisfy the needs of EEA. ETC-AQ participated in the two early attempts to assess air quality on a European scale: The "Dobriš Assessment" (EEA, 1995), and ETC-AQ's "Air Quality in Europe, 1993 - A pilot report" (Larssen and Hagen, 1996b) .

The data gathering for local air quality for the Dobriš report was done through extensive questionnaires to all cities with a population above 0.5 million people (more than 100 cities). For the Air Quality in Europe 1993 project work, an update of the APIS database with data for 1993 was required. As it turned out that such data were available extensively from only a few countries (4 EU Member States), ETC-AQ had to resort also to available national reports. Consistency between these information sources proved to be a problem.

Both these exercises showed that to be able, at the present state of information availability and exchange, to report on European local/urban air quality from a fairly recent year, many person months of work are necessary to collect data, harmonise the description, attempt to fill gaps, and summarise. As a rule data are not available such that they can be used in an efficient way to produce what deserves to be called a *comprehensive status description of European air quality*, within a reasonable time (1-2 years) after actual monitoring took place. The work in 1997 on the EEA's "Air Pollution in Europe 1997" (EEA, 1997) report showed that data availability has not changed much since the earlier report. In the 1997 report, mostly 1993 data on urban air pollution still had to be used since not much later data was available.

Our experiences make it quite clear that to be able to fulfil the information requirements of the EEA, as stated above, it is necessary to establish a Europe-wide, harmonised network with operative procedures for data quality control and regular transfer to the reporting agency/institution. Without such a designated, representative network, the information requirements to the Agency can hardly be fulfilled. The background for EUROAIRNET, its goal and objectives and steps in its development were first presented at the first European Workshop on Air Quality Monitoring and Assessment held at EEA in Copenhagen in April, 1996 (Larssen, 1996).

Site and network representativeness, and data quality are two important issues for EUROAIRNET. An ETC-AQ report: First Evaluation of Representativeness and Quality of Monitoring Networks and Stations (Helmis et al., 1998, in press) has addressed the questions of representativeness of networks and stations, and of quality requirements.

EUROAIRNET will put emphasis on the monitoring of air pollution in urban areas across Europe. However, as EEA assessments should cover materials and ecosystems as well, the regional scale should also be included. To this end, a close co-ordination with the data collection networks on the regional scale in Europe must be developed, particularly with the EMEP network, but also with WMO/GAW. The recent EMEP-WMO Workshop on Monitoring Strategies (Schaug and Uhse (eds.), 1997) provides important summaries of experiences on regional scale monitoring in Europe, and conclusions and recommendations regarding monitoring requirements for various purposes and uses of the data.
A number of items need to be considered in the development and establishment of EUROAIRNET:

– Define goals, objectives and strategies related to the objectives.
– Select areas to be monitored (cities, industrial areas, rural areas) and as part of that: Address the question of representativeness.
– Select compounds, indicators and methods.
– Set quality requirements.
– Establish data transfer procedures (transfer to the ETC-AQ central database, AIRBASE).

The development of the criteria for selection, and the actual selection of stations will be done in co-operation between the countries and ETC-AQ. For that purpose, representatives from ETC-AQ visit the countries' NRCs to discuss these items. The present report represents the consensus between the Topic Centre and the NRCs on the criteria for area and station selection for EUROAIRNET. In the Phare countries a similar consensus will be established between the NRCs and the Phare Topic Link - Air Quality.

EUROAIRNET as a network, and the criteria and procedures involved in its definition and operation should have a strong element of stability and continuity, but undoubtedly there will be a need for regular evaluations and revisions. Procedures for evaluations and revisions will be proposed after establishment and first experiences of the first version of the network.

3.2. Goal of EUROAIRNET

The *goal* of the European Air Quality Monitoring Network (EUROAIRNET) is:

> *to establish a network with sufficient spatial coverage, representativeness and quality to provide the basic data as soon as possible, with a time delay not longer than six months, to fulfil the information requirements of EEA*[3].

3.3. Objectives of EUROAIRNET

The EUROAIRNET shall provide information to support and to facilitate the assessments of air quality to be produced by EEA. The information shall be available in such a form that it is suitable:

- to facilitate a general description of air quality, and its development over time (trend);
- to enable comparison of air quality across Europe;
- to produce estimates of exposure of the European population, and of materials and ecosystems;
- to estimate health effects;
- to quantify damage to materials and vegetation;
- to produce emissions/exposure relations and exposure/effect relations;
- to support development of cost-effective abatement strategies;
- to support legislation (in relation to air quality directives);
- to influence upon, inform, and assess effectiveness of policies.

The assessments should be based upon concentration fields (space-time fields) produced by the monitoring network or by a combination of monitoring and modelling, and should cover local as well as regional scale. The modelling efforts are essential in forming the link between emissions on the one hand and exposure and effects on the other hand.

The specific objectives behind the EUROAIRNET network can be separated in three stages:

Stage 1 objective:	Air pollution exposure assessments on the European scale to be produced by monitoring alone.
Stage 2 objective:	Air pollution exposure assessments to be produced by a combination of monitoring and modelling.
Stage 3 objective:	The network will support quantitative assessments of exposure and effects, a basis for proposing cost-effective abatement strategies.

[3] The EEA's tasks related to monitoring and information collection are listed in Annex 2.

The Stage 1 objective requires a network that is representative for the different exposure situations in the various cities and regions in Europe.

The Stage 2 objective requires in addition that stations are selected that are suitable for comparison with calculations using dispersion models. Also, meteorological measurements in the various areas (i.e. cities) are necessary, and also local inventories of emissions, spatially distributed in a grid net.

The Stage 3 objective requires in addition quantitative information about details in the distribution of the exposed objects (population, materials, ecosystems), and dose-response relationships. For example, assessing detailed population exposure to quantify health effects needs models for coupling between air quality and population in space and time, and dose-response relationships for the various health effects.

In the first phase of EUROAIRNET establishment, the Stage 1 objective should be the guiding one, but the Stage 2 objective should also be fulfilled in some selected cities.

3.4. Strategy for air quality assessment and control using EUROAIRNET and additional networks and other elements of air quality management

A long term strategy for assessment and control of air pollution and its effects should in principle follow the concept visualised in Table 1-1.

The establishment and operation of EUROAIRNET should answer to the need for monitoring data for a first estimate of the exposure and thereby the effects. To enable cost-efficient abatement of air pollution on the local urban scale, several preparatory steps are necessary for a harmonised analysis to be carried out under the responsibility of local authorities:

- selection and validation of dispersion modelling tools, for local, urban and larger scales;
- development of methodology for urban emissions inventorying, and subsequent use in cities all over Europe;
- improvement of dose-response relationships to estimate effects;
- cost-benefit or cost-effectiveness analysis.

4. Criteria for the design and establishment of EUROAIRNET

Criteria for the following items are described below:

- Selection of areas to be monitored;
- Classification of monitoring sites (location);
- Area of representativeness of monitoring stations;
- Selection of compounds;
- Quality assurance and quality control (QA/QC).

In this chapter, design criteria are described that are related to Stage 1 of EUROAIRNET, that is assessment from monitoring alone.

4.1. Selection of areas to be monitored

EUROAIRNET should give a “representative” picture of air quality in Europe. The term “representative” is defined here in terms of pollution effects, which again are a function of the *exposure* of people, objects and ecosystems to the air pollution. Thus, EUROAIRNET should give a representative picture of the exposure. Criteria for selection must then relate to:

- the spatial distribution of populations, objects and ecosystem;
- the range of exposure situations in space and time, from low to the highest exposure.

This spatial exposure distribution is different for each compound and for each type of exposed “stock at risk” (people, objects, ecosystems). The national states are suitable entities on which to apply the criteria for selection. Many smaller geographical entities like country regions will not have a sufficiently extensive monitoring network to fulfil the selection criteria. Even some states will not fulfil the criteria, so the fulfilment of the selection criteria must be judged for the whole of Europe, or for regions of Europe separate.

4.1.1. Representative monitoring of population exposure

The total population of Europe was in 1995 790 million. 370 millions live in the 18 EEA member states, 115 millions in the 13 PHARE countries, 230 millions in the seven TACIS countries and 75 millions in the six other countries Turkey, Switzerland, Croatia, Serbia-Montenegro, Cyprus, and Malta. In all of Europe, there are some 120 cities with a population of more than 500,000, with a total of more than 140 million inhabitants. This is shown in Table 4-1, together with a further roughly estimated sub-division of the city population.

Due to differences in the level of economical and technical development, sources of air pollution, and thus the air quality, differ between the broad regions of EEA, PHARE and TACIS countries. There are also differences, however smaller, between regions within each of these groups of countries.

Within each of these regions, cities experience different air pollution levels due to differences in (in approximate decreasing order of importance): dispersion conditions, source composition, size. In rural areas, the pollution level also varies spatially, dependent upon the city emission sources, larger power plants and industrial complexes, and regional traffic activity in the area at a distance of 100-500 km.

Table 4-1: Population data, Europe.

	Total population (millions)	Population in sub-divisions (millions)	No. of units
Europe	790		
EEA countries		370	18 countries
PHARE countries		115	13 countries
TACIS countries		230	7 countries
Other countries		75	6 countries
Urban population[1)]	295		
In cities with >0.5 mill.		140	≈ 120 cities
In cities with 0.25-0.5 mill.		43	≈ 130 cities
In cities with 0.05-0.25 mill.		112	≈ 1300 cities
Rural population[2) 3)]	495		

[1] Excl. urban population in Cyprus, Croatia, Malta, Serbia-Montenegro, Switzerland, and Turkey.
[2] Incl. towns with less than 50,000 inhabitants.
[3] Incl. urban population in the six "other" countries.

EUROAIRNET must eventually cover all these different types of areas in such a way that the whole population is represented.

Table 4-2 shows the criteria proposed for selecting the areas to be monitored: cities of different sizes, rural areas of different categories and industrial areas outside cities.

Cities

With other parameters equal, city centre pollution levels increase with the city size (i.e. population), although considerably less than proportionally. All large cities (defined as >0.5 mill. inhabitants) and country capitals as appropriate should be selected for EUROAIRNET. For the smaller cities, a subset must be chosen. Somewhat arbitrarily, it is proposed that at least 25% of cities of 0.25-0.5 mill. inhabitants (medium cities), and 10% of cities of 0.05-0.25 mill. inhabitants (small cities) should be included. These criteria result in a total of 118 large, ≥33 medium and ≥115 small cities in Europe to be included (see Table 4-2). Selected arbitrarily within each size class (taking account of the frequency distribution of city sizes in Europe), the selected cities would then account for about 45% of the urban population in Europe, of which 80%, 9% and 11% live in large, medium and small cities, respectively.

When selecting the cities, the extent of industrial sources with significant air pollution impact within the cities should be considered. Within each size range, cities with low, medium and high level of industrialisation should be represented.
In the selected cities, all monitoring stations should be part of EUROAIRNET, to get as good basis as possible for estimating the population exposure. A good spatial distribution of urban background stations is particularly important.

Rural areas

In rural areas (which here means areas outside cities larger than 50,000 inhabitants), emphasis on air monitoring for health effects should be on secondary pollutants such as ozone, and PM_{10} (and finer particles, $PM_{2.5}$).

Areas with population density over a certain level should be identified in each country. Many of those areas should be monitored, such that a substantial part of the rural population is covered by the monitoring network. Each country should evaluate the necessary extent of monitoring in populated rural areas, based upon:

- a listing of the areas with population above a certain density limit (to be decided by each country);
- the area of representativeness of monitoring stations located in the areas, based upon knowledge of the spatial variation of the air pollutant in question.

Industrial areas outside cities

Such areas exist in most countries. Areas should be selected where such industries cause air pollution levels approaching those of medium size cities, or approach WHO Air Quality Guidelines or the proposed new EU Limit Values (CEC, 1997).

Summary

According to Table 4-2, the criteria result in a total of more than 260 cities to be monitored, and maybe a total of 100-200 rural areas, in addition to industrial areas outside cities.

