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# Enhanced environmental protection inspection for efficient control of air quality monitoring and of all entities under obligation within system of greenhouse gas emission allowance trading, in order to achieve better quality of air in Republic of Croatia

REPUBLIKA HRVATSKA
MINISTARSTVO ZAŠTITE OKOLIŠA I ENERGETIKE

EKONERG

safu SREDIŠNJA AGENCIJA ZA FINANCIRANJE I UGOVARANJE

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EKONERG Energy Research and Environmental Protection Institute

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# THEME 5: Network Design

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# 5.1 THE MAIN OBJECTIVES

**The first step in designing the air quality monitoring network is to define the goals that this network must meet. When designing a network, it is important to keep in mind that investments do not stop with the purchase of very expensive equipment. It is a long-term expenditure for measuring and technical network management.**

# 5.1 THE MAIN OBJECTIVES

At the beginning, before any investment is necessary to make clear to investors that it is a narrowly specialized field and that from the moment of design through the selection and procurement of equipment and of defining the measurement points to the performance measurement and data processing the job must entrust the competent and well trained a group of people ready to work hard.

In his work the author has witnessed cases of large investments that are due to the wrong choice of experts ended without achieving a basic goal – high quality data on air quality.

# 5.1 THE MAIN OBJECTIVES

**Defining the goals of the network is the first step in the design of each network.**

Setting too ambitious or too simple goals will lead to a network that will not be easy to manage and the measuring data will not be sufficiently exploited or those who fund the network will think they do not get enough of their investment. For this reason, investors and experts in air quality must be involved in this business, as well as the final beneficiaries of monitoring data. It is wrong to focus only on one goal, eg meeting regulatory requirements, because the information obtained by monitoring can certainly be used for other purposes as well.

## 5.1 THE MAIN OBJECTIVES

**Air quality data must be available to anyone who requests them. Each properly designed network will fulfill the goals for which funds are invested in its setup and management. Although each network has its own general and specific goals and they can, however, be grouped into several basic ones as shown in the Table.**

| Područje u kojemu se podaci koriste | Glavni cilj monitoringa |
|---|---|
| Implementacija regulative i ispunjavanje međunarodnih ugovora i obveza | Utvrditi zadovoljavaju li se regulativom zadane granične vrijednosti |
| | Kategorizacija kakvoće zraka |
| | Osigurati podatke za međunarodnu razmjenu |
| Ekologija | Utvrditi rizik za ekosustav |
| | Utvrditi glavne izvore onečišćenja i validirati modele širenja onečišćenja |

# 5.1 THE MAIN OBJECTIVES

## Extension of table

| Područje u kojemu se podaci koriste | Glavni cilj monitoringa |
|---|---|
| Javno zdravstvo | Utvrditi izloženost i rizik za zdravlje ljudi |
| | Informirati javnost o kakvoći zraka |
| | Uspostaviti alarmne sustave |
| | Osigurati podatke za epidemiološka ispitivanja |
| Strategija razvoja i urbanizam | Osigurati podatke za izradu urbanističkih planova |
| | Osigurati podatke za strategiju zaštite zraka |
| | Odrediti trendove za pojedine onečišćujuće tvari da bi se mogli predvidjeti mogući problemi |

**Of course, some of these goals can and should be used in more than one area which will only improve the utilization of the data and information obtained by monitoring.**

# 5.2 SELECTION OF MEASUREMENT POINTS

Each measurement station analyses the air that is located directly around it. There is a known case when measuring stations have not recorded any unusual air pollution despite of large fire of the industrial plant in their vicinity.

On the other hand, it happens to be recording a great instantaneous pollution just for burning nearby weeds. For this reason, during the design of the network, special attention has to be paid to the choice of measuring points.

# 5.2 SELECTION OF MEASUREMENT POINTS

Measurement sites must be representative for the area which should be covered and for pollutants that we want to monitor. Some of the basic factors that need to be taken into consideration when defining the location of measurement locations are as follows:

- the major sources of emissions in the area of the future network
- the results of periodic measurements and/or model
- meteorological factors
- topographical factors on the makrolocation and mikrolocation level
- demographic and epidemiological factors.

