

The impact of smoking cigarettes on particulate levels in private vehicles

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Aims of the study

- The purpose of this study was to investigate the levels of particulate matter as $PM_{(2.5)}$ within private vehicles whilst cigarettes were being smoked. Measurements were undertaken so as to reflect the normal behaviour of smokers within their own vehicles during short journeys.
- The study aimed to simulate the exposure of passengers within the vehicle to second hand smoke (SHS) and in particular the potential exposure to children whilst seated in child restraining seats.
- Also under investigation was the period of time that the $PM_{(2.5)}$ levels remained at elevated levels above monitored base levels.

Why are we interested and what do we already know

- Particulate matter (PM) is a term used for particles found in the air including dust, dirt, smoke and liquid droplets. Such particles originate from many sources the major manmade emitters being industrial processes, vehicle exhausts and other combustion sources.
- Particles $2.5\mu\text{m}$, or less, in diameter are referred to as “fine” particles and these are roughly $\frac{1}{30}$ th the diameter of a human hair. There is emerging evidence to suggest that the adverse health effects of such particles are due principally their ability to penetrate deep into the respiratory tract.
- Environmental Tobacco Smoke (ETS), also referred to as second-hand smoke (SHS) or passive smoke, consists of a combination of mainstream smoke exhaled by the smoker and sidestream smoke from the burning of tobacco products.

- SHS is a toxic air contaminant and is known to contribute to preventable adverse health issues. Amongst adults SHS exposure is associated with cardiovascular disease, cancers and respiratory problems. Children exposed to SHS show a greater likelihood of lower respiratory infections, ear infections and increased severity of asthma symptoms.
- These particles can be suspended in the air for long periods of time. This characteristic is of great significance when considering the impact of passive smoke on non-smokers.

Existing Legislation

- Legislation came into force in Wales in April 2007, making enclosed public places smoke-free. Public support for this legislation has proved highly popular, achieved widespread compliance, improved indoor air quality, and reduced passive smoke exposure.
- Increasing numbers of people are taking measures to make their homes and private vehicles smoke-free. This was highlighted by the difficulties experienced when trying to obtain volunteers for this study.

- The Health Act 2006 is the current legislation in the UK enforcing smoke-free premises, places and vehicles. The legislation applies to all forms of public transport (eg buses, coaches, trains, taxis) and also to vehicles used for work purposes. The legislation does not apply to private vehicles used primarily by the owner or a person whom has a right to use it.
- Legislation banning smoking in private vehicles where children are passengers has been introduced in the United States of America, Canada, Australia and South Africa, with substantial success.

Methodology

- PM_(2.5) concentrations were measured using a TSI SidePak AM510 Personal Aerosol Monitor. The 2.5µm impactor fixed to the inlet of the SidePak ensured that particles greater than this size would not enter the device and would therefore not be recorded.
- Sampling was designed, as far as possible, to reflect the normal behaviour of the volunteers participating in the study i.e. replicating the smoking activity of persons within vehicles during short journeys. Monitoring positions were chosen to reflect the location of the respirable zone of a child whilst restrained in a child seat. This was achieved through the positioning of the Tygon™ tubing, attached to the inlet of the SidePak at that of a child's head height.
- In order to give comparative data PM_(2.5) concentrations were measured within vehicles of both smokers and non-smokers. Measurements were also taken in both diesel and petrol powered vehicles when static and during short journeys.

TSI Model AM510 SIDEPAK Personal Aerosol Monitor



Methodology

- Four main vehicles were used for data collection sessions : a Mazda MX5, a Citroen Picasso, a Citroen Berlingo and a Ford Fiesta. All these vehicles were owned and driven by volunteers recruited from the general Community who confirmed that they routinely smoked whilst driving.
- Test conditions were recorded. These included vehicle type; the use of mechanical and artificial ventilation; type of cigarette smoked (proprietary brand or hand-rolled); the number of cigarettes smoked during the test period and the length of time since smoking had occurred within the vehicle prior to the test commencing.
- Having measured and recorded the $PM_{(2.5)}$ concentrations, the SidePak was connected to a personal computer and the data was downloaded using the “TrakPro” software.
- Each test, other than the static tests, was undertaken under driving conditions reflecting the normal behaviour for the volunteer taking part. Typically this would be a journey to work or a shopping trip.

