What are the Drivers and Legal Requirements for Ambient Monitoring?

National and local Government and devolved administrations are committed to meeting people's right to clean air. It is essential for a good quality of life. The Environment Act 1995 required the UK Government and the devolved administrations for Scotland and Wales to produce a national air quality strategy containing standards, objectives and measures for improving ambient air quality and to keep these policies under review. There is equivalent legislation in Northern Ireland. There is also an EU Directive 96/62/EC which also sets a framework for how the UK must monitor and report ambient levels of air pollutants.

The most recent strategy was published in July 2007 (Air Quality Strategy for England, Scotland, Wales and Northern Ireland, published in July 2007 Cmd paper No 7169) which sets out the overall air quality standards and objectives.

Since 1997 when the first strategy was published, local authorities in the UK have been carrying out a review and assessment of air quality in their area. The aim of the review is to assist authorities in carrying out their statutory duty to work towards meeting the national air quality objectives. If a local authority finds any places where the objectives are not likely to be achieved, it must declare an Air Quality Management Area (AQMA) there. Typical criteria would combine the population density in conjunction with the results of air quality from a short monitoring campaign.

Objectives for air pollution are concentrations over a given time period that are considered to be acceptable in the light of what is known about the effects of each pollutant on health and on the environment. They can also be used as a bench mark to see if air pollution is getting better or worse.

Many regions and conurbations have now implemented best practice guidance alongside the statutory requirements to help reduce emissions from these sources. Many integrated traffic management plans are now also in operation where the objective is to work towards lower emissions by enforcement. A recent Air Quality Strategy targeting freight vehicles has just been published for London, which focuses on reducing this significant source of air pollution in the city. There is also published best practice guidance for operators of construction and demolition sites, to help minimise emissions particularly of particulates from their processes.

The latest report form DEFRA (March 2010) indicates that although most of the legal limits on ambient air quality are now met across most of the UK, some hotspots still remain in urban areas, and effort is still needed. A new framework for PM2.5 particulate levels reduction means that exposure rates must be driven down in order to meet 2020 target levels. Legislation continues on the principle that it is best practice to reduce all levels as low as is practically possible.

Monitoring Networks:

There are over 1500 monitoring sites across the UK which monitor for local air quality and these are organised into networks that gather specific information, using a particular method. A network is where groups of local authorities make their air quality data available for other authorities to download. Current National Networks are the Automatic Urban and Rural Network (AURN), (currently around 150-200 sites) which is the UK's largest automatic monitoring programme. It includes automatic air quality monitoring stations measuring oxides of nitrogen (NO_x), sulphur dioxide (SO_2), ozone (O_3), carbon monoxide (CO) and particles (PM10). These are monitored on an hourly basis at measurement sites throughout the UK.

Automatic Hydrocarbon Network taking hourly measurements of speciated hydrocarbons, via advanced automatic gas chromatograph (VOCAIR), started in the UK in 1991. By 1995, monitoring had expanded considerably with the formation of a 13-site dedicated network measuring 26 species continuously at urban, industrial and rural locations.

The London Air Quality Network (LAQN) is managed by The Environmental Research Group of Kings College London. Hourly pollutant concentrations are measured and data collected from the individual sites by modem. The data are held here in the Air Quality Archive database.

There are also many non automatic networks such as the Ammonia network and the Nitrogen Dioxide network which utilises passive sampling tube technology.

For all these networks to operate efficiently together with the highly accurate hardware, a telemetry & computer system is essential for data is the key output required.

A network of Air Quality Monitoring stations can be local or nationwide; eg DEFRA has set up (127 stations) or Area wide as in Kent (26) or Tyne and Wear (22). Even individual councils can have several stations such as London Borough of Greenwich which has 11. The pollutants measured and method used by each network depend on the reason for setting up the network, and what the data is to be used for. There are two major types - automatic and non-automatic networks.

Some monitoring is undertaken by Local Authorities but outside the auspices of national networks, and this data is also very important to help generate the overall picture of pollution in the UK. Information from these monitoring sites provides a sound basis for Local Air Quality Management, planning and decision-making. The quality of data from these programmes can also be high. Many sites not affiliated to national networks are now subject to the same level of quality assurance and control procedures as used in these programmes; this ensures that measurement quality and integrity is fully harmonised with national networks.

Sources of pollutants:

In developed countries, the major historic air pollution problem has typically been high levels of smoke and Sulphur Dioxide arising from the combustion of Sulphur-containing fossil fuels such as coal for domestic and industrial purpose. These are now generally under stricter control and the major threat to clean air is now posed by traffic emissions.

Petrol and diesel-engined motor vehicles emit a wide variety of pollutants, principally carbon monoxide (CO), oxides of nitrogen (NO_x), volatile organic compounds (VOCs) and particulates (PM10), which have an increasing impact on urban air quality. In addition, photochemical reactions resulting from the action of sunlight on nitrogen dioxide (NO_2) and VOCs from vehicles leads to the formation of ozone, many of these pollutants due to their small size are transboundary in nature and can travel long distances, making source apportionment very difficult.

What parameters and species are monitored?

Firstly due to the level of detection (ppb or ppt) ,sensitivity and resolution required it is essential that all analysers and particulate samplers are manufactured to strict guidelines and are traceable to internationally agreed equivalency criteria.

Oxides of Nitrogen (NO_x)- The main concern is Nitrogen Dioxide which is considered as harmful to health as well as significant in the formation of Ozone. It is thought that power stations contribute 25% of NO_2 while road transport may contribute up to 50%. Whilst technology in industry has developed to aid in the reduction of NO_2 emissions, the increase in vehicles to the UK roads may well have cancelled out this reduction.