# 5.2 SELECTION OF MEASUREMENT POINTS

In order to avoid obtaining accurate but useless data, attention must be paid to both the macrolocation and microlocation positioning of the stations and the sampling system, and they need to be matched to the monitoring goals of the particular network.

According to the monitoring objectives, the location of the stations and the pollutants that are being monitored are also different. Based on that, the name and type of station are defined. The most important station types are shown in the Table.

# 5.2 SELECT MEASUREMENT POINTS

## Types of stations with respect to the objectives and the location

| Tip postaje | Podtip postaje |
|---|---|
| Postaje u naseljenim područjima | Urbane pozadinske postaje |
| | Urbane prometne postaje |
| | Urbane industrijske postaje |
| | Urbane postaje u centru grada |
| Industrijske postaje | Urbane industrijske postaje |
| | Industrijske postaje izvan urbanih centara |
| Pozadinske postaje | |
| Postaje za praćenje regionalnog i prekograničnog daljinskog prijenosa | |
| Postaje za mjerenja u okviru međunarodnih obveza RH | |
| Postaje za mjerenje na područjima kulturnog i prirodnog naslijeđa | |

**Since this is an extremely complex area of great importance for achieving monitoring goals, this area is legally regulated in the world but also in our country.**

# 5.2 SELECTION OF MEASUREMENT POINTS

## Ordinance on air quality monitoring, (NN19/2017)

**Appendix 1**

**The locations of fixed measurement points for measuring concentration of sulphur dioxide, nitrogen oxide, nitrogen dioxide and airborne particulate matter (PM10 and PM2, 5), lead, benzene and carbon monoxide in the air**

**SECTION B**

**Positioning of sampling points at the macro level**

1. Protection of human health
2. Protection of vegetation and natural ecosystems

**SECTION C**

**Deployment of the measurement points on the micro level**

# 5.2 SELECTION OF MEASUREMENT POINTS

## Ordinance on monitoring air quality (NN19/2017)

**Appendix 4**
**Criteria for classifying and setting points of sampling to estimate concentrations of ground-level ozone**

**SECTION A**
**Macro location**

**SECTION B**
**Micro location**

# 5.3 METHODS OF MEASUREMENTS

## Measuring and non-measuring equipment

**The equipment required to create air quality monitoring network must be such as to enable getting targeted quality of data. In short, it must enable continuous measurements by prescribed methods with as little interruption as possible and with as much accuracy as possible, i.e. measurements within the prescribed uncertainty measurement.**

# 5.3 METHODS OF MEASUREMENTS

**In order to achieve this, it is also necessary to provide, besides measuring equipment (measuring instruments), non-measuring equipment (isothermal shelters, sampling systems, air-conditioning systems, fire-fighting and fire alarm systems and alarm systems). In General, equipment in air quality monitoring networks can be divided into two basic groups: measuring and non-measuring devices.**

# 5.3 METHODS OF MEASUREMENTS

## Measuring devices

Selection of measuring devices will be defined by measurement method which is, for the most important pollutants, defined by regulation. Although regulations in the Republic of Croatia and the EU defines standardized methods (most commonly called CEN standards in professional surroundings), it allows the use of other methods for individual pollutants as long as it can be proven that they are equivalent to standardized methods.

# 5.3 METHODS OF MEASUREMENTS

**In practice, it is much simpler for regulatory-defined measurements to immediately decide on instruments that use metering methods defined by regulation because proof of equivalence of alternative methods may have a price higher than the price of such instruments.**

**The choice of these instruments, in the case of classical pollutants, is facilitated by the CEN standards, which as their constituent part define the so-called TYPE APPROVAL.**

