DEVELOPMENT OF A MICRO MONITORING STATION FOR HOT SPOT NARROW STREET MEASUREMENTS

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ABSTRACT

*Environnement S.A has finalized an ambitious research and development program whose main objective, besides improving the analyzers metrology, was to shrink by ten the size, volume, weight and power consumption of the analyzers. Novel SMD (Surface Mounted Device) electronics and true modular design made it possible to manufacture a prototype analyzer with up to three different optical measurement cells (Chemiluminescence, UV Photometry, IR Gas Filter Correlation), a common electronics in a single low volume housing (tight box) and in accordance with internationally approved monitoring methods. Built around this new multi-gas analyzer, the **MMS** is a small shelter similar to those used by telephone companies within which a wall-mounted tight box version of the multigas analyzer is placed. Optionally, a suspended particulate analyzer such as a beta attenuation instrument MP101M.C (equivalent certified instrument with EN12341 for automatic PM_{10} measurement) or model PM162M automatic sampler compliant with the reference method EN12341, can be placed inside. The MMS addresses one of the biggest problem with Air Quality monitoring: finding space for a shelter. This is becoming more important in countries where local government must monitor where the pollution is highest. These «Hot spots» can be typically described as locations with relatively narrow carriageways with high buildings on both sides. The **MMS** offers the unique privilege of monitoring these street canyons . The system is also ideally suited for indoor air quality monitoring and on-board applications such as airborne surveillance campaign or indoor vehicle air monitoring. Description of the system, as well as the first campaign of measurements using this technology in the UK and France are presented.*

INTRODUCTION

Urban air quality monitoring networks are necessary where air pollution is a potential source of problem. Monitoring is essential for assessing the effectiveness of air pollution control programs. The goal of an air quality information system is to keep authorities, major polluters and the public informed in real-time about the short and long term changes in air quality, thereby, helping to raise awareness and assess the results of abatement measures thus providing feedback to the abatement strategy. The choice of the pollutants to be used as indicator of the air quality situation depends upon the composition and extent of sources in the city. Experience of air quality assessments in European [1] cities indicates that, in general, there is no need to increase sulphur dioxide (SO_2) monitoring points. Actually, pollutants requiring increased attention are oxides of nitrogen (NOx), ozone (O_3), particulate matter (PM_{10} or $PM_{2.5}$), carbon monoxide (CO) and more recently benzene.

Fine scale meteorology often determines what measurements are necessary. It is fundamental to carefully set up monitoring sites to avoid pollution traps that may not represent true background levels for the study area. Comprehensive monitoring programs can be a waste of resources if the monitors are located in the wrong place [2]. Regional pollution hot spots can be identified by, either, mobile monitoring, modelling or using simple (and relatively cheap) screening programs. Traditional ambient air quality monitoring systems are housed in containers with a minimum size of 2.5 x 2.5 x 2 m making them impossible to locate in areas where pollution is the highest, such as towns with narrow streets or road canyons with residential properties within 5m or so of the curb. Environnement S.A has designed a new compact micro monitoring station for monitoring NO, NO_x, NO_2, CO, CO_2, O_3 and suspended particulate matter ideally suited to meet these extreme space constraints.

DESCRIPTION OF THE CONCEPT

Gases are monitored in the ambient air at ppb level with specific analyzers that use ISO internationally approved measuring technologies [3]: Chemiluminescence, UV Photometry, IR absorption, UV Fluorescence. Hence, criteria pollutants are continuously monitored generally with single 4U gas analyzers that are most of the time integrated into a rack cabinet housed in an air conditioned shelter.

Figure 1 : Fixed station and analysers housed in 19" rack cabinet

Novel SMD (Surface Mounted Device) electronics and true modular design made it possible to manufacture a prototype analyzer with up to 3 different optical measurement cells (Chemiluminescence, UV Photometry, IR Gas Filter Correlation), a common electronics in a single low volume housing (tight box) and in accordance with internationally approved monitoring methods. This unique and remarkable achievement, sponsored by the French ADEME, is the outcome of a company commitment to design leading edge technology analyzers. Built around this new multi-gas analyzer, the **MMS** is a very small shelter (1.5 x 0.4 x 0.7m) within which a wall mounted tight box version of the multigas analyzer is placed. The system performs automatic span checks to compensate for drift and its internal memory can store external data such as

those of meteorological sensors. Optionally, a PM_{10} suspended particulate analyzer such as a beta attenuation instrument MP101M.C (EN12341 equivalent certified instrument) or a PM162M automatic dust sampler, EN12341 compliant can be placed inside.