SIDEPAK AM510

Showing typical
monitoring position

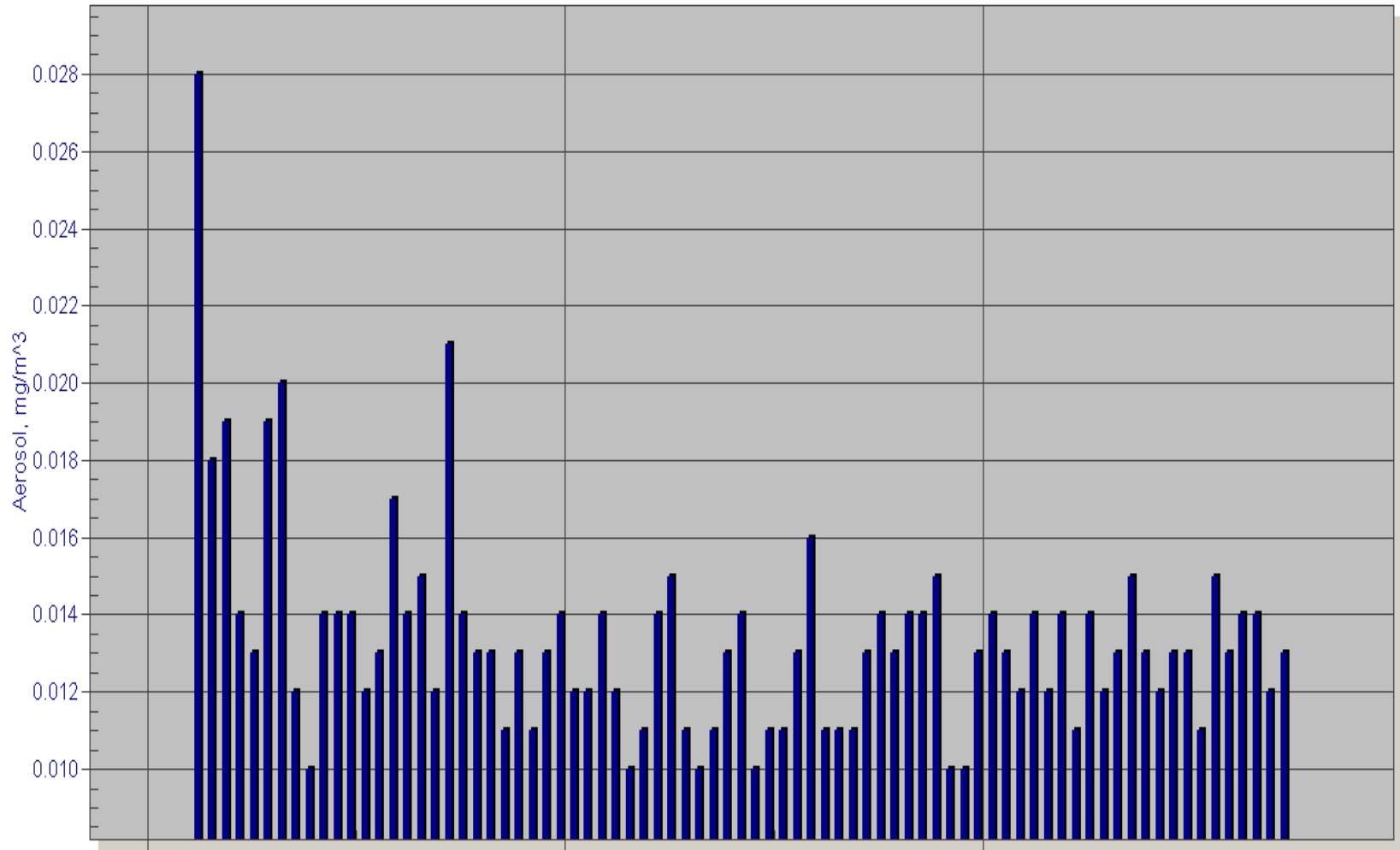


Results

- The data obtained revealed elevated levels of PM 2.5 which were significantly higher during active smoking than the pre- and post -smoking periods. As expected the levels were higher when vehicles windows were closed.
- The time taken to return to pre-smoking levels was variable; those tests undertaken with windows open returning to pre-smoking levels quicker than those undertaken with windows closed, as had been predicted.
- Tests were undertaken smoking both branded and hand-rolled cigarettes. On average the branded cigarettes contained 3 times more tobacco and levels of PM 2.5 were twice as high as those for hand-rolled cigarettes.