# 5.3 METHODS OF MEASUREMENTS

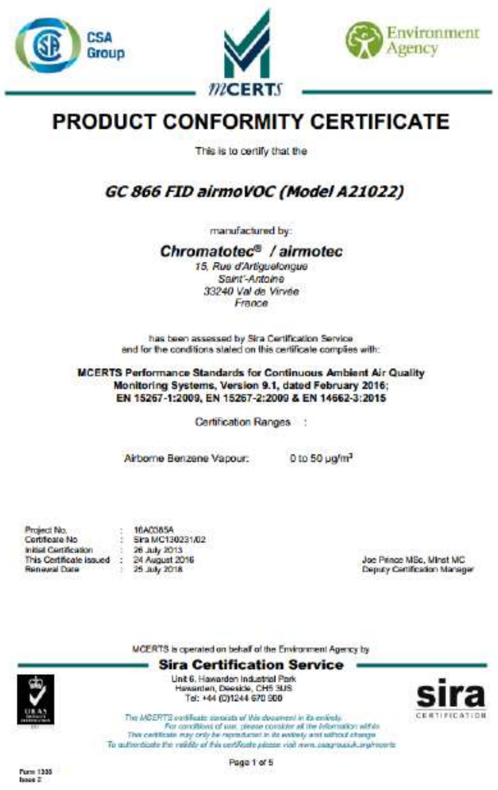
Type Approval Tests are in fact a series of testing of individual instrument types in order to demonstrate the ability of the instrument to meet the standard of precisely defined performance characteristics that a particular type of instrument must have. If a type of instrument satisfies these requirements, the EU Member State issues the Certificate with the most basic data on the type of instrument and the test results. This certificate is called the type approval.

Type approval is valid for all instruments of the same type of some manufacturer for which it has been proven (by an independent laboratory) to meet the standard performance criteria.

# 5.3 METHODS OF MEASUREMENTS

## Type approval Mcerts (UK)

http://www.csagroupuk.org/services/mcerts/mcerts-product-certificati



CSA Group

MCERTS

Environment Agency

**PRODUCT CONFORMITY CERTIFICATE**

This is to certify that the

***GC 866 FID airmoVOC (Model A21022)***

manufactured by:

***Chromatotec® / airmotec***
*15, Rue d'Artiguelongue*
*Saint'-Antoine*
*33240 Val de Virvée*
*France*

has been assessed by Sira Certification Service
and for the conditions stated on this certificate complies with:

**MCERTS Performance Standards for Continuous Ambient Air Quality Monitoring Systems, Version 9.1, dated February 2016; EN 15267-1:2009, EN 15267-2:2009 & EN 14662-3:2015**

Certification Ranges :

Airborne Benzene Vapour: 0 to 50 µg/m³

| | | |
|---|---|---|
| Project No. | : | 16A0385A |
| Certificate No | : | Sira MC130231/02 |
| Initial Certification | : | 26 July 2013 |
| This Certificate issued | : | 24 August 2016 |
| Renewal Date | : | 25 July 2018 |

Joe Prince MSc, MInst MC
Deputy Certification Manager

MCERTS is operated on behalf of the Environment Agency by

**Sira Certification Service**
Unit 6, Hawarden Industrial Park
Hawarden, Deeside, CH5 3US
Tel: +44 (0)1244 670 900

sira CERTIFICATION

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Form 1330
Issue 2

## Type approval UBA (NJE)

http://www.qal1.de/en/index.htm

Umwelt Bundes Amt

TÜVRheinl
Precisely Right.

**CERTIFICATE**

**about Product Conformity (QAL1)**

**Number of Certificate: 0000028756_01**

| | |
|---|---|
| **Certified AMS:** | APNA 370 for $NO_x$ |
| **Manufacturer:** | HORIBA, Ltd.<br>2 Miyanohigashi<br>Kisshoin Minami-ku<br>Kyoto 610-8510<br>Japan |
| **Test Institute:** | TÜV Rheinland Energie und Umwelt GmbH |

**This is certifying that the AMS has been tested and found to comply with:**

**VDI 4202-1: 2002, VDI 4203-3: 2004, EN 14211: 2005, EN 15267-1: 2009, EN 15267-2: 2009**

Certification is awarded in respect of the conditions stated in this certificate (see also the following pages).
The present certificate replaces Certificate No. 0000028756 of 09 February 2011.