These criteria can be applied as a guideline by each state to select its areas to be monitored as part of EUROAIRNET. However, for each state, particularly those with a limited number of networks, it may prove difficult to fulfil the criteria in Table 4-2, unless new networks/stations are established. It will be of importance to ensure, though, that viewed as a whole, the total EUROAIRNET stations selection will approximately fulfil those criteria.

Table 4-2: Criteria for selecting areas to be monitored for representative population exposure assessment in Europe[1)] (Population in millions)

	Total population (millions)	EEA		PHARE		TACIS		Selec-tion criteria	Total number of areas to be monitored	Total population covered
		No. of units	Σ Pop.	No. of units	Σ Pop.	No. of units	Σ Pop.			
Cities										
> 0.5 mill.	140	67	79	11	12	40	49	All	118	140
0.25-0.5 mill.	43	56	18	23	8	50	17	≥ 25%	>33	~15
0.05-0.25 mill.	112	659	63	195	19	302	30	≥ 10%	>115	~20
Rural areas [2)]	495									
Industrial areas outside cities [3)]										

1) This does not cover 6 "other" countries: Cyprus, Croatia, Malta, Serbia-Montenegro, Switzerland, Turkey.
2) Rural monitoring needs and networks to be determined and selected by each country.
3) Monitoring in all areas with significant pollution levels (approaching WHO-AQG or EU Limit Values) in populated areas near the industries.

4.1.2. Representative monitoring of exposure of materials

Most material exposure is related to human activities and is well correlated to the population in the areas. Urban and industrial areas will therefore represent the major part of and the highest cost of material damage. In rural areas the total amount is much smaller. Even so, valuable and prestige buildings and monuments are also found in rural areas.

The building techniques and materials used may differ between states and for bigger states even inside the country. The selection of sites must take this variation in customs and techniques into account, to have representative sites for the different areas.
Inside a city the deterioration is affected by the pollution levels observed. Three sites might be chosen, representing the highest city background level (often near the city centre), a more average background level in the city, and a traffic hot-spot station.

In industrial areas, two sites representing the high and medium pollutant levels of the area could be selected.

The material deterioration is also affected by the climatic conditions. The sites should therefore be selected so the different climatic conditions inside a country are represented by the site selection.

There is an existing network of atmospheric corrosion stations in Europe, operated under the UN/ECE Convention of Long Range Transboundary Air Pollution (LRTAP), Working Group on Effects (WGE): the International Co-operative Programme (ICP) on effects on materials (Swedish Corrosion Institute, 1989; UNECE, 1997). The 31 stations in 16 countries (overview, see Table 4-3) all measure weight loss of material samples (steel, zinc, copper) as well as air pollutants and meteorological variables of significance to the corrosion process. This network may represent a start of a more complete network of combined corrosion/air quality stations. Further analysis of the data available from this network will be required before proposing whether or not extension of the network is required.

Table 4-3: Classification of the monitoring sites included in the ICP on Effects on Materials.

Countries	Number of sites				
	Traffic	Industry	Urban background	Near city	Regional
EEA countries					
Belgium			1		
Finland					1
France			1		
Germany		1	1	1	1
Greece			1		
Italy	2		1		1
The Netherlands		1			1
Norway			1		2
Portugal			1		
Spain		1	1		1
Sweden			2		1
United Kingdom			2		
PHARE countries					
The Czech Republic		1	1		
Estonia					1
TACIS countries					
Russia			1		
Other countries					
Switzerland					1
TOTAL	2	4	14	1	10

In addition to these, a large number of stations measuring only corrosion (weight loss) exist in Europe, in local and national programs. These are not operated under one network, and there is no central data base for this.

4.1.3. Representative monitoring of exposure of ecosystems

The ecosystems and the natural factors influencing them (e.g. the atmosphere, soil and water conditions) vary of course strongly from region to region in Europe, and also within regions. Also, since the air pollution concentrations and deposition varies strongly, representative monitoring of ecosystems means that a monitoring programme needs to cover a large selection of ecosystems, i.e. the regions and areas within regions.

The potential impacts of air pollutants on ecosystems or parts of ecosystems are investigated through various national and international monitoring programmes. Under the UN/ECE Convention of Long Range Transboundary Air Pollution (LRTAP) a Working group on Effects (WGE) has been established which consists of four International Cooperative Programmes (ICPs) dealing with various types of eco-systems (UNECE, 1997). The ecosystems dealt with are:

- fresh waters,
- forests,
- agricultural crops,
- whole ecosystems by integrated studies of waters, soil, forests.

(Sea Waters is not included in the WGE ICP programme.)

The main focus of these ICPs has been to provide information on the sensitivity of the ecosystems to pollutant loads, that is in particular to provide a scientific basis for emission control strategies. In all ICPs one of the main objectives is to assess the impact of air pollution with respect to regional variation. The ICPs on forests and integrated monitoring include regional measurements of air pollutants. The monitoring sites are preferably located in rural areas.

The ICP on *Forests* includes more than 660 permanent observation plots in 29 countries. Measurements include atmospheric deposition and meteorology in a number of these plots, and it is foreseen that this will be covered in about 70% of the plots.

In the ICP on *Crops and Non-Wood Plants*, attention is focused on ozone-induced damage. Regular monitoring of ozone and S- and N-compounds in air is performed at 46 experimental plots in 17 countries.

The ICP on *Integrated Monitoring* database includes, in principle, data from 59 plots in 20 countries with a varying program of air and precipitation chemistry measurements.

To give a representative picture of exposure of ecosystems to air pollution, the network of stations in these programs needs to be combined with other monitoring networks on the regional scale, such as the EMEP stations, and other regional monitoring stations in national networks, with emphasis on measurements of ozone, SO_2 and NO_2, and deposition of S- and N-compounds.

Ecosystem types and ecosystem spatial distribution over the country show considerable variation across Europe. It is therefor proposed that, for the moment, each country should develop its own plan of monitoring air pollution and deposition such that a representative picture of exposure of the ecosystems can be given. On the basis of a subsequent evaluation of this information, a common European Strategy may be developed.

4.2. Classification criteria for monitoring stations

Under the EoI Decision described in Chapter 2.2, stations are classified according to the following criteria:

- Type of station (traffic, industrial, background)
- Type of zone (urban, suburban, rural)
- Characterisation of zone (residential, commercial, industrial, agricultural, natural and combinations of these, e.g. RES/COM, COM/IND, IND/RES, RES/COM/IND, AGR/NAT).

Table 4-4 shows the classification scheme (details in Annex 3).

For traffic stations, EoI asks for the additional information:

- type of street (wide, narrow, canyon, highway or “other”, for example cross roads, bus stop, etc.),
- traffic amount (in 3 classes: <2,000, 2,000-10,000, >10,000 vehicles per day).

Except for traffic volumes used to classify traffic oriented stations, there are no written criteria or definitions, quantitative or qualitative, on which to base the classification of EoI stations. This may give rise to different interpretations by the Member States.

Table 4-4: Exchange of Information (EoI) site classes.

Type of station		Type of zone		Characterisation of zone	
Traffic	(T)	Urban	(U)	Residential	(R)
Industrial	(I)	Suburban	(S)	Commercial	(C)
Background	(B)	Rural	(R)	Industrial	(I)
				Agricultural	(A)
				Natural	(N)
				Res/Com	(RC)
				Com/Ind	(CI)
				Ind/Res	(IR)
				Res/Com/Ind	(RCI)
				Agri/Natural	(AN)

The EoI classification has 3 types of stations: traffic, industrial, background.

The background station class has the subclasses *urban, suburban* or *rural.* Rural stations can be located fairly near or very far from sources. For rural sites located relatively close to emission sources, the pollution level will be dependent on actual distance, especially for primary pollutants. For ozone, distance to sources of NO_x is important.

Additional classification of rural stations is therefore beneficial, in order to be able to compare stations (see Annex 3, chapter 3 for details):

- Urban and suburban background stations:

  Located within urban areas/agglomerations.

- Rural stations

  - Near-city background stations:

    Located in rural/agricultural areas, with a distance of 3-10 km from built-up areas and other major sources.

  - Regional stations:

    Located in rural/agricultural areas, with a distance of 10-50 km from built-up areas and other major sources.

  - Remote stations:

    Located in rural/natural areas, with a minimum distance of 50 km to built-up areas and other major sources.

The rationale for the subclass "near-city background stations" is to have a separation between stations that are influenced by nearby large agglomeration(s), and the regional stations influenced more by an ensemble of upwind sources (long-range transport) with no discernible influence from a single source area. Rural stations in areas with many closely located cities, such as in the Ruhr area and parts of the Netherlands, may be near-city background stations.

The EoI station classes are relevant to differing degrees for exposure of populations, materials and ecosystems:

Station classes	*Relevant for exposure of* Population	Materials	Ecosystems
Traffic stations	x	(x)	
Industrial stations	x	x	x
Background stations			
- Urban/suburban background stations	x	x	(x)
- Background stations			
- Near city background stations	x	x	x
- Regional background stations	x	(x)	x
- Remote stations			x

The EoI classification is described in more detail in Annex 3, together with the detailed information concerning stations, station environments, etc.

The classification of stations under EUROAIRNET will generally follow the EoI classification. This means that in connection with selecting and reporting data from stations for the EUROAIRNET process, countries will not be requested generally to classify stations differently from the EoI classification.

However, to enable the use of EUROAIRNET data for comparison of air pollution levels between cities, countries, or different environments, some specific additional information about the stations may be needed; information that is not part of the EoI classification. Such additional information includes for instance:

For Traffic stations:

- Traffic volume (accuracy: ± 2,000 vehicles/day)
- Traffic speed (accuracy: ± 5 km/h, average daytime traffic)
- Distance from kerb (accuracy: ± 1 meter

For Background/Rural stations:

- Distance to nearest built-up areas and other major sources.

For such stations, countries will be asked for the additional data and information.

4.3. Area of representativeness of a monitoring station

A monitoring station gives air quality data that are representative for a certain area around the station. The area in which the concentration does not differ from the concentration measured at the station by more than a specified amount can be called the *area of representativeness* of the station. The specified amount could be the total measuring uncertainty, or the data quality objective (quantitative value) for the pollutant under consideration (see chapter 4.5).

A determination of the area of representativeness (quantitatively, or qualitative evaluation) is of value when monitoring data are to be used to calculate exposure (of the population, or materials, or ecosystems), and also when used to validate dispersion models.

The area of representativeness varies with type of station. For a traffic hot-spot station it may be in the order of less than 10 metres. For a regional station it might have a radius of tens of kilometres. It depends strongly on the concentration difference allowed in the definition, and on the immediate environment of the stations, its morphology and sources. This immediate environment will be described for each site, as part of the meta-information in AIRBASE.

The area of representativeness is not easily determined. It requires either extensive monitoring at several adjacent sites covering an area around the station, or rather detailed dispersion model calculations based upon detailed emission inventories, both for the area in question and the larger surrounding area.

In practice, such determinations are rarely performed. However, an evaluation of the representative area is of considerable value when using monitoring data from a network, such as EUROAIRNET, to estimate exposure. Thus the determination of station class should be accompanied by an evaluation of the station's area of representativeness.

Table 4-5 lists indicative typical ranges of the area of representativeness (radius of area) for the various station classes.

Table 4-5: Area of representativeness (radius of area) for various station classes. Range of values.

Station class	Radius of area
Traffic stations	*)
Industrial stations	10-100 m
Background stations:	
- Urban background stations	100m-1 km
- Near-city background stations	1-5 km
- Regional stations	25-150 km
- Remote stations	200-500 km

*) not applicable. See page 30 for details.

This indication should not be used directly, without an evaluation for each station. When evaluating the area of representativeness, account should be taken of:

- the emission variations in the immediate surroundings and possible localised influence of dominating sources further away,
- topographical features (both buildings and natural) influencing the dispersion and transport of the emissions.

