# Report on Turnkey Osiris Particle Results at the Southampton Hotel, Weighbridge May 2002 - January 2003

## Executive Summary

The Health Protection Department have monitored air quality since 1994. This initial monitoring involved nitrogen dioxide ($NO_2$), volatile organic compounds (VOCs) and sulphur dioxide ($SO_2$). However, in 2002 further equipment was acquired which allowed particulate measurement ($PM_{10}$). Particulates include dust and smoke and have a well documented respiratory effect on human health.

Results for the period 4th May, 2002 to the 7th January, 2003 measured at the Weighbridge exceeded the EC and UK Air Quality objective by 20 times. These objectives should be complied with by 2010 in the UK and allow 7 exceedances per calendar year.

The results give additional support to the importance of the Air Quality Strategy (see www.health.gov.je).

Further work is necessary to assess levels of particulates in Jersey compared to traffic numbers, mix and speed, also meteorological conditions. Again, this is part of the Integrated Air Quality Strategy. It is recommended that the daily real time results are uploaded to an Internet website for easier public access.

## Introduction

The Turnkey Osiris Particle Monitor (OSIRIS: Optical Scattering Instantaneous Respirable Dust Indication System) was purchased in March 2002. It was designed to continuously monitor particle levels in particular Total suspended particles (TSPs), $PM_{10}$ (Particles with an aerodynamic diameter of 10, $PM_{2.5}$ 2.5and 1 micron(s)) and $PM_{1.0}$.

The aim of the monitoring is to assess real time particle levels in the Weighbridge area which is known to exceed the EC directive limit for Nitrogen Dioxide. The results provide information on compliance with the EC and UK Air Quality Strategy limits and trends overtime to determine possible air quality improvements.

## Particles: Sources and Health Effects

Particles in the atmosphere originate from a wide variety of sources. They take the form of dust; smoke of very small liquid or solid particles called aerosols. Particles may be either emitted directly into the atmosphere (ie primary particles)or formed subsequently by chemical reactions (ie secondary particles). $PM_{10}$, (particles are defined as having an average particle size of 10 microns in diameter (10 millionths of a metre), and have well documented respiratory effects on human health. These include effects on the respiratory and cardiovascular systems, asthma and mortality.

The Expert Panel on Air Quality Standards (EPAQS) concluded that particle air pollution episodes are responsible for causing excess deaths among those with pre-existing lung and heart disease. EPAQS also believe that any risk of lung cancer from the concentrations found in the streets of the UK is likely to be exceedingly small. However prolonged exposure for example 20 - 30 years to particles, which are likely to be combined with Polycyclic Aromatic Hydrocarbons (PAH) originating from unburnt or partially burnt fuel, is likely to be carcinogenic.

There is a wide range of human activities that produce particulate emissions, including; motor vehicles (mainly diesel), solid fuel burning, industrial processes, power stations, incinerators and construction activity.

Emissions from mainland Europe may make a significant contribution to secondary particles in Jersey. The UK Airborne Particles Expert Group's findings suggest that in a typical year with typical meteorology, about 15% of the UK's total annual average $PM_{10}$ concentrations (about 50% of secondary particles) are derived from mainland Europe. In years of higher frequency of easterly winds, with large movements of air from mainland Europe, emissions in mainland Europe account for a considerably higher proportion of $PM_{10}$ concentrations, particularly in south and east England. No work as yet has been carried out to try and establish the contribution of secondary particles originating from Europe onto Jersey.

A UK government Air Quality Strategy Objective and a European Community Directive regulates concentrations of $PM_{IO}$ in the UK (see below). The States of Jersey has agreed to work towards the limits set out in the European Daughter Directive 99/30/EC which deals with particles, sulphur dioxide, nitrogen dioxide, and lead.