Figure 2: Multigas ambient air micro monitoring station (MMS)

The MMS addresses one of the biggest problem of Air Quality monitoring: finding space for a shelter. This is becoming more important in countries where local Government must monitor where the pollution is highest. These «Hot spots» can be typically described as locations with relatively narrow carriageways with high buildings on both sides.

CAMPAIGN OF MEASUREMENTS IN UK

A campaign of measurement was started in May 2003 by the Environmental Services Division of Wycombe District Council using the analyzer in its basic version (only NO-NO_2 and NO_x monitoring by chemiluminescence).

The station is located in Wycombe's Air Quality Management Area (AQMA) where air pollution has been considered the highest in the district. Modelling has predicted that the NO2 concentration will not meet the UK national objective, which is 40 µg/m^3 annual average not to be exceeded by 31 December

2005. The monitor is there to confirm or refute this prediction and so far all the data have confirmed that the level of NO2 pollution is above the 40 µg/m^3 limit.

Figure 3: Hot spot location of the MMS

The location (in a private property, 25 metres away from the motorway) was researched with the local Council Member of the time and with the kind co-operation of one of the resident of the village of Stokenchurch a spot was found in a garden close to the source of pollution. The spot was quite tight and there was little room for manoeuvre. The instrument records NOx, NO and NO_2 emissions from traffic and is at a location of relevant exposure as people live there permanently and is almost at the same level as the traffic. It will not suffer unusual local events such as road works or traffic jams from local roads which could damage the validity of the dataset (the Council is monitoring the motorway and not local traffic). The AC32M-CF (basic version of the MMS), was ideal for the situation as you can see on the pictures. Full access was given to the garden, little noise and visual disturbance was created and the electricity consumption was found to be minimal.

RESULTS

A selection of data for two specific days during 2004 are presented hereafter, in two accidental situations. The figure presented below show the location of the monitoring site in front of the road.

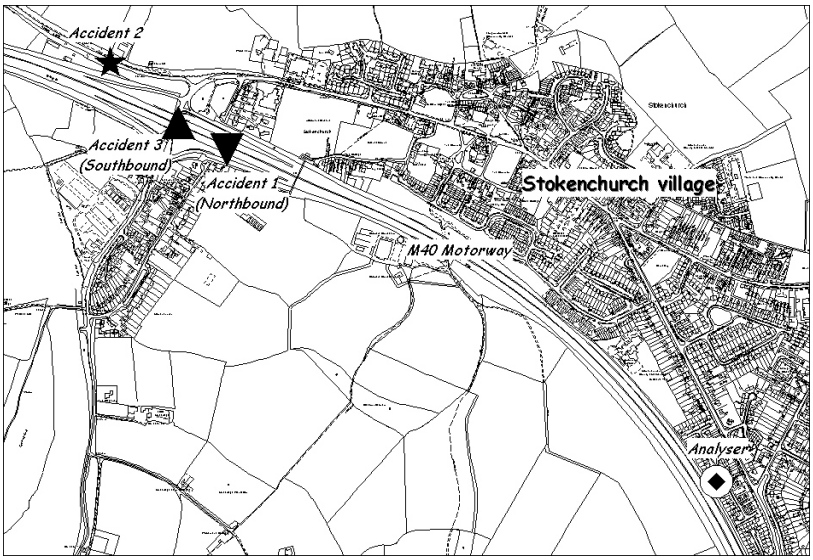

Figure 4: Map localisation reproduced from Ordnance Survey material with the permission of Ordnance Survey on behalf of the controller of Her Majesty's Stationery Office. © Crown Copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings. Wycombe District Council. Licence LA 086207 2004.

The data recorded by the monitor indicates the evolution of the three parameters a few hours after the event.

On Sunday 4th of January the traffic is quite low at this junction of motorway and rises progressively from 9:00AM onward. After the occurrence of accident 1 at 5:00PM as reported by Mott MacDonald, one can see the increase in concentration for one hour until the accident is cleared. The concentrations remain stable for some time until just before midnight indicating a constant flow of traffic due to the return from holiday.