Carbon Monoxide (CO) - CO effects the ability to transfer oxygen around the body, which can have serious health effects. It is thought that road transport contributes up to 90% of CO and is particularly worse at roadside locations.

Ozone (O_3) - O_3 at ground level is an irritant to lungs amongst other affects. O_3 is also an oxidant and can damage materials and crops over time. In fact in some industries Ozone is used as a method to age components for testing purposes. O_3 is not directly emitted but is formed by complex atmospheric chemistry involving NO_x and Hydrocarbons in the presence of sunlight.

Sulphur Dioxide (SO_2) - SO_2 is an irritant to lungs and consequently can cause many different chest problems. Around 65% of the UK release of SO_2 comes from power stations, mainly from coal. There has been a decrease as a result of cleaner power stations and less reliance on coal.

Particulate Matter (PM10 & PM2.5) - Particles of 10 microns have generally been on the increase due to the popularity of Diesel vehicles

over the past five years. Focus is also now turning to monitoring particles of 2.5 microns. Particles often are made up of different chemical compounds and thus it is considered that they have a toxic effect as well as contributing to reduced lung efficiency. The focus is to reduce where possible emissions of particulates.

What are the National Air Quality Objectives?

Pollutant	Objective	Measured as
Benzene	16.25 µg/m^3	Running Annual Mean
Benzene	5 µg/m^3	Annual Mean
1,3-Butadiene	2.25 µg/m^3	Running Annual Mean
Carbon monoxide	10.0 mg/m^3	Maximum daily running 8 Hour Mean
Lead	0.5 µg/m^3	Annual Mean
Nitrogen dioxide	200 µg/m^3	1 Hour Mean
Nitrogen Oxides	30 µg/m^3	Annual Mean
Ozone	100 µg/m^3	Running 8 hour Mean
Particles (PM10) (gravimetric)	50 µg/m^3	24 Hour Mean
Sulphur dioxide	266 µg/m^3	15 Minute Mean

What measurement techniques are utilised to monitor these parameters?

NO_x - Chemiluminescence, this is the mixing of a ref gas and the gas of interest. The mixing of the gases causes a chemical reaction that results in light (in the form of photons) being generated. The light is measured with a detector known as a photomultiplier tube.

SO_2 - Fluorescence, this is where SO_2 molecules are exposed to UV light at a wavelength of 214nm. The UV excites the SO_2 molecules and as it decays from its excited state, it emits UV at a wavelength of 330nm. This method does require the use of optical filters.

Ozone - UV absorption. A UV lamp at 254nm is passed through an optical path made of inert material. As Ozone passes through the cell, the UV falling on the detector is reduced according to Beer Lamberts Law. Ozone analysers require a two phase measurement process where one phase is a reference measurement where any Ozone in the sample has been removed.

CO - Non Dispersive Infrared. An IR beam centred at 4.7um is passed through an optical path that contains the sample to be measured. CO absorbs IR at 4.7um resulting in a reduced signal at the detector. To make the measurement process accurate and specific to CO a gas filter wheel chops the IR beam causing a reference and measure signal.

How is the network maintained and operated?

There are a number of organisations that support the operation of AQ stations:-

LSO - Local Site Operators are responsible for fortnightly calibration checks of analysers and sample filter changes. LSO's also visit the AQ stations in the event of suspicious data being produced. If faults are suspected the LSO would contact the ESU.

ESU - Equipment Support Units are usually the AQ system supplier. The ESU provides routine preventative maintenance twice a year. In the event of equipment breakdown the ESU provides an emergency 48 hour site response. Analyser up - time is critical, since annual data capture targets of 90% are required.

DMU - Data Management Units ensure that automated data retrieval systems are always operational and thus storing data. Data is then examined in detail compared with analyser daily automated calibration checks and the fortnightly LSO checks. Sometimes data is corrected to compensate for instrument drift or unexplained anomalies.

QA/QC - Quality Assurance & Quality Control - In more sensitive areas, some customers opt for a QA/QC service. This service provides a higher degree of instrument testing, this involves the use of specialist test equipment. The QA/QC checks are carried out twice a year.

What happens to the data?

Data is collected twice a day from the stations (this rate can be increased if required) and corrected for inaccuracies due to instrument drift or local conditions and fed into an area database which can be stored for records or displayed on their website for public interest. A traffic-light index can be created which shows pollution in general as low, moderate, high or very high Various software packages exist, Casella Monitor utilise a bespoke package called Enview 2000.

Air Quality Stations that monitor pollutants such as NO_2, SO_2, O_3, CO & Particulates across the UK, are setup with scheduled polling to meet the customers and users requirements. The data from each individual station can be downloaded twice a day and stored on a central database, which is then automatically displayed on a website or other public access media.

An example website run by Casella Monitor is www.air-quality.net. Individual station pages can be viewed showing the latest downloaded readings and graphical reports for the past 24 hours. An AQI indicator in the form of a coloured dial displays the current level of pollution at the station. The higher the API value the greater the level of air pollution and consequently the greater the health concern. Further reports can be downloaded from both individual stations and group reports comparing pollutant levels across a region or the UK.

This website and the information it provides is accessible to anyone with an internet connection so both customers and the general public can access local and national air quality data.

The future of Networks:

Internet hosting of data will make significant steps over the next few years, and TCP/IP technology embedded within the systems will become commonplace. This will allow more real time data to be accessed and collated on a regional, national and indeed international level. Remote diagnostics and automation of calibration will also provide lower operating costs for users and enable greater density of monitoring stations throughout the UK and overseas. Many systems are already implemented which integrate air monitoring with traffic control and management systems, enabling greater local control of traffic pollution, but the ultimate goal is to move to lower polluting vehicles and reduce emissions at source, improving air quality for all.

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