4.4. Selection of compounds/indicators and methods

4.4.1. Compounds/statistics

Compound specific EU directives exist and are being modified or developed for SO_2, NO_2, O_3, CO, benzene, lead and particulate matter (previously: SPM; in future: PM_{10} and even finer particle fractions, such as $PM_{2.5}$, PM_1). The Framework Directive lists these compounds, and in addition PAH (BaP) and the heavy metals As, Cd, Hg and Ni as compounds that should be taken into consideration. The EoI Decision lists a total of 37 compounds for which countries should report air concentrations and deposition if available (see Box 1, chapter 2.2).

The World Health Organization (WHO) has described air quality criteria for 29 compounds (WHO, 1987). Revised criteria have been defined for the substances PM, NO_2, O_3, and SO_2 (WHO, 1996).

Table 4-6 gives an overview of the compounds mentioned.

When selecting compounds to be included in EUROAIRNET, the following criteria should be considered:

- The compounds should be related to actual air pollution problems in Europe, at present and foreseen in the future.
- The compounds should be measured fairly extensively in Europe, or the extent of monitoring should be increasing due to emerging concerns (for example: PM_{10} and $PM_{2.5}$).
- Only compounds for which quality assurance and control procedures exist or are being developed should be included.

The compounds listed in Table 4-7 is proposed for inclusion in EUROAIRNET, Phase 1, for the 3 types of receptors: population, materials, ecosystems. The compounds and indicators are listed in 3 groups of priority. The networks and stations selected should first cover at least most of the Priority 1 compounds.

Data should be reported (transferred to AIRBASE) according to the indicated averaging time for each component. Statistical parameters will be calculated by the ETC-AQ.

When making assessments of the air pollution situation in cities, regionally, for the whole of Europe, certain combinations of compounds and averaging time are often selected to give an adequate description of the situation without going into more detail than necessary. Such selected compounds may thus be called pollution *indicators*. Indicators can also be made as combinations of 2 or more compounds (then often called *pollution indices*).

Table 4-6: List of harmful substances in air considered by EU and by WHO.

Substances for which criteria have been considered by WHO (WHO, 1987; 1996)	Substances selected by EC (EoI Decision, 97/101/EC)	Substances for which Limit and/or Guide Values have been given by EC, or considered ( )
Sulphur dioxide*	Sulphur dioxide	Sulphur dioxide**
	Acid deposition	
Acid aerosols	Strong acidity	
Suspended particulates (total)	Suspended particulates (total)	Suspended particulates
Suspended particulates* (<10 µm)	Suspended particulates (<10 µm)	Suspended particulates (<10 µm)**
Black smoke	Black smoke	Black smoke
Ozone*	Ozone	Ozone
Nitrogen dioxide*	Nitrogen dioxide	Nitrogen dioxide**
Nitrogen oxides	Nitrogen oxides	
Carbon monoxide	Carbon monoxide	(Carbon monoxide)
Hydrogen sulphide	Hydrogen sulphide	
Lead	Lead	Lead **
Mercury	Mercury	(Mercury)
Cadmium	Cadmium	(Cadmium)
Nickel	Nickel	(Nickel)
Chromium	Chromium	
Manganese	Manganese	
Arsenic	Arsenic	(Arsenic)
Carbon disulphide	Carbon disulphide	
Benzene	Benzene	(Benzene)
Toluene	Toluene	
Styrene	Styrene	
Acrylonitrile	Acrylonitrile	
	1,3 Butadiene	
Formaldehyde	Formaldehyde	
Trichloroethylene	Trichloroethylene	
Tetrachloroethylene	Tetrachloroethylene	
Dichloromethane	Dichloromethane	
Benzo(a)pyrene	Benzo(a)pyrene	
Polyaromatic hydrocarbons	Polyaromatic hydrocarbons	(Polyaromatic hydrocarbons)
Vinyl chloride	Vinyl chloride	
	Volatile organic compounds	
	Volatile organic compounds (total)	
	Peroxyacetyl nitrate	
	Ammoniac	
	Wet nitrogen deposition	
	Wet sulphur deposition	

* Revised by WHO, 1996. ** New proposed EU Limit Values (CEC, 1997).

Table 4-7: Selected compounds and indicators to be included in EUROAIRNET, Stage 1.

	Population exposure		Materials exposure		Ecosystems exposure	
	Aver. time	Medium/ compound	Aver. time	Medium/ compound	Aver. time	Medium/ compound
Priority 1	1h (24h)[1)] 1h or 24h 24h or[2)] longer	Air. SO_2, NO_2, NO_x, O_3 PM_{10}, $PM_{2.5}$ Pb	24h or longer " aa	Air: SO_2, O_3, NO_2, temp., relative humidity Precipitation: mm, pH Materials[3)]: Weight loss, steel panels	1h 24h aa 24h	Air: O_3 SO_2, SO_4^{2-}, NO_2 NO_x Precipitation: SO_4^{2-}, NO_3^-, NH_4^+, Ca^{2+}, pH, (H+)
Priority 2	1h 1h or 24h 24h or[2)] longer	CO SPM (or TSP), BS Benzene, PAH, Cd, As, Ni, Hg	24h or longer " " aa	Air: HNO_3 (gas) Precipitation: Cl, SO_4^{2-}, NO_3^- Soiling: PM_{10}, SO_4^{2-} Materials[3)]: Weight loss, zinc panels	1h	Air: VOC, NO_x
Priority 3	Other compounds		aa	Materials[3)]: Weight loss, copper panels. Damage to calcareous stone		

aa: Annual average/exposure.

1) To be able to fully evaluate the measured levels relative to guidelines, these compounds should be reported as 1-hour averages.
24-hour average data from integrating samplers will also be accepted.

2) For these compounds, mainly long term average concentrations are of interest for the assessment of effects. However, measurement methods often take much shorter samples (for example 24-hour or weekly samples), and shorter samples are also needed in order to explain variations in terms of source contributions, etc.

3) Measurements of weight loss of standardised panels of material, measured according to standard procedures (Swedish Corrosions Institute, 1989).
Priority 1 Steel
Steel is the most frequently used reference material for characterisation of the corrosivity of the environment through out the world. Several ISO standards use this material since the corrosivity of steel is highly reproducible if the same production badge is used for the exposure.
Priority 2 Zinc
Zinc is used as reference material in standards in the same way as steel. Zinc tends to give slightly different results compared to steel mainly because zinc gives larger spread in the exposure results.
Priority 3 Copper and calcareous stone
These two materials are to a less extent used as reference materials. However, they are important materials for our cultural heritage. Copper has a slow corrosion rate and may need longer exposure time than one year. Calcareous stone will differ in quality from stone quarry to stone quarry. Each country is recommended to select its own reference material for stone among the most frequently used calcareous stone types there.

4.4.2. Methods

For all compounds, either *reference methods* must be used, ***or else*** *equivalent methods.* That is methods that have been demonstrated, to the EU Commission, to have a satisfactory correlation (in quantitative terms) with results from the reference method.

The European standards organisation CEN is presently working on harmonisation of measurement methods for the pollutants dealt with in the proposed new EU Daughter Directives (SO_2, NO_2, PM_{10}, Lead). It is anticipated that new standards will be available in time for the implementation of the Directives. Annex 4 refers to the existing reference methods for sulphur dioxide, nitrogen dioxide and lead to be carried forward and to a draft CEN standard for sampling PM_{10} to be adopted as a first step. The Air Quality Framework Directive (EU Dir. 96/62/EC) includes procedures for adapting measurement methods to technical progress when the new CEN standards are available for consideration. The same procedures will enable criteria and techniques for other assessment methods also to be adapted as necessary to technical progress.

4.5. QA/QC for the EUROAIRNET

4.5.1. Background

In air quality measurement systems, the **Quality system**, comprising Quality Assurance and Quality Control (QA/QC) is concerned with all the activities that assure that a measurement meets defined standards of quality.

The quality terms relevant for QA/QC procedures and criteria can be defined as follows (ISO 8402, 1994):

- Quality is the totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs.
- Quality Assurance involves the management of the entire process which includes all the planned and systematic activities which are needed to assure and demonstrate the predefined quality of data, to provide adequate confidence that an entity will fulfil requirements for quality.
- Quality Control comprises the operational techniques and activities that are undertaken to fulfil the requirements for quality.

The Quality Assurance activities cover all the pre-measurement phases, ranging from definition of data quality objectives to equipment and site selection and personnel training. The Quality Control operational functions cover, directly, activities connected to the measurements such as routine checks, calibration and data handling. An extended review of the above mentioned procedures is given in Lalas and de Saeger (1996).

After the establishment of the air quality measurement network and stations, Quality Assurance may also be viewed as “external quality control”. That is the activities performed on a more occasional basis, usually by a person apart from the normal routine operations, for example independent audits and inter-laboratory comparison. The latter is, sometimes, called Quality Assessment.

The parts of a quality plan, Quality Assurance - Quality Control - Quality Assessment, may be separate but must be operational and co-ordinated and must be considered as a necessary part of any air quality monitoring system.

The Quality system of a monitoring network must explicitly define the responsibility and authority for each of the activities contributing to data quality, and the co-ordination between them (Schaug, 1998). Each network should have a designated **Quality Assurance Manager**, responsible for implementing the Quality System, and for activities improving the quality.

4.5.2. Data Quality Objectives related to monitoring objectives

The first step in designing and implementing a QA/QC plan is to define the monitoring objectives. The objectives of EUROAIRNET are described in chapter 3.3. Afterwards, **Data Quality Objectives** (DQO) must be established to ensure that the data collected are sufficient and of adequate quality for their intended uses derived from the monitoring objectives.

In this approach, an assessment of the necessary accuracy of the data should be made, based upon the intended use of the data (i.e. the monitoring objective). This would then be the DQO regarding accuracy.

For clarification, consider the following two examples:

1. In the analysis of air pollution trends at a certain station, an estimate of the expected trend should be made, as well as an assessment of how to correct for the interannual variation in meteorology. Current normal trends are in the order of 10-50% per decade. This infers accuracy DQOs of the order of 1-5% for trend detection, if the trend is to be detected over (after) a few years.
2. As another example, consider acid deposition. The DQO for measurement of a certain component (for instance nitrate in precipitation) will depend on the accuracy required in the total acid deposition (N+S), and on the contribution of nitrate wet deposition to this total acid deposition. If this contribution is small, a relatively large uncertainty in the measurement will not affect the result very much. This example illustrates that DQOs may vary over Europe.

DQO may depend on the statistical parameter considered (averages, percentiles), on the averaging time (1h, 24h) and on the period (summer, year).

As it is often not easy to formulate requirements for the accuracy of assessment results, such as trend, deposition or exposure, this uncertainty analysis is often omitted. Instead, surrogate DQOs are formulated which reflect more the current best measuring practice and best available technical means.

Such surrogate DQOs have the advantage that realistic objectives are set which can be achieved at reasonable costs, and that comparable procedures are recommended. The obvious disadvantage is that, if the DQO does not satisfy the assessment need, the measurement is not useful for the intended purpose.

There is often a difference between the Data Quality Objective (which is dependent of the use of the data) and currently best achievable data quality (surrogate DQO). If best available data quality is used for the definition of DQO, it should be realised that the measurement quality may not satisfy all user needs.

The DQOs for EUROAIRNET may be defined in terms of the following parameters, which are indicators of data quality:

- precision,
- accuracy and/or correctness,
- representativeness,
- data capture,
- time coverage,

See Box 2 for definition of these data quality indicators.

It is of key importance that DQOs are to be met with regard to the overall uncertainty of the measurements in the field. It may however be difficult to estimate these uncertainties for the indicators mentioned on the basis of laboratory and field tests and data collection characteristics.

Having defined the DQOs it is necessary to establish a QA/QC plan. This is a technical document that shall specify all the QA/QC activities required to achieve the data quality objectives (DQOs). It should also describe how the data will be assessed for precision, accuracy, representativeness, completeness (combined data capture and time coverage) and comparability. Finally, it should describe the mechanisms to be used when corrective actions are necessary.