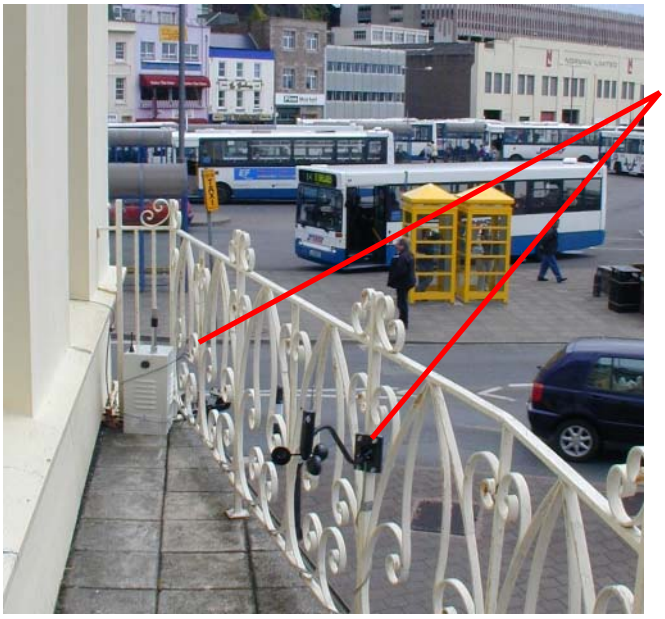
**Background**

The Turnkey Osiris Particle Monitor (Optical Scattering Instantaneous Respirable Dust Indication System) (see the photograph) was purchased in March 2002. It was designed to continuously monitor particle levels in particular Total suspended particles (TSPs), $PM_{10}$ (Particles with an aerodynamic diameter of 10, 2.5and 1 micron(s)) $PM_{2.5}$ and $PM_{1.0}$.


A wind direction and speed monitor was also provided to give meteorological information. The Osiris is served by a GSM modem, which allows Officers from this Department to dial it up at any time and download the results using the Air Q 32 Software (see Appendix 5). It is hoped that the supplier Turnkey Instruments Ltd can provide a computer programme, which will allow results to be automatically uploaded to an Internet website. This would provide easier public access to the data.

The Osiris is also fitted with a filter, which traps particles as they are sized and counted. The filter was removed from the unit in September 2002 and sent to TES Bretby UK Ltd for further analysis. A new pre weighed filter was placed into the unit. The filter analysis allows the weight of particles to be determined and compared with the Osiris' computer calculated weight (ie accuracy of the Osiris). The analysis by TES Bretby of the filter also allows the sources of particle and percentage contribution to be determined. The results are provided below.

The unit is sited on a balcony approximately 4 m above the pavement and approximately 5 m from Mulcaster Street/Esplanade (see the photograph below). The Osiris samples particles as 15 minute averages.