- Complying with 2008/50/EC
- TUV approved
- Annual inspection

Publication in the German Federal Gazette (BAnz.) of 14 October 2008

The certificate is valid until 25 January 2018

Umweltbundesamt
Dessau, 16 March 2012

I. A. Dr. Hans-Joachim Hummel

TÜV Rheinland Energie und Umwelt GmbH
Köln, 16 March 2012

ppa. Dr. Peter Wilbring

Accreditation according to EN ISO/IEC 17025 and certified according to ISO 9001:2008.

qal1.de info@qal1.de page 1 of 10

# 5.3 METHODS OF MEASUREMENTS

**Manufacturers of measuring instruments finance the making of type approvals for their instruments.**

**By purchasing measuring instruments that have type approval, it is possible to measure according to regulatory requirements and greatly simplify the selection of measuring equipment.**

**Thus, when purchasing instruments, it is often enough to require that the instrument has a valid type-approval in accordance with the CEN standard defined for the pollutant to be measured.**

# 5.3 METHODS OF MEASUREMENTS

**The picture shows an instrument for carbon monoxide (CO) measurement having a valid type-approval in the Republic of Croatia and EU according the CEN-standard HRN EN 14626. The producer is Horiba company from Japan.**


**Horiba APMA-370 monitor carbon monoxide in the air.**

# 5.3 METHODS OF MEASUREMENTS

Of course, during purchasing of equipment, it is necessary to ask for the type approval certificate issued by a competent authority in one of the Member States of the EU.

Measuring equipment, in a broader sense, besides instruments includes the system for the automatic checking of the instrument's response to the default calibration gases.

Measurements of meteorological factors are often performed with air quality measurements at the same station. Most commonly, measurements of temperature, humidity and air pressure, as well as speed and wind measurements.

# 5.3 METHODS OF MEASUREMENTS

## Non-measuring equipment

**Non-measuring equipment in networks represents all the equipment needed for the operation of the network and ensuring the optimal conditions in which instruments can be properly and long-term work. Non-measuring equipment and its functions are shown in the table.**

| Oprema | Funkcija opreme |
| --- | --- |
| izotermičko sklonište (slike 9.6 i 9.7) | - osiguravanje fizičke zaštite instrumenta<br>- osiguravanje ispravnog smještaja instrumenata<br>- osiguravanje optimalnih mikroklimatskih uvjeta za rad instrumenata |
| sustav za uzorkovanje (slika 9.8) | - osiguravanje dovođenja optimalne količine uzorka vanjskog zraka do instrumenata<br>- osiguravanje kemijski nepromijenjenog uzorka i uzorka odgovarajućih fizičkih karakteristika |
| klimatizacijski sustav | - osiguravanje optimalnih mikroklimatskih uvjeta unutar izotermičkog skloništa |
| vatrodojavni i vatrogasni sustav | - osiguravanje zaštite instrumenata u slučaju požara ili pak prekoračenja zadanih mikroklimatskih uvjeta (kod prekoračenja zadane temperature zraka u postaji automatski isključuje instrumente) |

# 5.3 METHODS OF MEASUREMENTS

## Extension table

| Oprema | Funkcija opreme |
|---|---|
| informatički sustav | - osiguravanje prihvata, prijenosa i pohrane mjernih podataka<br>- osiguravanje objavljivanja sirovih podataka putem weba i/ili javnih displeja |
| gromobranski sustav | - osigurava instrumente od oštećenja koja mogu nastati uslijed atmosferskih električnih pražnjenja |
| električni sustav s UPS-om | - osigurava kvalitetan i siguran dovod električne energije do svih elemenata postaje koji trebaju električno napajanje<br>- osigurava prenaponsku zaštitu<br>- osigurava napajanje najvažnijih komponenti tijekom prekida mrežnog napajanja |

# 5.3 METHODS OF MEASUREMENTS

Selection of the non-measuring equipment is almost as important as the selection of measuring equipment.