The QA/QC plan should assure that the quality of the data is known, and the total measuring uncertainty can be quantified and is available to users of the data.

Suggested DQOs for EUROAIRNET are given in Section 4.5.4.

4.5.3. QA/QC criteria for the selection and quality classification of EUROAIRNET stations

Data quality and reliability are considered to be key elements for the achievement of EUROAIRNET's goals. The existence and implementation of QA/QC plans are thus a necessary feature of the networks and stations that are included in the EUROAIRNET structure, so that the reliability of the air quality monitoring data is assured.

Since EUROAIRNET is mainly going to be assembled from already existing air quality monitoring stations from various networks, and with varying degree of QA/QC plan completeness, a set of QA/QC criteria had to be developed for the selection and classification of the stations.

The characteristics of EUROAIRNET related to QA/QC plan are:

- EUROAIRNET shall cover all of Europe. It means that it will cover 31 European countries and numerous monitoring stations will be candidates (chapter 3.1).
- The objectives of EUROAIRNET that guide the quantification of DQOs, are:
  - the data shall enable comparison of air quality across Europe,
  - the data shall enable detection of the current trends in air quality in Europe, as well as in each area where stations are located, over a reasonable time period (3-5 years, dependent upon the magnitude of the trend).
  - the data shall enable the assessments of exposure.
- The quality of the data, and the compliance with the QA/QC criteria and requirements set for EUROAIRNET (see Section 4.5.4), is the responsibility of the data providers.

The existing candidate stations are in operation under several organisational structures, with different methodologies and techniques of air pollution measurements. Consequently, stations of EUROAIRNET will operate under different QA/QC plans. These plans will range from complete ones (not necessarily identical) to minimum QA/QC plans. Thus, **a minimum QA/QC plan** should be developed, based upon which stations can be accepted. This minimum QA/QC plan shall satisfy stated minimum data quality objectives (DQOs).

The common minimum QA/QC plan should not be in conflict with the existing complete plans, but be consistent with them. However, efforts must be made to improve the less complete plans of individual networks.

A proposed approach towards the selection of the air quality monitoring stations of EUROAIRNET based upon QA/QC criteria, is through the quality classification of the existing stations. The classification scheme defines levels according to, mainly, the degree of development of the implemented QA/QC procedures.

Box 2: Definition of Data Quality Indicators.

Precision. The closeness of agreement between independent test results obtained under stipulated test conditions.

Notes : Precision depends only on the distribution of random errors and does not relate to the true value or the specified value.

The measure of precision is usually expressed in terms of imprecision and computed as a standard deviation of the test results. Less precision is reflected by a large standard deviation.

"Independent test results" means results obtained in a matter not influenced by a previous result on the same or similar test object. Quantitative measures of precision depend critically on the stipulated conditions.

Repeatability and reproducibility conditions are particular sets of extreme conditions (ISO 5725-1, 1994).

Repeatability: Precision under repeatability conditions (ISO 5725-1, 1994).

Repeatability conditions: Conditions where independent test results are obtained with the same method on identical test items in the same laboratory, by the same operator, using the same equipment within short intervals of time (ISO 5725-1, 1994).

Reproducibility: Precision under reproducibility conditions (ISO 5725-1, 1994).

Reproducibility conditions: Conditions where independent test results are obtained with the same method on identical test items in different laboratories, with different operators, using different equipment (ISO 5725-1, 1994).

Accuracy. The closeness of agreement between a (one) test result and an accepted reference value.

Note : The term accuracy, when applied to a set of test results, involves a combination of random components and a common systematic error or bias component (ISO 5725-1, 1994).

Correctness. The closeness of agreement between the average value obtained from a large series of test results and an accepted reference value.

Notes: The measure of correctness is usually expressed in terms of bias.

It was referred to as "accuracy of the mean" which is not recommended (ISO 5725-1, 1994).

Representativeness. This parameter expresses the degree to which the air pollution measurement data are adequately representative, both of the *location* in which monitoring is taking place, and of the *time period* to be covered. The location (spatial) part can be quantified by the *area of representativeness*: the area in which the concentration does not differ from the concentration measured at the station by more than a specified amount (see chapter 4.3). The temporal part is covered by the data capture and time coverage indicators below.

Data capture. The percentage of measurements made which are judged to be valid measurements.

Time coverage. The percentage of time covered by the operational time of the measuring device.

Comparability. This is a qualitative parameter expressing the confidence with which one set of air pollution measurement data can be compared with another. Data representative of air pollution levels of a location should be possible to compare with measurement data of another similar location. It should be noticed that data of known precision and accuracy and with a high degree of representativeness and completeness can be compared with confidence.

This classification makes it possible to assist in upgrading the data quality levels, through the upgrading of the corresponding QA/QC procedures.

The criteria for classifying stations according to QA/QC level, are given in Table 4-8. Each level is a combination of a type of network or station and a type of QA/QC procedure.

According to the criteria presented in Table 4-8, it is proposed that stations classified as level 1, 2, 3 or 4 should be, initially, accepted in the EUROAIRNET. Those are stations from national or local networks or affiliated stations, having at least a minimum documented QA/QC plan (level 4).

Stations on Level 4 will be accepted only on a temporary basis. Networks with such stations should provide an upgrading plan to stay within EUROAIRNET.

In terms of QA/QC, the candidate stations for EUROAIRNET can be divided into 3 categories:

- *Levels 1 and 2a*

  Stations that are part of the national air quality monitoring network. Such stations may belong directly to the national network or a national sub-network. A complete QA/QC plan implemented on national level is the key feature that differentiates the first two levels from the rest. This is usually adopted by national sub-networks, based on a central laboratory (accredited or not), providing nation-wide comparability.

- *Levels 2b and 3*

  Stations that are part of a local air quality monitoring network. In this case the complete QA/QC plan is implemented on local basis and does not have systematic relation with the national QA/QC plan.

- *Level 4*

  Individually operated networks or stations (or even a national network) implementing a minimum QA/QC plan.

Level 5 includes networks and stations with no documented QA/QC plan, and as such not acceptable for EUROAIRNET.

Table 4-8: QA/QC criteria for classification and the selection of stations accepted to be included in the EUROAIRNET

	Criteria						
	Type of network/station			Type of QA/QC procedure			
			Local	Accredited	Central		
1	√			√			
2 a	√				√		
b			√	√			
3			√		√		
4	√	or	√			√	
5							√

4.5.4. Data Quality Objectives for EUROAIRNET

As stated in chapter 3, the objectives of EUROAIRNET that guide the quantification of DQOs, are:

– the data shall enable comparison of air quality across Europe;
– the data shall enable detection of the trend in air quality in Europe, as well as in each area where stations are located, over a reasonable time period (3-5 years, dependent upon the magnitude of the trend).
– the data shall enable the assessments of exposure.

Regarding the first two monitoring objectives (related to mapping, comparability and trend detection) we propose in general terms the following DQOs for EUROAIRNET data. Regarding the monitoring objective related to exposure (of population, materials, ecosystems), the quantification of DQOs requires further analysis, to be carried out as a next step.

We do not at this point differentiate between compounds, that is we propose the same DQOs for all compounds. The requirements should basically be the same.

DQO Summary
A summary of the proposed DQOs for EUROAIRNET data is given in Table 4-9. They are described in more detail below.

Table 4-9: A summary of DQOs for EUROAIRNET.

Monitoring objective	Data Quality Objectives				
	Accuracy	Precision	Data completeness		Representative-ness (spatial)
			Temporal	Spatial	
Mapping, comparability	≤ 10%	≤2 ppb	≥90%	1)	1), 2)
Trend detection	3)		≥90%	1)	1), 2)

1) The DQOs are set for station-by-station comparison (for same station class) and for trend detection at any one station.
   In the case of comparisons of, for example cities or larger entities, or trend assessment for larger areas, the requirements to spatial coverage and representativeness would be strict, and to quantify those requires more analysis.
2) To be eligible for comparison with a station of the same class in another location (city, country), representativeness criteria should be complied with, as described on page 37-39.
3) To detect a trend with a certain accuracy, the combined accuracy and precision of the measurement must be considerably better than the expected trend (expressed as relative change) (see page 39).

The DQOs in Table 4-9 should be considered as a proposal to be discussed and commented by the participating countries. Some more detailed analysis may be needed to provide further justification of the proposed DQOs.

We are aware that the DQOs for accuracy and precision for mapping/comparability are fairly strict, and stricter than those required in the EU Directives or by WMO or EMEP (see page 40-41). The quantitative expression of the DQOs for trend detection, resulting from further analysis, will show that these are even stricter. The EUROAIRNET DQOs are set so that EEA can comply with the essence of its requirement: That the information it produces should be policy relevant. The monitoring data must be able to provide answers to, for example, the following questions:

– Are the currently implemented abatement strategies effective, in that we see their effect on the air quality?
– Are there regional differences in trends and policy implementation?
– Is the quality of emission inventories adequate?

If such questions can be answered from the monitoring data, then the money spent on monitoring can be justified. Such answers can be provided only when the data comply with DQOs defined on the basis of the monitoring objectives. We have attempted to quantify DQOs that would give data of sufficient quality, with a view at the same time to what can be achieved in real monitoring networks, when state-of-the-art methods and QA/QC procedures are used conscientiously.

All networks participating with stations in EUROAIRNET should strive to accomplish the indicated combined accuracy and precision in their measurements.

DQOs for mapping/comparability

Accuracy and precision:

Accuracy and precision: ≤ 10%; Precision ≤ 2 ppb.
This applies to all statistics of interest for comparison (for example annual average, 98- (or other high) percentiles). These requirements combine to produce an overall uncertainty requirement that is dominated by the precision requirement at low concentrations and the accuracy requirement at higher concentrations.

A 10% accuracy means that the statistics of two stations must differ more than 20% from each other to be sure that they measure different pollution levels. We consider this an acceptable least accuracy for broad comparisons of air pollution across Europe, in the first phase of EUROAIRNET.

Data completeness (temporal):

Requirements for data completeness can also be seen as an integral part of the DQO for accuracy, so that the DQO for data completeness is auxiliary. To show a 10% accuracy in an annual average, or indeed a high percentile, a high data coverage is needed.

Data completeness, on annual basis, should be ≥90%. This is the same as required in the EU Daughter Directives. We would additionally require a ≥ 90% coverage in each of the winter and summer half-years.

We are aware of the less strict completeness requirements of the EoI Decision (97/101/EC). We believe that the 90% requirement of the Daughter Directives is more consistent with the above DQO for accuracy.

Representativeness:

We quantify the DQO in terms of *area of representativeness*: The area within which the concentration does not differ from that at the monitoring station by more than ±20%.

Consider the concentration field over a city as a topographical map, where areas of high concentration and hot-spots would be high plateaux and hills. Most often a station will be located on a "hillside", and sometimes on a "plateau" (this would be an urban background station), while hot-spot stations will per definition be on "top of hills", if the siting is correct. At "hillside" stations the concentrations will be near the average concentration in the area of representativeness (see above), while for a "plateau" station the station will be in the maximum area, and the limits of the area of representativeness will be where the concentration has been reduced by 20%. In most city atmospheres a ±20% variation would allow for areas of representativeness with radius in the order of 1-3 km for urban background ("plateau") stations.

We realise that substantial efforts are required to determine the area of representativeness (see chapter 4.3). Still we request that network operators use the information and knowledge at their hand to determine or estimate the area of representativeness of their stations.

To be eligible for comparison with a station of the same class in another location, the representativeness of stations should comply with the following criteria:

Stations in urban and industrial areas:

- Urban background stations: The location must comply with the requirements in Annex 3, Table A3.4. Furthermore, we consider that the estimated area of representativeness should be ≥ 3-6 km^2 (radius larger than about 1-1,5 km) to be a basis for meaningful comparison between stations.