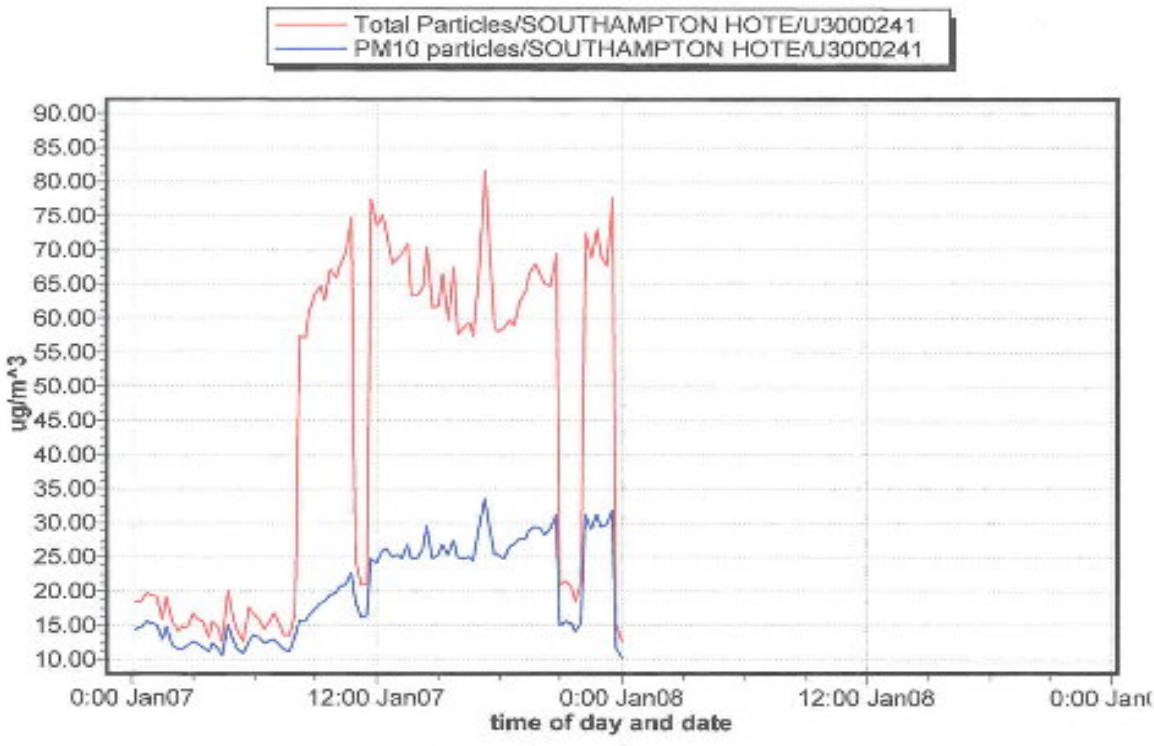


Osiris particle monitor and weather station

It was decided to position the Osiris at this particular site because it has generally the poorest air quality compared to the other monitoring sites. Unfortunately the Public Services Department were not able to provide a traffic monitor at the site. Therefore there is limited data on the speed, volume or mix of traffic using Mulcaster Street. However the Nitrogen dioxide diffusion tube sited on the Police Surveillance tower suggests that the older type buses and taxis contributed to the poor results. It is likely the air quality will improve with the provision of the new Connex buses from 29th September 2002, which are the cleaner Euro 3 engines.

**Results**

The particle results (ie TSP, $PM_{10}$, $PM_{2.5}$ and $PM_{1.0}$) are presented in tabular form in Appendix 3 and graphical form in Appendix 4. Figure 1 below shows the particle levels over time during a 24 hour period 7th - 8th January, 2003. Levels of particles increase up to lunchtime and remain generally high till approximately 11.00 pm. This indicates that particle levels follow traffic volume and mix.



The Turnkey Osiris Particle Monitor uses a heated inlet (50°C) to evaporate water vapour particles which cause inaccurate readings, however it is believed that evaporation of volatiles also occurs resulting in lower than actual results. Research has suggested that such results should be increased by 30% to increase their accuracy. This percentage will differ depending on the area. For more information on how the OSIRIS measures particles can be found in Appendix 1.

The European Union requires the use of a gravimetric (filter based) method to prove compliance, and the UK has suggested that its preferred Tapered element oscillating microbalance (TEOM) measuring devices are adequate if the results are multiplied by up to 30%. There is concern that the 30% increase may lead to false exceedances. It is recommended the gravimetric method is run in conjunction with other methods which use heated inlets to confirm the percentage increase. The Osiris although not as accurate as the TEOM provides useful indicative results. The twenty uncorrected exceedances are shown in Table 1 below.

| **Table 1 Exceedances** | | | |
|---|---|---|---|
| | | | |
| Exceedance: greater than:50 µg/m$^3$ as 24 hour average - | | | |
| (7 exceedances allowed per year to be achieved by 31/12/10) | | | |
| | | | |
| **$PM_{10}$ ( mg/m3)** | **Result** | | |
| | | | |
| 09/05/02 | 67.7 | May: 5 exceedances | |
| 10/05/02 | 60.5 | | |
| 11/05/02 | 52 | | |
| 22/05/02 | 56.7 | | |
| 24/05/02 | 53.8 | | |
| 03/09/02 | 72.5 | September: 6 exceedances | |
| 04/09/02 | 50.6 | | |
| 12/09/02 | 75.7 | | |
| 13/09/02 | 98.4 | | |
| 14/09/02 | 76.7 | | |
| 20/09/02 | 59.7 | | |
| 11/10/02 | 59.7 | October: 4 exceedances | |
| 26/10/02 | 57.6 | | |
| 30/10/02 | 56.6 | | |
| 31/10/02 | 65.3 | | |
| 03/11/02 | 53.6 | November: 2 exceedances | |
| 04/11/02 | 66.4 | | |
| 02/12/02 | 55.3 | December: 2 exceedances | |
| 03/12/02 | 53.2 | | |
| 07/01/03 | 57.7 | | |
| | | | |
| Total | 20 exceedances – uncorrected. (62 exceedances – corrected) | | |