Non Smoker

Static



Tue 22 Feb 2011

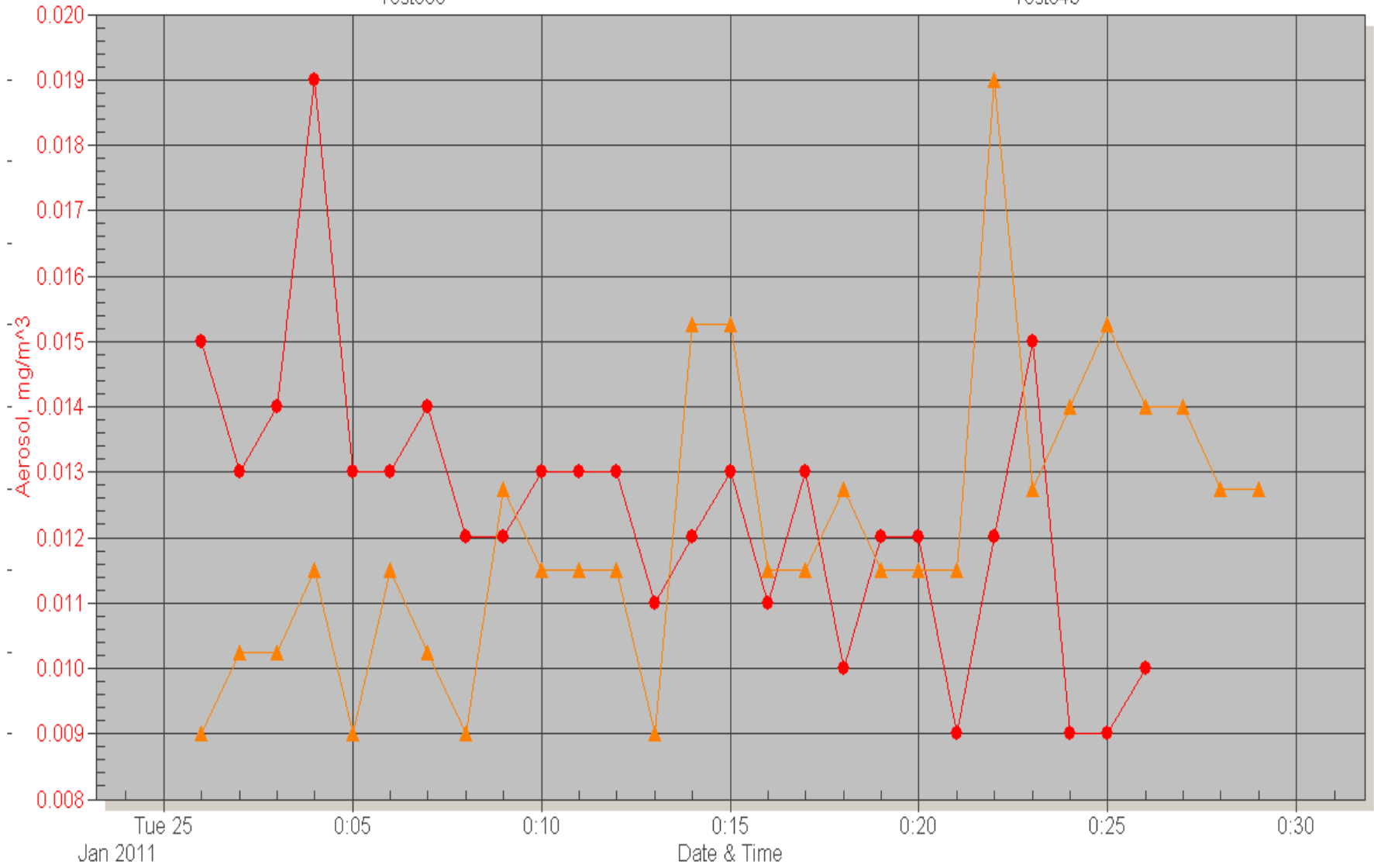
Date & Time

SMOKER

static