- Traffic stations: Traffic stations are typically hot-spot stations located in areas of very sharp concentration gradients. Thus, *area of representativeness* does not apply as for urban background stations. Rather, the area of representativeness can be defined in terms of length of road: Stations suitable for comparison with others should be located such that it represents reasonably well a road/street length of some 100 metres or more in central city areas and some 1,000 metres or more in suburban/other areas. Such stations should be located away from street junctions (at least 25 metres), to avoid an influence from other streets that cannot be adjusted for in such comparisons.
  Furthermore, the location of the station must be well described in terms of the parameters noted below, and comparison can only be made between stations of reasonably equal values of those parameters:

  * For kerb-side stations:
    – the distance from the centre of the street or kerb.
    – also distance between the facades on each side of the street (if

any), and height of facades should be known.
  – the traffic volume (annual average daily traffic, AADT) should be known, as well as traffic speed and composition (for example percentage of heavy duty vehicles).

  * For other types of traffic stations (for example street crossings, pedestrian areas near traffic), the local environment near the stations may be so different that direct comparison between stations may be less meaningful. In any case, maps showing the nearby areas in detail, with traffic flow data for dominating streets, should be provided.

- Industrial stations — Also such stations are typically hot-spot stations located in areas with sharp gradients. To be able to make meaningful comparisons of air pollution in industrial areas or near specific industrial sources, to be used in a European perspective, the following should be known or complied with:
  * name and geographical location of area;
  * type of industrial main source;
  * the station should be located in the most exposed nearby residential area;
  * distance and direction from the station to the main source.

Rural and remote stations:

The location requirements of EMEP have been adopted here (see Annex 3, chapter 3).

Area of representativeness:

Near-city background stations:	> 100	km^2	(radius larger than about	5 km)
Regional " " :	> 1,000	km^2	(radius larger than about	20 km)
Remote " " :	>10,000	km^2	(radius larger than about	60 km)

DQOs for trend detection

Accuracy and precision:

- Accuracy and precision shall be sufficient to detect currently occurring accumulated trends in Europe over (after) a period of 3-5 years (depending upon magnitude of trend);
  If current trends in air quality indicators in Europe are 1-5% per year, the accumulated trend (if continuous) will be 3-25% after 3-5 years. An assumption underlying this point is that it is possible to correct for the major part of the effect of inter-annual variations due to meteorological factors;

- To quantify this DQO, an estimate of the expected trend is needed. Such an estimate may be hard to obtain. For primary compounds, the expected changes in emissions in the area affecting the air quality at the station will provide an estimate of expected trend. For secondary compounds, deposition, etc., a trend estimate must take into account both trends in emissions of the parent compounds as well as the processes leading to the secondary compound, the deposition, etc.

The above give an indication of the very strict requirements that must be put on measurement accuracy for detection of trends of typical magnitude in Europe at the present time. It cannot be expected that most stations will be able to comply with this DQO. It is hoped, however, that a number of stations of particularly high quality, spread over a number of countries, will be able to obtain this accuracy, and thus form a subset of EUROAIRNET stations that can be used, e.g. for trend detection.

Data completeness:

Same requirement as under Mapping/Comparability (see this).

Representativeness:

A station used for trend detection must comply with rather strict requirements related to representativeness:
- the spatial representativeness should be according to the requirements listed under the "mapping/comparability" section;

- it should be possible to correct for the influence on the air quality data of changes in parameters or conditions that are not considered part of the trend definition. One such example is the need to correct for changing meteorological conditions from year to year, if one wants to detect "net trend" related to emission trends.

To comply with this DQO, availability of representative meteorological data is required.

Stability of station environment, methods and procedures

Changes in the near-station environment, methods and procedures may affect the value measured at the station and are thus connected to the DQO. In order to comply with strict DQOs, stations should be located such that unintended changes do not affect the measured value noticeably.

Requirements for station location and operating procedures thus include:

- no unintended changes in surroundings that may affect the measured value noticeably;
- no changes in instrumentation or procedures, unless the impact of the changes on the measured value is carefully evaluated and documented.

Comparison with DQOs of other networks

For comparison, the DQOs of EU Daughter Directives, and of the EMEP and WMO/GAW networks are summarised in Table 4-10.

EU Daughter Directives

The minimum DQOs are set in the proposed Council Directive for new target values for SO_2, NO_2, PM and Pb (CEC, 1997). They are set to provide a guide to quality assurance programmes.

These DQOs are set with a view to the practical measurement accuracy achievable in the field with typical present-day procedures. The proposed EUROAIRNET DQOs are stricter.

EMEP

DQOs of the EMEP network are shown in Appendix 5.

EMEP DQOs specify a 15-25% "uncertainty" for combined sampling and chemical analysis, varying between compounds (to be specified). Its data completeness DQO is 90% (Schaug, 1998). It should be born in mind that the main basis for the EMEP DQOs is to provide measurements to control modelling results, and an accuracy of 15-25% is considered sufficient for that purpose.

WMO/GAW

WMO/GAW DQOs (WMO, 1992) are also shown in Appendix 5 for some gaseous compounds and for $PM_{2.5}$. The accuracy DQOs vary between 10% and 20% for the individual gases. For tropospheric ozone, for instance, it is 15%. The data completeness DQO is 80% (per month) for gases, and 90% for $PM_{2.5}$. One should bear in mind that the required accuracy, in absolute terms, naturally is much higher in the WMO network than in urban networks.

Table 4-10: Data Quality Objectives of some monitoring programmes

Monitoring programme/ *Monitoring objective*	Compounds	Accuracy	Precision	Data time coverage
EU Regulatory Monitoring 1) *Detect non-compliance with directives*	SO_2, NO_2 PM, Pb	15% 2) 25% 2)		90% annual "
EMEP *Provide basis for control of models*		15-25% 3)		90% annual
WMO-GAW *Detect trends over short term (5 years)*	Examples: O_3 NO_2 $PM_{2.5}$	 15% or 3 ppb 20% or 50 ppt 0,05+5% M	 10% or 1 ppb 10% or 25 ppt 10%	 80% monthly " 90% monthly

1) Minimum DQOs. Final approval of the directive (EC 97/0266(SYN)) is pending (as of July 1998).
2) Combined accuracy and precision.
3) Total "uncertainty (combined accuracy and precision) for sampling and analysis combined). Dependent upon compound.

4.5.5. The minimum QA/QC plan

The quality procedures that characterize a minimum, documented QA/QC plan are:

- DQOs are set on a minimum basis regarding:
  - Accuracy and precision.
  - Data capture.
  - Time coverage.

  Regarding accuracy, precision, data capture, and time coverage, both values and a detailed description of the method used for the estimation shall be reported. Those values should at least comply with EU legislation (Table 4-10). Preferably, they should comply with the EUROAIRNET requirements (Table 4-9).
- It is considered that those minimum DQOs will enable a first comparison of data from different countries and networks. They will, however, generally not be sufficient for detection of trends as they currently occur in Europe.
- A reporting organisation exists, responsible for collecting the data, performing a subjective quality check on the data, and finally collecting, reporting and archiving the output of the QA/QC procedures.
- Site selection was done according to justifiable criteria.

  Site description (position on maps of relevant scale, local sources, immediate environment) shall be available for all sites.
- The measuring devices of the candidate station may be either continuously operating, (automatic methods), or integrating sampling devices (manual methods).

  The measuring methods must be either reference or reference equivalent according to EU legislation and/or internationally accepted standards.

  Both reference and equivalent methods shall be those officially documented by an approved testing institute or laboratory.

Reference method is defined as a measurement method for the complete determination of specific air pollution compound that can be handled by many users and which is based on well-founded experience over many years. Also, the method has to be successfully tested experimentally by an officially approved testing institute or laboratory (Lahman, 1992).

Equivalent method is defined as a measurement method experimentally proven to be equivalent to a reference method, by an officially approved testing institute or laboratory, using an officially approved suitability test based on documented technical requirements (Lahman, 1992).

- A documented calibration program along with an instrument performance checking program. This should include at least:
  - For automatic methods and for each measuring device:
    Regular zero-span checks, multi-point calibrations, and precision-checks.
  - For manual methods and for each measuring device:
    Flow and leak checks, routine calibration procedures in the laboratory, precision-checks with collocated identical samplers, and determination of the method's accuracy on a regular basis.

  The frequency of the above mentioned procedures should be set according to the network manager's experience and in any case assure, in an unambiguous way, that the DQOs are met. All calibration activities shall be logged and reported.

- Data validation procedures complying with the EoI Decision (97/101/EC).

All the above mentioned QA/QC procedures can be performed by the networks'/stations' operators and maintenance personnel, under the condition that they have the proper equipment, which typically includes:

- Certified reference material approved-traceable to official primary and secondary standards (e.g. calibration gases, permeation tubes), mostly for the implementation of the inter-calibration procedure;
- operational (secondary or transfer) standards for routine procedures, for example calibration, precision check, zero-span check;
- proper technical equipment;
- sampling and analysis Standard Operating Procedures (SOPs).

4.5.6. The complete QA/QC plan

The elements comprising a complete QA/QC plan, characterising levels 1, 2, and 3 of the proposed categorisation are:

Quality assurance

- Setting monitoring objectives and associated DQOs, as mentioned above. It should be noted that DQOs should be specifically stated in a complete QA/QC plan, and that all resources (equipment and human) necessary for the achievement of those objectives should be available.

  In advance of this procedure the quality policy should be defined and stated, that is the overall intentions and direction of an organisation with regard to quality, as formally expressed by top management.

- Procedures for site selection and air quality monitoring network design shall be described. Tools for the selection of the stations' positions are, among others, indicative air quality measurements, emission sources inventories, and application of air pollution modelling.

- A main feature of the air quality monitoring network, national or local, should be the central institution or laboratory that is responsible for the implementation of the QA/QC plan. It can be either public, managed by government or the city authorities, or authorised private.

  Common factors that should be considered in defining the central institution or laboratory include:

  - It should manage the overall activities of the QA/QC plan on local or national basis.
  - It must be the organisation that validates in a final stage and reports directly or indirectly the air pollution measurement data.
  - It should possess the appropriate facilities and equipment including primary calibration standards for the implementation of QA/QC plan, mainly for the Quality Assessment procedures.
  - The staff must be qualified with special training or have considerable practical experience.

  One of the most important criteria for a candidate station of levels 1 or 2b, is the existence of an accredited laboratory, according to national officially approved standards or to European standards.

  A fundamental obligation of an accredited laboratory is to develop, implement and follow up an internal Quality Control plan and to allow assessment to be carried out by the accreditation authorities.

  It should be noted that regardless of whether official accreditation is required or not, a laboratory offering services and/or data has certain professional obligations to meet. Laboratories that have implemented a self evaluation program and have an ongoing internal audit program to evaluate compliance and performance, have the capacity to produce technically sound data. Therefore, it is strongly suggested that even central laboratories with no official accreditation, (selection criterion 4), should have developed an internal QA/QC plan.

- Instrumentation should be selected according to justifiable criteria, and must completely fulfil the requirements of a reliable QA/QC plan. The instrumentation may include:

  - Measuring devices (automatic, semiautomatic, manual).
  - Calibration instrumentation and standards such as:
    * Primary standards (for the central laboratory), that are defined as the substances or a mixture of substances, whose specific properties with respect to the purpose of the measurement are known. These properties are gained by measuring base quantities or by deriving quantities from these measurements.
    * Secondary standards (field useable) whose value is based upon comparison with a primary standard.
  - Measurement data management and processing equipment.
  - Infrastructure equipment, for example sampling lines, station shelters, air conditioning systems, etc.

- The central laboratory must have:

  - The capability to prepare primary standards (for example static dilution, permeation tubes) or acquire them.
  - Equipment suitable for the implementation of the below mentioned Quality Assessment procedures.

- Adequate education and training of personnel are prerequisites for reliable measurement capability. Thus, a documented personnel training program must be included.

- A detailed QA/QC manual should be prepared, including, with proper justification, all the procedures relevant to the QA/QC plan. All QA/QC operations should be performed in the way they are described in the manual.