In the period from the 4th May, 2002 - 7th January 2003 there were twenty exceedances (uncorrected) and sixty two exceedances (corrected) of the European Union Daughter Directive 1999/30 and UK Air Quality Strategy limit value (ie 24 hour mean of 50 μg/m$^3$ both to be achieved by the end of 2010). Note: To correct the results each result is increased by 30% to account for particles volatilised and lost by the Osiris' heated inlet. The average results over the period were:

**A) 33.10μg/m$^3$ (uncorrected)**
**B) 43.03μg/m$^3$ (corrected)**

The results from the filter analysed by TES Bretby in the UK are shown in Appendix 2. The examination procedure is based on the assessment of approximately 50 individual particles selected at random. The estimated percentage is based on a comparison of the relative number of particles counted in each category. The filter was exposed for 646 minutes and the mass was 6.84 mg. Interestingly a large amount of the particles analysed was either sea salt (32%), or Amorphorous dirt (Aluminium/Silicon rich) (42%). Care must be taken interpreting theses results as only a very small number of particles were analysed. Unfortunately the costs are prohibitive for greater in depth analysis.

**Comparison with EU and UK Guidelines**

The EU Directive also details an: (24 hour limit value)

(a) **Upper Assessment threshold: 60% of the limit value (30 μg/m$^3$) not to be exceeded more than 7 times in any calendar year.**

(b) **Lower Assessment threshold: 40% of the limit value (20 μg/m$^3$) not to be exceeded more than 7 times in any calendar year.**

The upper Assessment threshold is presently being exceeded. Improvement in traffic management flow reduction will be needed to ensure the Upper Assessment threshold (UAT) is not exceeded in 2010. Improvement should occur in the next few years with the relocation of the bus station to the Island site, new cleaner Connex buses and road changes as part of the St Helier Life program.

The UK guidelines include:

(a) **Air Pollution Bandings : As a running 24 Hour mean**

| | |
|---|---|
| **Low Air Pollution:** | **<50 μg/m$^3$ (211 results)** |
| **Moderate Air Pollution:** | **50 - 74 μg/m$^3$ (17 results)** |
| **High Air Pollution:** | **75 - 99 μg/m$^3$ (3 results)** |
| **Very High Air Pollution:** | **>= 100 μg/m$^3$** |

(b) **The UK Air Quality Strategy Objective for 31st Dec 2004:**

**24 Hour daily mean: 50 μg/m$^3$ not to be exceeded more than 7 times per calendar year.**

**Calendar Year Annual Mean: 40 μg/m$^3$**

The $PM_{10}$ particle results for the Weighbridge site presently exceed the UK 24 hour limit value of 50μg/m$^3$ ie (20 exceedances uncorrected and 62 exceedances corrected).

However the results comply with the annual mean value of 40μg/$m^3$ when uncorrected (33.10 μg/$m^{3)}$ but exceed the annual mean when corrected (43.03μg/$m^3$), however these results equate to 7 months worth of data. According to the Air Pollution Bandings the air pollution at the Weighbridge **was low on 211 days**, **Moderate on 17 days and High on 3 days).**

**Comparison with other sites in Jersey and UK**

Particle measurements carried out at other sites in Jersey are generally lower than at this site. Surveys have been carried out at:

(a) Halkett Place 1997 and 2000 Jan - March: Average $PM_{10}$ levels in 1997 and 2000 were 27 μg/$m^3$. The Weighbridge site varied between 33.10 μg/$m^3$ for the 8 month period.

(b) New Street: Levels of $PM_{10}$ in January 2000 varied between 13 - 27 μg as a running 24 hour average and no exceedances. The Weighbridge site varied between 5.4 μg/$m^3$ and 98 μg/$m^3$.

(c) Savile Street: Levels of $PM_{10}$ varied in January - February, 2001 from 21 μg/$m^3$ to 59 μg/$m^3$ as a running 24 hour average with one exceedance. The Weighbridge site varied between 5.4 μg/$m^3$ and 98 μg/$m^3$.

$PM_{10}$ concentrations in Jersey were generally higher than the UK comparison sites (Ref NETCEN) but broadly similar to those found in London and Bristol. Levels at the Weighbridge site are broadly what could be expected at a roadside location in the UK.