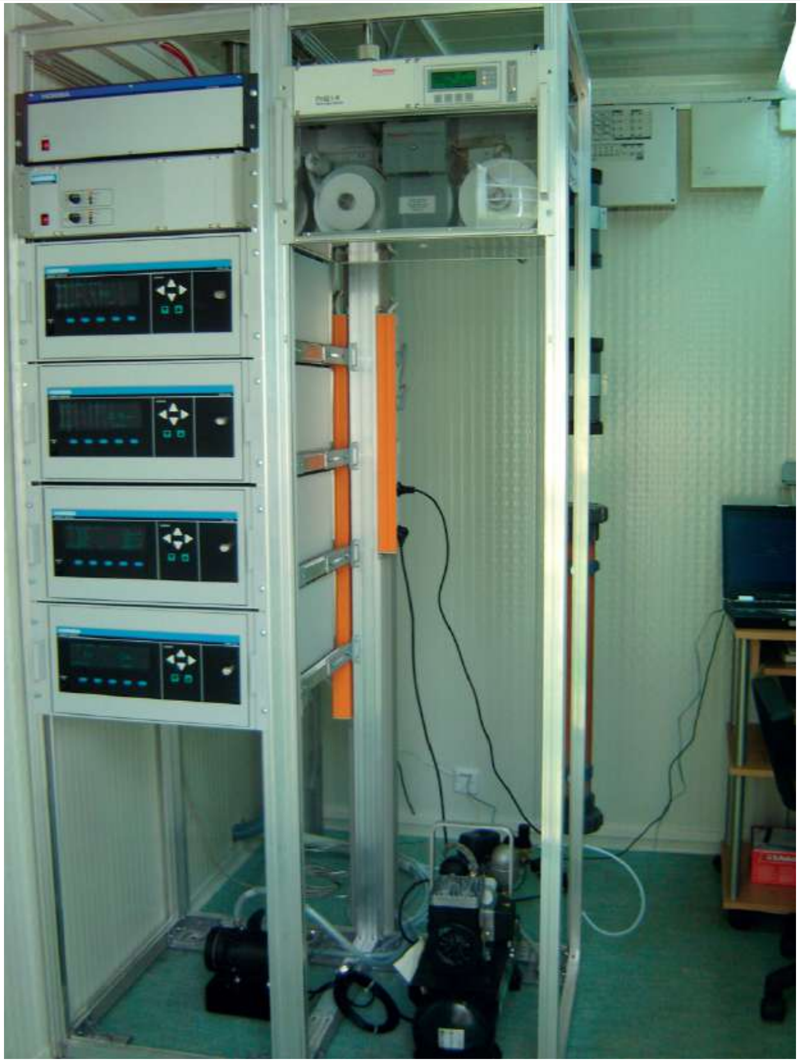
Only properly selected non-measuring equipment will enable measurements that will result in the data of satisfactory quality and will ensure investment in measurement equipment.

For this reason, it is important during purchasing such equipment does not use improvisations and unjustified economy. It should be noted that some of the components of the non-measuring equipment are subject to regulations in the field of fire protection and safety at work and that their design, maintenance and certification require engage of authorized institutions.

# 5.3 METHODS OF MEASUREMENTS

**Izothermic shelter from the outside (also the elements of sampling and air conditioning systems are visible).**

# 5.3 METHODS OF MEASUREMENTS



Isothermal shelter from the inside (measuring instruments placed in appropriate standardized frames).