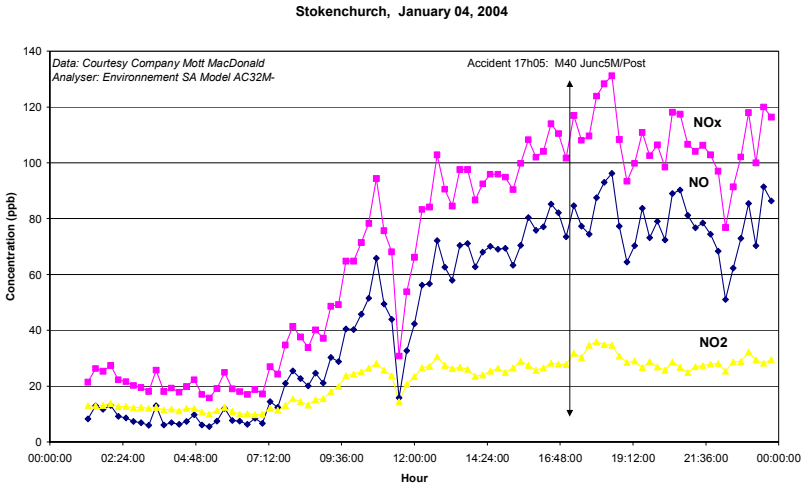

Figure 5: Nitrogen oxides record during Jan 04

On Monday 5th January at 8:32AM, the results show a different behaviour as this is a working day. The traffic is initiated at 5:30AM and remains almost constant until 8:00PM when it begins to decrease.

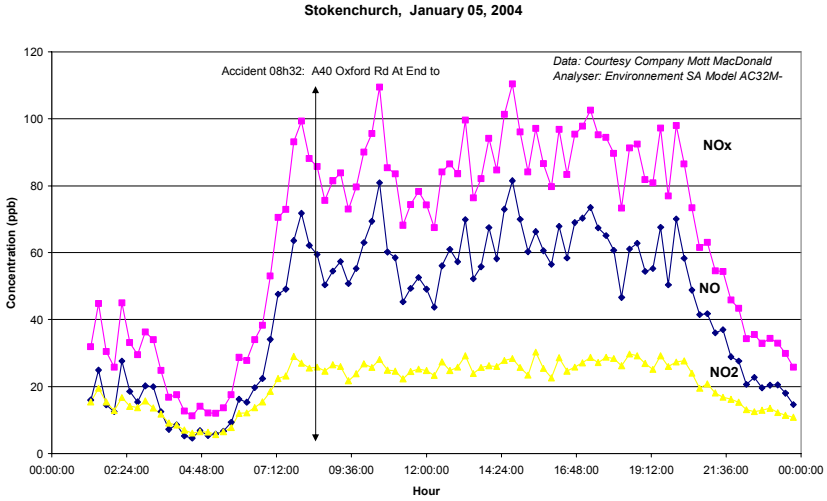

Figure 6: Nitrogen oxides record during Jan 05

CAMPAIGN OF MEASUREMENTS IN FRANCE

In this application a micro monitoring station including a multi-gas analyser combined, firstly, to an automatic particulate PM_{10} (EN12341 compliant) sampler and secondly, to a beta attenuation monitor, was used in a specially designed air conditioned housing.

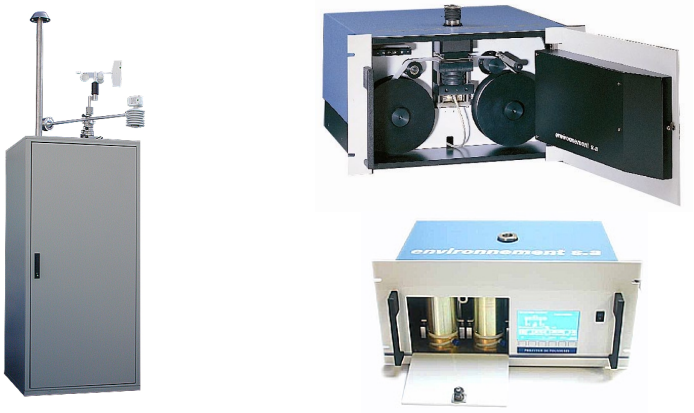

Figure 7: Particulate monitor and automatic sampler

Particulate matter measurements

The automatic sequential sampler model PM162M combines high accuracy reference sampling with compact lightweight design and large holder capacity. Compliant with European (EN12341, prEN14907) and American (40 CFR pt. 50) standards, the instrument performs sampling of particulate matter through PM10 and PM2.5 size selective inlets on ∅ 47 mm filters for gravimetric mass calculation and heavy metals analysis. The suspended particulate monitor model MP101M allows for continuous mass measurements of between 1 to 24 hours averaging time by way of beta attenuation gauge.

Both the PM162M and the MP101M can be fitted with a specially designed Regulating Sampling Tube (RST). Atmospheric pressure, temperature and relative humidity at the inlet are essential factors that must be taken into account in order to maintain accurate and reliable sampling.

Underestimation or overestimation of the particulate matter concentration may in fact result in evaporative losses during sampling, water condensation, or inaccurate sampling flow. The RST line has temperature and humidity sensors located at the sampling point. The sampling temperature is maintained as close as possible to ambient temperature and, depending on ambient relative humidity, regulated to less than 3 to 5°C above ambient temperature. The results show neither condensation nor loss of semi-volatile compounds. Moreover, using the data of the sensors of the RST system, the instruments perform a true volumetric air flow control as required by international standards.