**Conclusions**

1. The Turnkey Osiris particulate monitor was set up on the Southampton Hotel's balcony at the Weighbridge in May 2002 and measures particles in real time (ie Total Suspended Particles TSP, Particles of a mean aerodynamic diameter of 10 microns $PM_{10}$, Particles of a mean aerodynamic diameter of 2.5 microns $PM_{2.5}$ and Particles of a mean aerodynamic diameter of 1 micron $PM_{1.0}$ ) as 15 minute averages.

2. Particles are associated with a range of health effects. These include effects on the respiratory and cardiovascular systems, asthma and mortality. The Expert Panel on Air Quality Standards (EPAQS) concluded that particle air pollution episodes are responsible for causing excess deaths among those with pre-existing lung and heart disease. EPAQS also believe that any risk of lung cancer from the concentrations found in the streets of the UK is likely to be exceedingly small. However prolonged exposure for example 20 - 30 years to particles, which are likely to be combined with Polycyclic Aromatic Hydrocarbons (PAH) originating from unburnt or partially burnt fuel, is likely to be carcinogenic.

3. The results show that the EU Directive health limit was exceeded 20 times in the 8 months sampling period. The EU Directive allows 7 exceedances and is to be achieved by the end of 2010.

4. The particle results follow traffic movements as particle levels increase up to lunchtime and remain high into the afternoon. Levels fall again after approximately 11.00 pm.

5. The relationship between meteorological conditions and particle levels is not clear. As wind speed increase particle levels reduce, however the position of the monitor is sheltered to northerly and north easterly winds.

6. The Osiris has a glass fibre filter which collects particle material, which was further analysed to determine the sources of the particles and percentage contribution. The results indicate that a proportion of particles are wind blown sea salt or sand deposits, which are non toxic. Care must be taken interpreting these results as only a very small number of particles were analysed. Unfortunately the costs are prohibitive for greater in depth analysis.

7. Most exceedances (6) occurred in September 2002. Interestingly the Connex bus contract started on September 29th 2002, which should have improved air quality as the buses are fitted with Euro 3 engines. It is difficult to conclude from the results whether any significant improvement occurred after this date.

**Recommendations**

1. Further long term research (until at least 2010) should be carried out to assess levels of TSPs/$PM_{10}$/$PM_{2.5}$/PM1.0 in Jersey compared to traffic numbers, mix and speed and meteorological conditions to establish trends and assess compliance with the European Union Daughter Directive objectives. This forms part of the integrated Air Quality Strategy. It is recommended the results are uploaded to an internet web site for easier public access.

2. Traffic data (eg volume, mix and speed) should be made available to allow more meaningful comparison with particle results.

3. Further work is needed to assess the relationships between meteorological data and particle levels.

4. It is likely that reductions in particle levels will occur because of improvement in emissions from the newer Connex buses, re-location of the bus station to the Island Site and road changes associated with the St Helier Street Life program.

5. Those objectives which impact on air quality in the Public Services Department's Sustainable Island Transport Strategy, the new Island Plan, Strategy on Sustainable Development and Jersey's Air Quality Strategy be implemented and supported.

6. Further work is needed to assess the contribution of secondary particles from mainland France to Jersey. Also sampling and analysis via gravimetric means should be carried out to confirm that the 30% increase in figures associated with the Osiris' heated inlet is correct for this particular monitoring site.

**Appendix 1: The Turnkey Osiris Particle Monitor**

Osiris stands for *Optical Scattering Instantaneous Respirable Dust Indication System*.

The Osiris is an investigational instrument that fulfils the dual role of a portable instrument or permanent installation.

The instrument is housed in a sturdy die cast metal box with internal rechargeable battery. The external power source was connected for the long term monitoring. The internal memory was used to record $PM_{10}$, $PM_{2.5}$, $PM_{1.0}$ and Total Suspended Particles (TSP) as 15 minute averages for the monitoring periods. Each 24 hour period is saved in a folder for downloading to a computer and analysing with the Air Quality Programme for Windows. The Air Quality programme allows the data to be graphed and copied into Microsoft Excel for further analysis.

The instrument measures and records the concentration of airborne particles using a proprietary laser (nephelometer). An internal pump continuously draws an air sample through the nephelometer which analyses the light scattered by individual particles as they pass through a laser beam. These same particles are then collected on the reference filter. The nephelometer's dedicated microprocessor can analyse the individual particles even if there are millions of them per litre. This allows the size fractions to be determined at concentrations up to several milligrams/$m^3$.