# 5.3 METHODS OF MEASUREMENTS

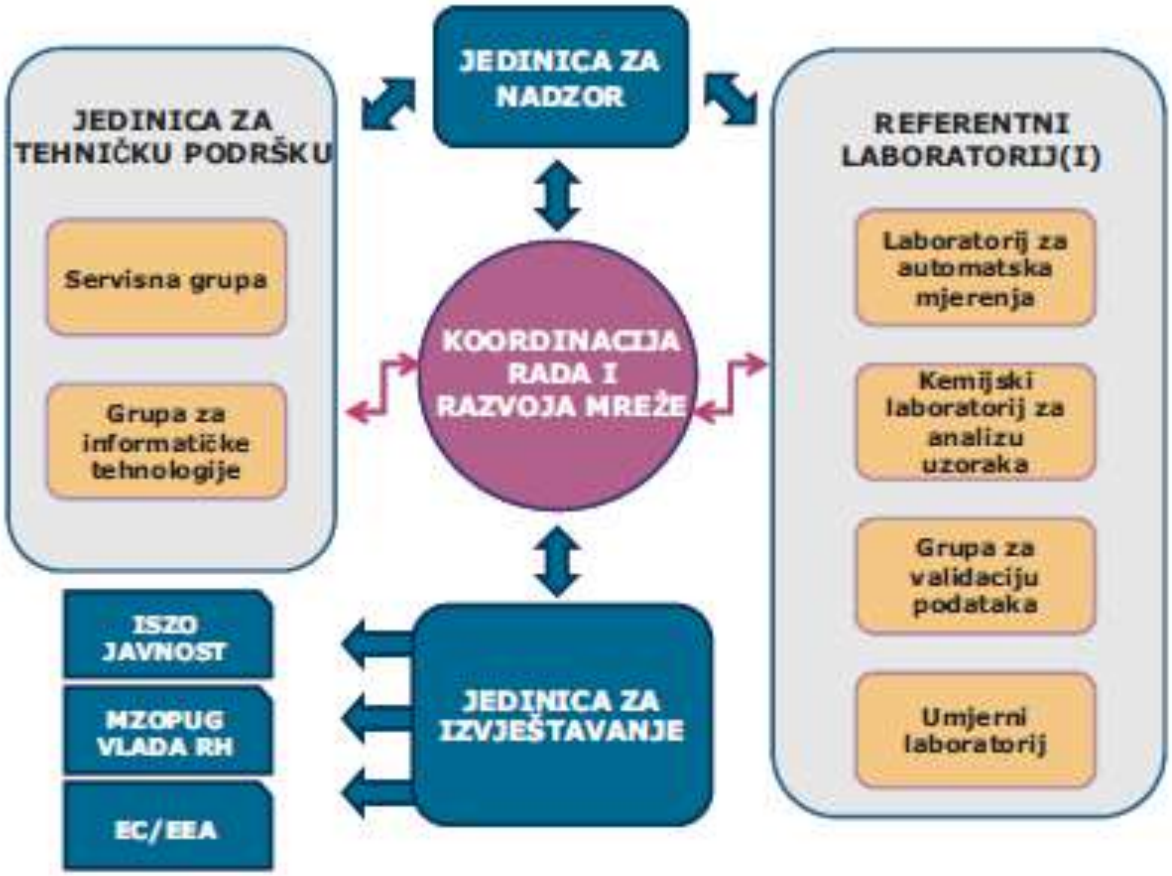
An air sampling system for measurement of gaseous pollutants.

# 5.3 METHODS OF MEASUREMENTS

## Network organizational structure

Managing of air quality monitoring networks is an extremely demanding task. Because of the multidisciplinarity, complexity and complexity of the work that must be done to make a network meet its goals, this job is rarely carried out by an institution independently. Most often, one umbrella organization coordinates the work of several institutions that carry out every part of their work. Although the organizational structure will depend on different factors, primarily on the goals and complexity of the network itself (covering area, number of stations, polluting substances monitored, equipment, etc.), the basic criterion for assessing a good network organization is its functionality.

# 5.3 METHODS OF MEASUREMENTS




The typical organizational structure of the network

# 5.3 METHODS OF MEASUREMENTS

To be able to perform its function properly, each of the organizational subunits should be well-teamed and equipped. Subgroups so assembled can often perform their specialized work for several different networks. In continuation the most important organizational subunits will be described.

## Coordination of network operation and development

This subunit, of course, is the most important for every network. Its basic function is to maintain functionality and meet network goals. In this subunit most often there are representatives of network investors, i.e. its owners.

# 5.3 METHODS OF MEASUREMENTS

It is their responsibility to ensure the data for which is invested into the network. To perform this task, they engage other subunits, monitor them and provide them with the necessary resources.

For large State-owned network, that work is usually performed by Ministry or agency responsible for the environmentally protection, and in local networks the offices of local governments responsible for the same area.