Quality control

The quality control includes preparation of protocols and implementation of procedures such as:

- Site operation and equipment maintenance that may comprise routine and non-routine site visits. During the visits the following actions may be taken:
  - Ensure proper running of equipment.
  - Make preventive maintenance and anticipate future problems.
  - Perform diagnostic checks.
  - Safety and security inspections.
  - Breakdown repairs.

- Calibration which is the most important operation in the measurement process. Calibration is the process of establishing the relationship between the output of a measurement process and a known input (e.g. primary and secondary standards).

  A calibration plan must be developed and implemented for all measured equipment.
- Data validation procedures should comply with the EoI Decision (97/101/EC), taking into consideration calibration and technical problems, off-scale measurements and unusually high variations.

  According to EoI, doubtful or potentially erroneous measurements should be detected using either historical data or existing relationships with other pollutants. The validation results should accompany the data set, as a separate list. All data should be marked either as not yet validated (code T), validated (code V), or erroneous/doubtful (code N).
- Completeness: Data from EUROAIRNET stations should comply with the DQO in Section 4.5.4.
- Reporting and documentation should comply with the AIRBASE requirements.

For a QA/QC plan to be characterised as complete, it should contain, as a minimum, the above mentioned QC procedures.

Quality Assessment

Quality Assessment techniques are usually performed independent of and in addition to normal QC checks. Quality Assessment procedures may be:

- Ring test; a process taking place at a competent laboratory and consisting of consecutive measurements carried out by the circulation of one or more reference material samples. The samples usually consist of a calibration gas mixture containing a known amount of pollutant, which is passed through the measurement equipment operated in parallel, using a ring circuit. The measurement equipment should be calibrated before the test is performed, by using its own standards. In this way, it is possible to assess the methods, the instrumentation, and the calibration systems of one or more networks.

- Inter-calibration of networks; a technique addressing the need to directly inter-compare the measurement procedures used in different networks. A nominated laboratory, capable of providing standard materials (e.g. standard gases), other required apparatus, and personnel to perform the fieldwork, carries out the inter-calibration. The true value of the standard material concentration should be independently quantified by the laboratory. Each monitoring station is visited in turn, and the in situ instrumentation is used to measure the concentration of the standards material. The results of the test are elaborated and evaluated by the laboratory.

- Round robin tests; usually the nominated laboratory mails a set of calibration standard gas cylinders to the participating stations or networks in turn. The standard gases are analysed and the results are sent to the responsible laboratory, which report the results of the test.
- Audits. There are two types of audit procedures:
  - System audit is the 'in situ' inspection of the measurement system taking into account all the measurement elements such as sample collection and analysis, data processing, etc. It is a qualitative appraisal of quality. The auditor inspects the QA/QC plan and the relevant documentation of the station and fills up the appropriate checking list.
  - Performance audit is a quantitative appraisal of quality that is carried out by standard material of the auditor. The standard should be measured by the instrumentation of each station, and the instrument performance (e.g. precision, accuracy, response time) is assessed.

Stations ranking as level 1, 2, and 3 must have implemented one or more techniques of Quality Assessment in order to evaluate the efficiency of the QA/QC procedures.

The implementation of one or more of the above mentioned techniques, on an international basis, including networks from two or more countries within the framework of EUROAIRNET, might be considered.

4.5.7. Summary

A classification scheme based upon QA/QC procedures, and Data Quality Objectives (DQOs) for EUROAIRNET networks and stations has been proposed. Also, a set of minimum QA/QC acceptance requirements for EUROAIRNET have here been drafted. These requirements are set to ensure that the data reliability would be at an acceptable level. Should a candidate station fail to meet some of the requirements, the cost for achieving compliance would be limited in terms of equipment and human resources.

The data providers have the basic responsibility for the quality of the data transferred to the EUROAIRNET data base, and that they comply with criteria and requirements.

Stations not implementing a documented QA/QC plan are considered as unsuitable candidates. Not because their measurements are considered erroneous, but due to the lack of an estimation of their reliability, which is a key feature for the creation of EUROAIRNET's database.

The need for establishing a QA/QC procedures manual for EUROAIRNET will be considered. Such a manual would be established in close co-operation with the EU Joint Research Centre (JRC) at Ispra. The purpose of such a manual would be to answer the need to work towards harmonisation of QA/QC procedures between the various networks, and also to deal with needs for training, audits, intercalibration exercises, etc.

5. Selection of monitoring stations for EUROAIRNET

The objectives of EUROAIRNET (see section 3.3) require that in Stage 1 of EUROAIRNET development, stations from the various classes are selected in several cities and other areas to an extent which makes it possible to

- describe in general the European air quality,
- compare air quality between states/cities,
- estimate exposure.

Each country should select and propose cities and other areas with a view to the criteria for selection in Chapter 4.1. It is clear, however, that each country separately will probably not be able to fulfil these selection criteria, due to incompleteness of monitoring networks. However, for the total European area, it is the aim to fulfil the criteria. As much use as possible should be made of sites already selected/required under EU Directives and the EoI Decision before adding more stations to EUROAIRNET.

For all selected stations, meta information should be made available. For this purpose, the ETC-AQ will make available a software module, the Data Exchange Module, to exchange the information in a consistent way.

5.1. Selection of areas and stations for population exposure assessment

ETC-AQ requests that each state select and propose for inclusion in EUROAIRNET areas/stations as far as possible according to the criteria listed in Table 5-1. Overall criterion: The QA/QC system should comply with the requirements of Level 1-4 (see Ch. 4.5). To provide a suitable overview of the selected areas and stations, each country will fill in a Network/Station information table, shown in Table 5-2.

Table 5-1: Assessment of population exposure: Criteria for selection of areas/ stations to be fulfilled by each state as far as possible.

Type of area	Criteria	
	Area selection	Station selection
Agglomerations		
>0.5 mill	All cities	All stations, for up to 20 stations in the agglomeration. When subset is selected (when >20 stations), the selection must contain all station categories represented in the city, and must be spatially distributed in the agglomeration to cover the whole population.
0.25-0.5 mill	At least 25% of the cities	The selected areas (cities) must represent high, medium and low levels of industrialisation, as occurring in the country.
0.05-0.25 mill	At least 10% of the cities	The selected areas (cities) must represent high, medium and low levels of industrialisation, as occurring in the country.
Rural areas	1)	
Industrial areas outside cities	All areas with air pollution above the WHO AQ Guidelines	All existing monitoring stations in these areas.

1) Monitoring needs and network/station selection to be done by each country. At least 50% of the rural population should be covered in terms of being reasonably well represented by monitoring stations.

Each country will also present a map with selected agglomerations or cities, rural stations and industrial areas indicated. The representation on the map should be coded according to the subclass of the area:

- For cities: according to population,
- For rural areas: according to area (diameter) of representativeness.

Also, maps showing details of the location of each station within the city or rural area should be given, choosing a suitable scale for each station. As a suitable background information, each country will be asked to describe its “philosophy” or criteria upon which the location of existing network and stations is based.

Table 5-2: Example of a filled-in Network/Station Description Table.

Country: The Netherlands EUROAIRNET – Station Information Table

Cities and agglomerations

City (c) Agglomeration (a)[1]	Popula-tion x 10^3	No. of sites (all)	Station name	Represen-tativeness radius (km) [2]	Type of exposure[3]	Site class [4] EoI	Com-pounds[5]	Aver. time[6]	QA/QC class[7]	Data providers[8]	Availability of quality controlled data Time series available in local or national data base, after XX months[9]	 Time series for one year's data ready for transfer to AIRBASE[10]
Amsterdam (c)	718	2	Cabeliaustraat	1	P	B/S/R	CO, NO_x, SO_2	1h	1	C	1	2
			Florapark	1	P	B/U/R	O_3, NO_x, SO_2, PM_{10}	1h	1	C	1	2
Apeldoorn (c)	151	3	Loolaan	0.03	P	T/U/R	CO, NO_x	1h	1	C	1	2
			Stationsstraat	0.03	P	T/U/RC	O_3, NO_x, PM_{10}	1h	1	C	1	2
							Benzene	1w	1	C	-	4
			Arnhemseweg	0.03	P	T/U/R	CO, O_3, NO_x, SO_2	1h	1	C	1	2
Breukelen (-)*	-*	1	Snelweg	0.03	P	T/R/A	CO, O_3, NO_x, SO_2, PM_{10}	1h	1	C	1	2
Dordrecht (c)	116	1	Frisostraat	1	P	B/S/R	CO, O_3, NO_x, PM_{10}	1h	1	C	1	2
Eindhoven (c)	197	3	Genovevalaan	0.03	P	T/U/R	CO, O_3	1h	1	C	1	2

1) Name of city or agglomeration. Put (c) or (a) in brackets behind the name, to indicate city or agglomeration.
Station sequence: Group the stations, following the EUROAIRNET main classes (see 3).

2) Radius of area for which the station is representative (estimate). Typical ranges of radii for different site classes: See separate page.

3) The station is relevant for assessment of: Population exposure (P), ecosystems exposure (E), materials exposure (M).

4) For definitions/abbreviations, see Table 4-4.

5) Methods: Fill in separate Table.

6) For each averaging time (1 h, 24 h, ...) list the compounds in question.
Example: 1 h: SO_2, NO_x, NO_2; 24 h: PM_{10}; 2 weeks: BTEX.

7) 1:Quality controlled by Accredited institution.
2:National QA/QC procedures.
3:Local, complete QA/QC procedures, but documented, and traceable back to absolute standards.
4:National or local, documented QA/QC procedures corresponding to the minimum QA/QC plan.

8) Central: All data from the country will be provided from one central data base.
Distributed: The data will be available from various data providers (local or regional).

9) The number of months it takes to make quality controlled monthly data available in the data base of the provider.

10) In which month after each new year is last year's data (time series (T) and/or data statistics (S)) available and ready for transfer to AIRBASE in the required format)

5.2. Selection of areas and stations for materials exposure

The already existing co-operative group on materials effects research in the UN/ECE ICP on materials programme should be responsible for the final selection of stations for the materials effects in EUROAIRNET and for the final interpretation of the results. Each state should select and establish stations as far as possible in accordance with the criteria listed in Table 5-3.

Table 5-3: Assessment of material effects. Criteria for selection of areas and stations, to be fulfilled by each state as far as possible.

Type of area	Criteria	
	Area selection	Station selection
Urban areas >0.05 mil	At least 10% of the cities	At least three stations in the selected area representing high urban pollution, traffic and average urban background.
Industrial areas	At least 5% of the areas	At least two stations in the selected area representing high and medium level of pollution.
Rural areas	Areas with different climatic conditions	One station in each of the different climatic areas of the state.

At materials exposure stations, there must be sufficient space for a test rack covering 1x1 meter. The rack should be freely exposed to the environment with a 45º frame angle, facing south.

5.3. Selection of areas and stations for ecosystems exposure

As stated in Chapter 4.1.3, for the moment, each country will be asked to develop its own plan for a monitoring network to give representative air pollution exposure of ecosystems. This information is to be evaluated, on the basis of which a European strategy may be developed.

In the stage 1 of EUROAIRNET, it can nevertheless be stated that:

- the EMEP stations should be included in EUROAIRNET;
- the rural ozone stations representing exposure of forests and crops should be included in EUROAIRNET;
- other existing rural stations monitoring S- and N-compounds in air and precipitation, and ozone precursors (NO_x and VOC) should be included in EUROAIRNET.

5.4. EUROAIRNET, Stages 2 and 3

Stages 2 and 3 should follow, when EUROAIRNET stage 1 is established according to the criteria developed in the present report.

Stage 2 will involve:

- the selection, validation and use of dispersion models on a fairly wide selection of European cities;
- the development of emission inventories in those cities according to a harmonised procedure, to support the use of dispersion models;
- monitoring of dispersion parameters in cities and areas selected, to support the modelling.