RESULTS

In Figure 8 an example of field data obtained with the reference sampler PM162M is shown equipped with a 2.3 m^3/h EN12341 PM_{10} inlet. The PM162M was integrated in an MMS box placed along a main street in the regional department of Yvelines, about 30 km N-W of Paris.

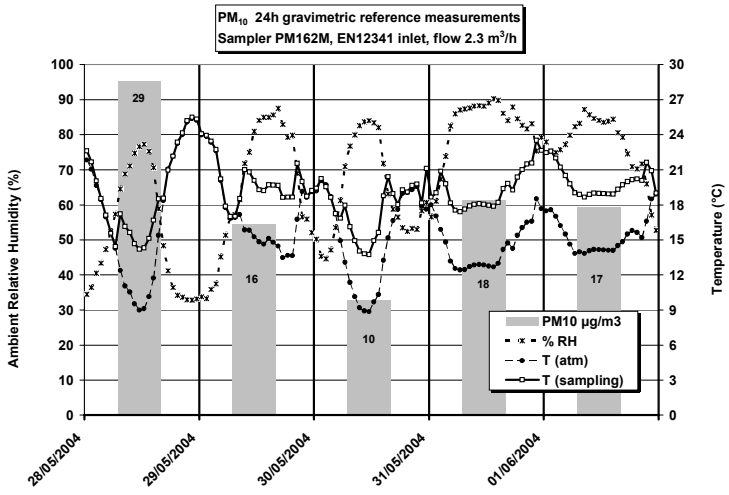

Figure 8: Reference PM10 measurements associated to meteorological parameters

All the critical parameters linked to a sample are recorded and stored in the instruments' internal memory and are accessible to the operator in real time on site or remotely: atmospheric temperature and pressure, ambient relative humidity, sampling temperature, filter temperature, pressure drop across the filter, flow rate stability, sampled volume.

In Figure 9 an example of continuous beta gauge measurements is reported. Data are recorded at the same site as above but with a MP101M monitor equipped with a 1 m^3/h US-EPA PM_{10} inlet.

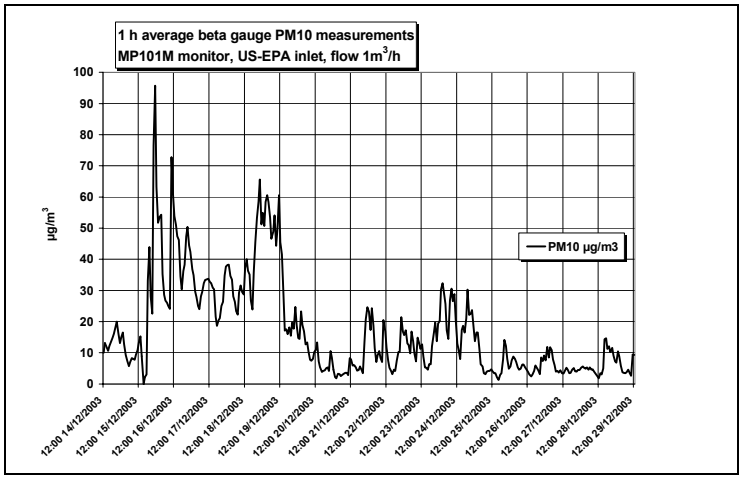

Figure 9: Hourly PM10 measurements by Beta gauge.

Accuracy of the hourly average PM10 measurements was found to be 2.5 µg/m^3. The advantage of using continuous hourly PM10 measurements is to detect discreet dust pollution events like the ones that occurred on the 15th, 16th and 18th of December 2003. During these days one hourly peak exceeds the value of 70-90 µg/m^3, indicating events where the coupling of traffic emissions and atmospheric stability generate high PM10 concentrations One can also notice the Christmas holiday period beginning 19 Dec. that resulted in a reduction of the peaks of lower levels of PM_{10}.

CONCLUSION

Field results have shown the main advantage of using this new concept of monitoring station and the benefits of space reduction in finding representative hot spot locations. The instruments used have shown similar levels of performance as the traditional rack mounted gas analyzers when compared with other stations of the network. QA/QC of the two field stations were under particularly scrutiny and have shown a reduction in the maintenance operations and time spent at the site. Moreover the instruments' remote facilities have allowed for minimum time spent on control, calibration and diagnostic by the operator through telephone/GSM communication.

REFERENCES

[1] Ambient air quality in Europe, http://europa.eu.int/comm/environment/air/ambient.htm

[2] "Classification and criteria for setting up air-quality monitoring stations", Alain Morcheoine - ADEME Editions, Paris 2002 – Ref./ 4307

[3] Monitoring methods for ambient air – Technical guidance note M9 – UK Environment Agency, 2000