The function of supervision over the work of the laboratory is most often done through inspection of environmental protection inspector sand/or quality of laboratory work is checked by the system of accreditation through the accreditation agency.

# 5.3 METHODS OF MEASUREMENTS

## Air quality laboratories

**Air quality laboratories represent a professional core of each network. They ensure the quality of the data obtained by automatic measurements or perform analyses of samples obtained by sampling at the stations. Fulfillment of these tasks requires the establishment of a quality system. With quality system, the provable conditions for obtaining the measuring data of the required uncertainty measurement are set and ensure that the measurements comply with the prescribed standardized methods.**

# 5.3 METHODS OF MEASUREMENTS

*Laboratory for continuous (automated) measurements*

**performs measurements at stations with automatic analysers for individual pollutants.**

**The job requires specialized personnel with the classic skills of good laboratory practices and knowledge related to modern telemetry techniques.**

**Since the measurements are automatic and continuous, a quality laboratory must know at all times all the facts related to the operation of measuring and non-measuring equipment that may affect the measurement quality.**

# 5.3 METHODS OF MEASUREMENTS

This part of work in networks is often neglected. Also, it is often case of a technical point of view only: "the instrument works or does not work" or "there is no need for measurement, instrument measures".

The results of such measurements can often be extremely uncomfortable due to regulatory consequences for plant owners. Therefore, the continuous measurement laboratory must be able to guarantee quality and documentation for each measurement data obtained by such measurements.

# 5.3 METHODS OF MEASUREMENTS

**Measured data thus obtained, before being validated, must undergo a procedure called validation and ratification.**

***Validation and ratification of data is the most demanding and the most responsible part of the work of the laboratory for automatic measurements.***

# 5.3 METHODS OF MEASUREMENTS

## *Calibration laboratory for air quality*

**in this context it implies laboratory for calibration of automatic instruments. The main task of this laboratory is to ensure measurement traceability of all automated measurements in a network.**

**This is accomplished by calibration of instruments in the laboratory and at the stations themselves with the help of certified standards (most often gas bottles) and by organizing intercomparative measurements (proficiency testing).**

# 5.3 METHODS OF MEASUREMENTS

Calibration laboratory for air quality

# 5.3 METHODS OF MEASUREMENTS

## *Laboratory for Sample Analysis*

***is the classic chemical laboratory which is in his work uses the most modern techniques. It is a laboratory that has a demanding task to designate a lot of different analytes from a relatively small sample at very low concentrations. The most common analytical methods in these labs are ionic chromatography (IC), atomic absorption spectrometry (AAS), inductively coupled plasma mass spectromerography (ICP MS) and gas or liquid chromatographic mass spectrometry (GC / HPLC MS). Such a laboratory must be teamed with exceptionally high quality, highly specialized laboratory personnel.***

# 5.4 MAINTENANCE AND NETWORK COSTS

## Unit for technical support

The operation of any air quality monitoring network is unthinkable without the quality of technical support. The task of this unit is to ensure the technical accuracy of measuring and non-measuring equipment across the network in 90% of the network operation time. This implies maintenance of measuring instruments, conditions in isothermal shelters, maintenance of sampling systems and samplers, maintenance of fire alarm and alarm systems, and provision of electronic communications with the stations and public communications systems.

# 5.4 MAINTENANCE AND NETWORK COSTS

At the same time, this unit must cooperate with the laboratories in a quality and continuous manner.

This demanding task can perform only extremely well-trained and highly specialized group of people with the technical education of information technology (it), electro-mechanical and mechanical proffesion ready for work with no fixed working hours, and on frequent trips.