Already in the first phase of EUROAIRNET, which mostly corresponds to stage 1, data fulfilling the requirements of stage 2 should be collected for a small number of cities, so that experience can be gained on the validation and use of models for air pollution and exposure assessment.

Stage 3 will in addition involve the use of dose-response relationships for various effects, as well as the use of detailed exposure models, involving for example the coupling between air quality and population distribution in space and time.

Stages 2 and 3 will require the involvement of local, and probably also national authorities in the work to establish and use dispersion models in cities, and also the use of dose-response relationships to estimate damage as a basis for cost/benefit analysis of abatement options.

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Annex 1: Summary of air quality monitoring stations in Europe, inventoried in 1995 by ETC-AQ.

Extract from the report: Air Pollution Monitoring Situation in Europe – Problems and Trends (EEA Topic Report 26:1996, Air Quality)

Table A.1: Spatial coverage, European AQ monitoring.

	LOCAL						REGIONAL			
	No. of sites	No. of cities/towns	Site class distribution				No. of sites	SO_2 +	Dep.	O_3
			UG	UT	UI	RI				
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	65[8)]		57[8)]
Greece	31	11	22	2	7	0	1	1	1	0
Ireland	81	15	45	25	10	1	12	7		5
Italy	129[3)]	41	129				3[4)]	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
Spain							21[9)]	6	6	21
Sweden	66	45	63	3			49	12	36	5
UK	51[5)]	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	650[1)]									
Estonia	16	9	8	2	6		2	2	2	2
Hungary	39		39				2	2	2	
Poland	>540	[7)]	>500		33		11			
Romania	152		152				138	4	137[2]	4
Slovak Rep.	37	17	14	6	10		7	7	7	4
Slovenia	86		86				4			
Switzerland	98[6)]		55	31	12		54			
TOTAL	>4983						>818			

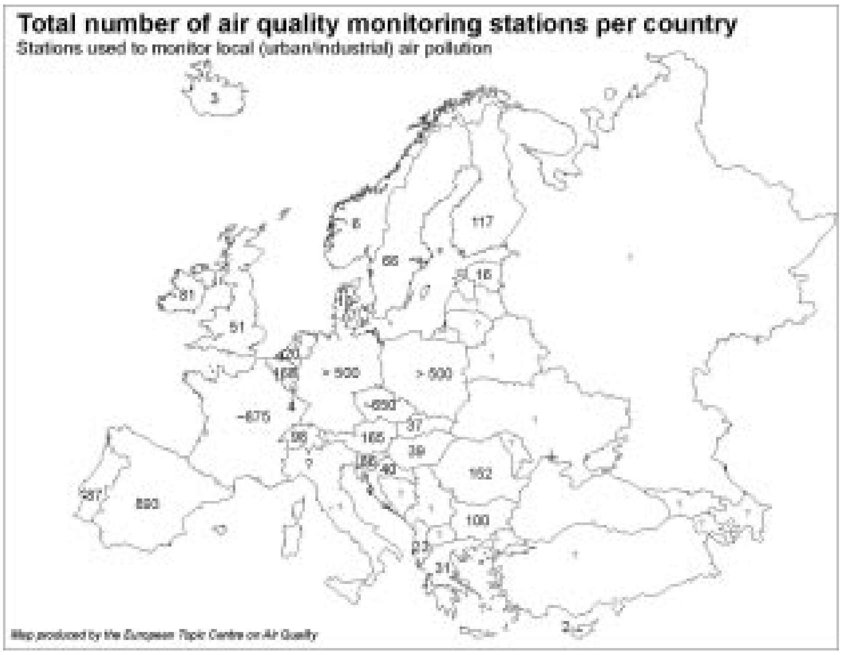
UG - Urban general (in-city background) site
UT - Urban traffic site
UI - Urban industrial site
RI - Industrial site not in urban area

SO_2+ - S and N compounds in air (gases and aerosol)
Dep - Precipitation chemistry
O_3 - Ozone

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 NO_2 sampling sites
6) Plus 12 passive SO_2 and 102 passive NO_2 sites.
7) All cities with >20,000 inhabitants.
8) The number of sites may not be quite correct
9) New information (1997)

Czech Republic: The number gives the sum of local and regional monitoring sites.

Figure A.1: Number of sites per country for the monitoring of urban/local/ industrial air pollution. Ref. year: About 1995 (somewhat varying between countries).



Czech Republic: Sum of local and regional sites. Romania: Stations with only precipitation chemistry (137) not included in the number.

Figure A.2: Number of sites per country for the monitoring of regional air pollution (incl. wet deposition). Ref. year: About 1995 (somewhat varying between countries).

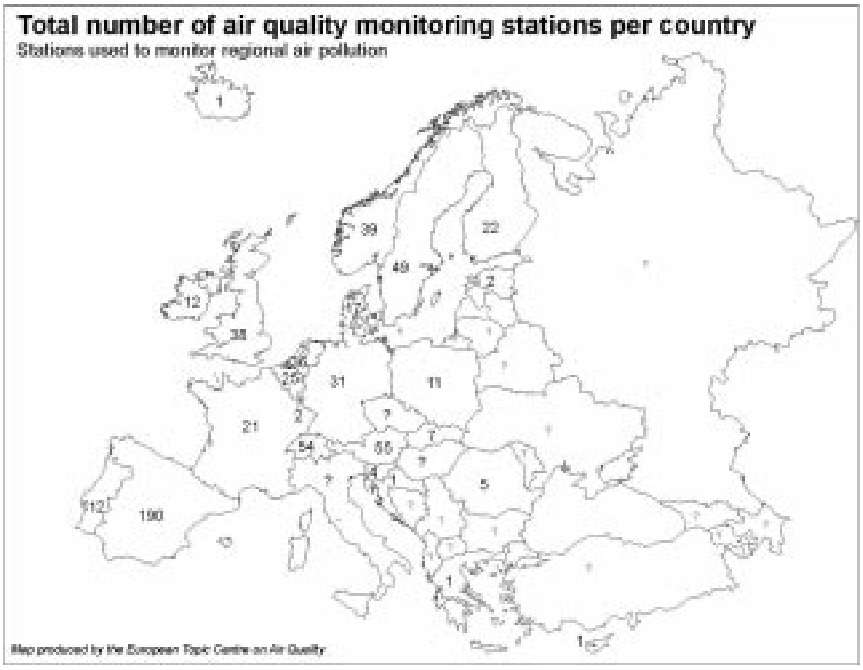


Table A.2: Summary of recent monitoring activities in Europe in international programmes. For all programmes: Not all compounds are measured at all sites.

Programme	Sites	Countries	Compounds (summary)
EMEP	126	28	S- and N-compounds, and heavy metals and POP in air (gases and particles) and precipitation, and O_3 and VOC in air.
OSPAR (1994)			
Precipitation	25	10	Cd, Hg, NO_3, NH_4, (priority) As, Cr, Cu, Ni, Zn, organo-halogens (grey list)
Aerosol/gas	12	6	Cd, Hg, a-HCN, g-HCN, HNO_3, NO_3, NO_2, NO, NH_3, NH_4 (priority) As, Cr, Cu, Ni, Pb, Zn (grey list)
HELCOM	31	8	N compounds in air (gases and particles), and in precipitation. Metals (Pb, Cd, Cu, Zn) in airborne particles and in precipitation. Cr, Ni, As, Hg in precipitation.
MEDPOL	13	10	Emphasis on heavy metals in aerosol, and heavy metals and major ions in precipitation.
GAW	61	23	Precipitation chemistry.
	100	29	"Trace gases": O_3 (81), NO_x (43), SO_2 (34), CO_2 (20), CH_4 (7), N_2O (3), CFCs (4).
	42	19	Aerosols
	16	5	Radiation
	14	10	Turbidity
TOR (1994)	29		O_3, NO, NO_2, NO_y, CH_4, CO, NMHC, J_{NO2}, met.data.
AMAP	5*	5	Acid.dep., heavy metals, pesticides, PCBs, PAH
GEMS/AIR (1993/94)	9	9	SO_2, SPM

* Only one site, Ny Ålesund at Spitzbergen, in Europe.

Annex 2: Information requirements of EEA

Information requirements of the EEA

The reporting tasks laid down in the EEA Regulation (No. 1210/90, EEC 1990) defines the requirements of the EEA to air quality information. The emphasis is put on the EEA's task (Article 1) to provide the European Community and its Member States with:

> *objective, reliable and comparable information at European level enabling them to take the requisite measures to protect the environment, to assess the results of such measures and to ensure that the public is properly informed about the state of the environment.*

With regard to monitoring and information gathering Article 2 lists the Agency's tasks to be:

- to establish, in co-operation with the Member States, and co-ordinate the network referred to in Article 4 (EIONET). In this context, the Agency shall be responsible for the collection, processing and analysis of data, in particular in the fields referred to in Article 3, among them: ambient air quality;
- to provide the Community and the Member States with objective information necessary for framing and implementing sound and effective environmental policies; to that end, in particular to provide the Commission with the information that it needs to be able to carry out successfully its tasks of identifying, preparing and evaluating measures and legislation in the field of the environment;
- to record, collate and assess data on the state of the environment, to draw up expert reports on the quality, sensitivity and pressures on the environment within the territory of the Community, to provide uniform assessment criteria for environmental data to be applied in all Member States. The Commission shall use this information in its task of ensuring the implementation of Community legislation on the environment;
- to help ensure that environmental data at a European level are comparable and, if necessary, to encourage by appropriate means improved harmonisation of methods of measurement;
- to promote the incorporation of European environmental information into international environment monitoring programmes such as those established by the United Nations and its specialised agencies;
- to ensure the broad dissemination of reliable environmental information. In addition, the Agency shall publish a report on the state of the environment every three years;
- to stimulate the development and application of environmental forecasting techniques so that adequate preventive measures can be taken in good time;
- to stimulate the development of methods of assessing the cost of damage to the environment and the costs of environmental preventive, protection and restoration policies;
- to stimulate the exchange of information on the best technologies available for preventing or reducing damage to the environment;
- to cooperate with the bodies and programmes referred to in Article 15.

Annex 3: Criteria for classification of air quality monitoring stations

Contents

1 INTRODUCTION

The main task of the European Environment Agency (EEA) is to provide reliable, objective and comparable information in support of environmental policy. The main goal of the European Topic Centre on Air Quality (ETC-AQ), under contract to the EEA, is providing all necessary air quality information in support to this basic task of the Agency, and to contribute to EEA studies that need air quality information.

In order to make European wide air quality assessments, monitoring information is needed from all countries. This information will be managed by ETC-AQ in a database called AIRBASE which builds on the experiences gained with the European databases APIS (air quality information) and GIRAFE (information on networks, stations and monitors).

Comparability of air quality data from different stations is of the utmost importance while making these assessments. One of the aspects of comparability is related to the classification of air quality monitoring stations. Stations must be classified unambiguously to avoid the comparison, for example, of traffic oriented stations with urban background stations.

Information on networks and stations in the European Union is currently defined in the framework of the on Exchange of Information (EoI) Decision. It includes a station classification based on station 'type' and the 'zones' in which the stations are located. This classification was adopted in APIS, and will be the basis for characterisation in EUROAIRNET.

The EoI classification for stations is reviewed in section 2. The EoI does generally not provide quantitative criteria/definitions for classification of existing or new stations. In section 4 quantitative criteria for classification are proposed for the different background station classes (urban/suburban, near-city, rural (regional), remote), mainly consisting of minimum distances to sources and source areas.

2 EXCHANGE OF INFORMATION

EU Member States exchanged air quality data in the framework of Council Decision 75/411 superseded by Decision 82/459. A revised version of the Decision was adopted in January 1997 (97/101/EC) [lit].

The new Decision requires Member States to transmit information on their networks, stations and monitors. This information includes a classification of stations based on station type and the zone in which the station is located:

EoI: Information to classify stations (Annex II)

- **Type of station**
  - -traffic
  - -industrial
  - -background
- **Type of zone**
  - -urban
  - -sub urban
  - -rural
- **characterisation of zone**
  - -residential
  - -commercial
  - -industrial
  - -agricultural
  - -natural

Traffic oriented stations are further characterised on basis of street width (qualitatively, e.g. 'narrow' or 'canyon') and traffic volume (quantitatively).