The light scattered by the individual particles is converted into an electrical signal which is proportional to the size of the particle. A unique feature of the Turnkey nephelometer is that only light scattered through very narrow angles 10 degrees or less is measured. At this narrow angle the amount of light scattered is virtually the same for say black diesel or white limestone particles of the same size. That is, it doesn't depend on the material composition of the particle. On the other hand, the easier to measure right angle 90° scatter used by some earlier scattering instruments is highly dependant on material composition with white particles apparently scattering much more light than black ones of the same size.

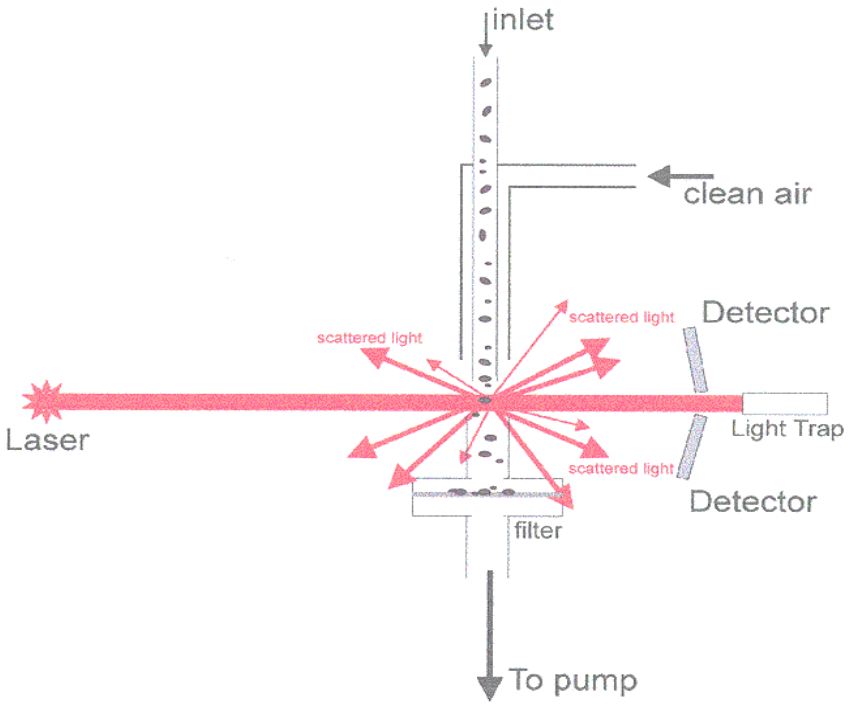
The light scattered by airborne particles can be thought of as consisting of three components. Light reflected from the surface of the particle, light refracted through the particle and light which is diffracted from its original path by the presence of the particle. The intensity of the light scattered by reflection or refraction strongly depends on the type of particle. Thus a white limestone particle will reflect much more light than a black diesel fume particle of the same size. On the other hand the diffracted component depends only on the size of the particle and is independent of its material composition.

For irregularly shaped particles, light, which is reflected and refracted, tends to be scattered over all possible directions. The diffracted component, however, tends to be scattered only through very small angles. For example, for a 5 micron diameter particle, 90% of the diffracted light is scattered by less than 10 degrees from the original direction of the light beam.(42)

The intensity of the light pulse is therefore an indicator of particle size, from this the microprocessor is able to calculate the expected mass of the particle. It assumes the material density of the particle is 1.5 grams per cc, which for most airborne dusts is a good approximation but the mass calibration factor can be adjusted to compensate for different material types.

Having evaluated the mass of the particle, the microprocessor then evaluates the likely chance of deposition of the particle according to the sampling convention being used ($PM_{10}$, thoracic, and so on) as shown in figure 19 below. Thus for the thoracic convention a 6 micron particle has an 80.5% chance of deposition, hence only this percentage of its evaluated mass is accumulated.(42)

**Diagram of the Osiris particle monitor**




**Mr A M Irving**
**Environmental Health Officer**

**Direct Dial: 01534 623732**

**Web Site: www.health.gov.je**

**March 2003**