# 5.4 MAINTENANCE AND NETWORK COSTS

## Network costs

**When designing a network it is necessary to have in mind that the establishment of a network is extremely expensive and that the financing of the network nearly does not end with the purchase of equipment.**

**The basic costs, some of which are one-off and some are continuous, are as follows:**

- the cost of designing network - one-off
- construction of infrastructure (electricity, phone, grounding, base station)- one-off
- purchase of measuring and non-measuring equipment – one-off
- the costs of setting up the stations - one-off
- attesting (electrical installations, fire protection system and fire alarm) - continuously

## 5.4 MAINTENANCE AND NETWORK COSTS

- the costs of the professional regular and intervention maintenance (labor, consumables, spare parts) – continuously
- laboratory Costs (Collection of Samples, Sample Analysis, Quality Assurance, Data Validation) – continuously
- material costs of quality assurance (reference material and devices, profficiency testing) – continuously
- data management costs (collecting, processing, publishing and storing data) – continuously
- operating costs (rental places, electricity, telephone) – continuously.

When trying to estimate ongoing costs on an annual basis, there is usually 10% of the initial investment amount.

# 5.4 MAINTENANCE AND NETWORK COSTS

The investement costs will depend on the design of the network (the number of stations, the location of the stations, measurement methods, as well as the choice of the manufacturer of the instruments).

When choosing instruments lowest price is often not the best choice.

There is also a need to consider service support in the country because a cheap instrument with an authorized service technician 1000 km away and several state borders often results in unsatisfactory data coverage and / or poor data quality.

# 5.4 MAINTENANCE AND NETWORK COSTS

## The cost of measuring equipment

| Metoda | Prednosti | Nedostaci | Cijena po analitu (€) |
|---|---|---|---|
| Automatska mjerenja referentne metode | - visoka vremenska rezolucija (sat) i raspoloživost podataka (on line)<br>- dokazana visoka kvaliteta i usporedivost podataka | - visoka cijena<br>- visoki troškovi održavanja<br>- potreba za visoko stručnim kadrom | 5 000 do 10 000 za plinove osim benzena<br>20 000 do 30 000 za benzen i druge lakohlapive ugljikovodike |

# 5.4 MAINTENANCE AND NETWORK COSTS

## Extension table

| Metoda | Prednosti | Nedostaci | Cijena po analitu (€) |
|---|---|---|---|
| Aktivni uzorkivači | - niža cijena<br>- jednostavnost rukovanja<br>- visoka osjetljivost metoda<br>- velik izbor analita<br>- visoka kvaliteta podataka | - niska vremenska rezolucija (24 sata) i raspoloživost podataka (1 do 2 tjedna)<br>- potreba za stalnim sakupljanjem i transportom uzoraka<br>- potreba za laboratorijem za analizu uzoraka | 1 000 do 3 000 |

# 5.4 MAINTENANCE AND NETWORK COSTS

## Extension table

| | | | |
|---|---|---|---|
| Pasivni uzorkivači | - vrlo jeftini<br>- mogućnost postavljanja velikog broja uzorkivača<br>- jednostavnost u rukovanju i očitavanju rezultata<br>- ne ovise o opskrbi električnom energijom<br>- dobri za grubu procjenu onečišćenja | - vrlo niska vremenska rezolucija (1 do 4 tjedna) i raspoloživost podataka (1 mjesec)<br>- nereferentne metode, nesigurne za neke polutante<br>- potreba za stalnim sakupljanjem i transportom uzoraka | 6 do 10 po uzorku |

# 5.4 MAINTENANCE AND NETWORK COSTS

## Sensors

**Still in development:**

- very large measurement uncertainty
- do not use the reference method
- unreliable
- cheap
- they achieve a good spatial and temporal resolution
- 1000-2000 EUR per sensor

## 5.4 MAINTENANCE AND NETWORK COSTS

By summing up the costs of setting up and maintaining the air quality monitoring network, we conclude that the use of reference methods for the needs of the network with the usual goals is still the most favorable (value for the funds invested). This would give start costs for the average station (measuring and non-measuring equipment and other costs) from 150 to 200 thousand euros per station.

# 5.4 MAINTENANCE AND NETWORK COSTSORK

The annual cost of the network, with the involvement of quality testing laboratory (which can guarantee targeted data quality and traceability), a reliable and fast service team, including the costs of consumables and spare parts, should range from 20 to 25 thousand euros per station.

For such investments each investor expects and requires a satisfactory quality data that meet all regulatory requirements.

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# THANK YOU FOR YOUR ATTENTION

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