Part of the classification was already used in Decision 82/459 and adopted in APIS. In APIS however, combinations of the zone characteristics are possible (e.g. zone: commercial/residential/industrial).

Annex II of the 97/101/EC EoI Decision states the information required concerning networks, stations and measurement techniques (quote):

INFORMATION CONCERNING NETWORKS, STATIONS AND MEASUREMENT TECHNIQUES

To the extent possible, as much information as feasible should be supplied about the following indicative points:

I. INFORMATION CONCERNING NETWORKS

- *Name*
- *Abbreviation*
- *Geographical coverage (local industry, town/city, urban area/conurbation, county, region, entire country)*
- *Body responsible for network management*
  ** name*
  ** name of person responsible*
  ** address,*
  ** telephone and fax numbers*
- *Time reference basis (GMT, local)*

II INFORMATION CONCERNING STATIONS

1. General information

- *Name*
- *Reference number or code*
- *Name of technical body responsible for the station (if different from that responsible for the network)*

– *Type of station*
  * traffic,*
  * industrial*
  * background*

– *Purpose of the station (local, national, EU dir., GEMS, OECD, EMEP ...)*

– *Geographical co-ordinates,*

– *Altitude*

– *NUTS level III*

– *Pollutants measured*

– *Meteorological parameters measured*

– *Other relevant information: prevailing wind direction, ratio between distance from and height of closest obstacles, ……*

2. *Local environment/Landscape morphology*

– *Type of zone*
  * urban*
  * suburban*
  * rural*

– *Characterisation of zone*
  * residential,*
  * commercial,*
  * industrial,*
  * agricultural,*
  * natural.*

– *Number of inhabitants of the zone.*

3. *Main sources of emission*

– *public power, co-generation and district heating,*

– *commercial, institutional and residential combustion,*

– *industrial combustion,*

– *production processes,*

– *extraction and distribution of fossil fuels,*

– *solvent use,*

– *road transport,*

– *other mobiles sources and machinery (to be specified),*

– *waste treatment and disposal,*

– *agriculture,*

– *nature.*

4. *Characterisation of traffic*
(only for traffic-orientated stations)

– *wide street with*

  * large volume of traffic (in excess of 10,000 vehicles a day),*
  * moderate volume of traffic (between 2,000 and 10,000 vehicles a day),*
  * low volume of traffic (less than 2,000 vehicles a day),*

– *narrow street with*

** large volume of traffic (in excess of 10,000 vehicles a day),*
** moderate volume of traffic (between 2,000 and 10,000 vehicles a day),*
** low volume of traffic (less than 2,000 vehicles a day),*

– *canyon street with*

** large volume of traffic (in excess of 10,000 vehicles a day),*
** moderate volume of traffic (between 2,000 and 10,000 vehicles a day),*
** low volume of traffic (less than 2,000 vehicles a day),*

– *highway*

** large volume of traffic (in excess of 10,000 vehicles a day),*
** moderate volume of traffic (between 2,000 and 10,000 vehicles a day),*
** low volume of traffic (less than 2,000 vehicles a day),*

– *others: crossroad, signal lights, parking, bus stop, taxi stop …..*

III INFORMATION CONCERNING MEASUREMENT TECHNIQUES

– *Equipment*

** name,*
** analytical principle,*

– *Characteristics of sampling*

* *location of sampling point (facade of building, pavement, kerbside, courtyard),*

* *height of sampling point,*
* *length of sampling line,*
* *result-integrating time,*
* *sampling time,*

– *Calibration*

* *type: automatic, manual, automatic and manual,*
* *method,*
* *frequency.*

3 PROPOSED CRITERIA FOR SUBCLASSES OF BACKGROUND STATIONS

Remote stations (REM)

Stations used to monitor base-line pollution levels resulting from natural sources ('natural background level') and long-range transport of air pollutants. Examples are stations from the EMEP network. Stations are located far away from emission sources. EMEP defined the minimum distances to emission sources in their Quality Assurance Plan. It is proposed to adopt these requirements for the classification of stations with some adjustments (bold) (see Table A3.1). We have made a separation between remote and regional stations, and have increased the necessary distance to domestic heating and traffic for the remote stations relative to the EMEP requirements.

Table A3.1: *Minimum distance to emission sources for remote stations. (Based on EMEP, 1995. Deviations from EMEP in bold.)*

Type	Distance	Comments
Large pollution sources (cities, power plants, major motor ways)	>50 km	Depending on prevailing wind directions
Small scale domestic heating with coal, fuel oil or wood	**>500 m**	A maximum of only one emission source at minimum distance
Minor roads	**>500 m**	Up to 50 vehicles per day
Larger roads	**>2 km**	Up to 500 vehicles per day
Application of manure, stabling of animals	>2 km	Depending on the number of animals and size of fertilised field or pastures **for ammonia related components**
Grazing by domestic animals on fertilised pasture	>500 m	Depending on the number of animals and size of fertilised field or pastures **for ammonia related components**

EMEP requires the following regarding "Representativeness with respect to topographic features":

The site must be representative also with respect to exposure to the air mass. Valleys or other locations which are subject to formation of stagnant air under inversion conditions should be avoided, also mountain tops and passes (cols). The ideal is a well exposed site in moderately undulating terrain, or, if valleys cannot be avoided, on the side of the valley above the most pronounced night-time inversion layer. Coastal sites with pronounced diurnal wind variations due to land-sea breeze effects are also not recommended. Vegetation is a sink for many air pollutants. It is important to avoid situations where sheltering by vegetation, for example by a stand of trees, results in lowered concentration when the wind is blowing from a particular direction.
This also applies to regional stations (see below).

Regional ('Rural background') stations (REG)

Stations used to monitor 'regional/rural background' air pollution levels resulting from long-range transport of air pollutants and from emissions in the region in which the station is located. The emission distance requirements for important emission sources are less strict than those set for remote stations (see Table A3.2). Stations can be located in agricultural areas.

Table A3.2: *Minimum distance to emission sources for rural/background stations.*

Type	Distance	Comments
Large pollution sources (cities, power plants, major motor ways)	10-50 km	
Small scale domestic heating with coal, fuel oil or wood	>100 m	A maximum of only one emission source at minimum distance
Minor roads	>100 m	Up to 50 vehicles per day
Larger roads	>500 m	Up to 500 vehicles per day

Near city background stations (NCB)

Stations used to monitor 'regional background' air pollution levels resulting from long-range transport of air pollutants and from emissions in the region in which the station is located. The emission distance requirements for important emission sources are less strict than those set for rural/background stations (Table A3.3). Stations are located outside cities in areas with many cities/communities close to each other.

Table A3.3: Minimum distance to emission sources for near city background stations.

Type	Distance	Comments
Large pollution sources (cities, power plants, major motor ways)	3-10 km	
Small scale domestic heating with coal, fuel oil or wood	>100 m	A maximum of only one emission source at minimum distance
Minor roads	100-500 m	Up to 50 vehicles per day
Larger roads	>500 m	Up to 500 vehicles per day

Urban/suburban background stations (URB)

Stations used to monitor the 'average' air pollution levels in urban areas (urban background concentration) resulting from transport of air pollutants from outside the urban area and from emissions in the city itself. The stations are, however, not directly influenced by dominating emission sources like traffic or industry (Table A3.4).

Table A3.4: Minimum distance to emission sources for urban background stations.

Type	Distance	Comments
Traffic	>50 m	Not more than 2500 vehicles per day within a radius of 50 m.
Industrial point sources	-	Expert judgement, depending on emission characteristics and prevailing wind direction, direct influence should be avoided.
Small scale domestic heating with coal, fuel oil or wood, small boiler houses	>50 m	Should be avoided as much as possible

Annex 4: Reference methods for assessment of concentrations of sulphur dioxide, oxides of nitrogen, particulate matter and lead

I. Analysis of sulphur dioxide

(Annex V of Council Directive 80/779/EEC of 15 July 1980 on air quality limit values and guide values for sulphur dioxide and suspended particulates).

II. Reference method of analysis of oxides of nitrogen

(Annex IV of Council Directive 85/203/EEC of 7 March 1985 on air quality standards for nitrogen dioxide).

III. Sampling method and reference method of analysing the concentration of lead in air

(Annex of Council Directive 82/884/EEC of 3 December 1982 on lead in ambient air).

IV. Reference method for sampling PM_{10}

The reference method used to sample PM_{10} shall be the method described in prEN 12341[4]

[4] "Air Quality - Field test Procedure to demonstrate reference equivalence of sampling methods for the PM_{10} fraction of particulate matter".

Annex 5: Data Quality Objectives set for WMO/GAW and EMEP networks

Selected WMO/GAW Data Quality Objectives (DQO) (WMO, 1992) WMO - Global Atmospheric Watch Gas Measurements Background station - Free Troposphere

Measurement	Recording frequency	Limits of detection	Accuracy	Precision	Completeness per month	Calibration levels	Calibration frequency	Zero/span frequency	Corrective action	Data validation	Audits
CONTINUOUS GAS MEASUREMENTS											
O_3	continuous	2 ppb	15% or 3 ppb	10% or 1 ppb	80%	0-160 ppb 5 points	annual or need	3 points daily	re-calibrate		
CO_2	See WMO GAW Report no. 77										
SO_2	continuous	10 ppt	20% or 10 ppt	10% or 10 ppt	80%	0-100 ppb 5 points	annual or need	3 points daily	re-calibrate		
NO	"	10 ppt (hourly values)	10% or 20 ppt	5% or 10 ppt	"	0-5 ppb 5 points	3 months or need	"	"		
NO_2	"	25 ppt	20% or 50 ppt	10% or 25 ppt	"	"	"	"	"		
NO_y	"	20 ppt	10% or 50 ppt	5% or 10 ppt	"	"	"	"	"		
FILTER MEASUREMENTS											
PM2.5 IMPROVE air sampler (25 mm teflon) Mass	72 hr; 96 hr	0.1 µg/m^3	0.05 + 5% M	±10% (1)	90%	0.3 µg/m^3	Daily		Daily		system annual

(1) Sampling and analysis.

EMEP Data Quality Objectives (DQO) (Schaug, 1998)

- 10 % accuracy or better for oxidised sulphur and oxidised nitrogen in single analysis in the laboratory,
- 15 % accuracy or better for other components in the laboratory,
- 0.05 units for pH,
- 15 - 25 % uncertainty for the combined sampling and chemical analysis (components to be specified later),
- 90 % data completeness of the daily values.

The targets, with respect to accuracy in the laboratory, for the very lowest concentrations of the main components in precipitation follow the WMO GAW (1992) recommendations for regional stations:

	Accuracy	
SO_4^{2-}	0.032 mg S/l	(1 µmol/l)
NO_3^-	0.014 mg N/l	"
NH_4^+	0.028 mg N/l	(2 µmol/l)
Cl^-	0.107 mg Cl/l	(3 µmol/l)
Ca^{2+}	0.012 mg Ca/l	(0.3 µmol/l)
K^+	0.012 mg K/l	"
Mg^{2+}	0.007 mg Mg/l	"
Na^+	0.007 mg Na/l	"

The targets for the wet analysis of components extracted from air filters are the same as for precipitation. For SO_2 the limit above for sulphate is valid for the medium volume method with impregnated filter. For NO_2 determined as NO_2^- in solution the accuracy for the lowest concentrations is 0.01 mg N/l.

The aim for data completeness is valid for the current definition used by the EMEP Chemical Coordination Centre (CCC).. This definition will, however, be harmonised with the WMO GAW definition and modified.

It is understood that there is a need to investigate additional uncertainty caused by local influence on the measurements at the sites (not representative siting).

It may be necessary to reconsider the DQO for volatile organic components (VOC), persistent organic pollutants (POP), and trace metals (HM).