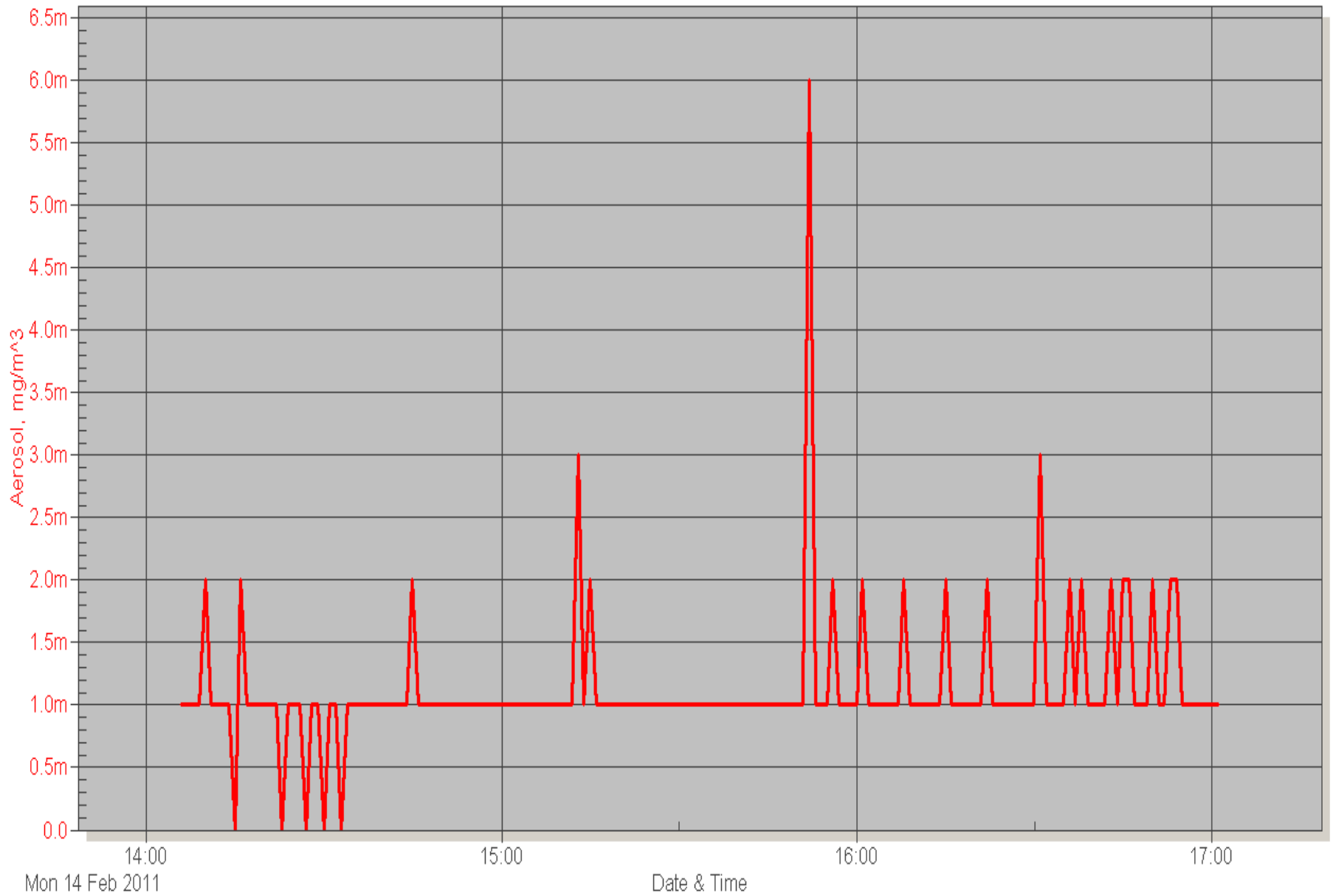
Test006

Test043



SMOKER

Static 2



Non Smoker Journeys

Test004

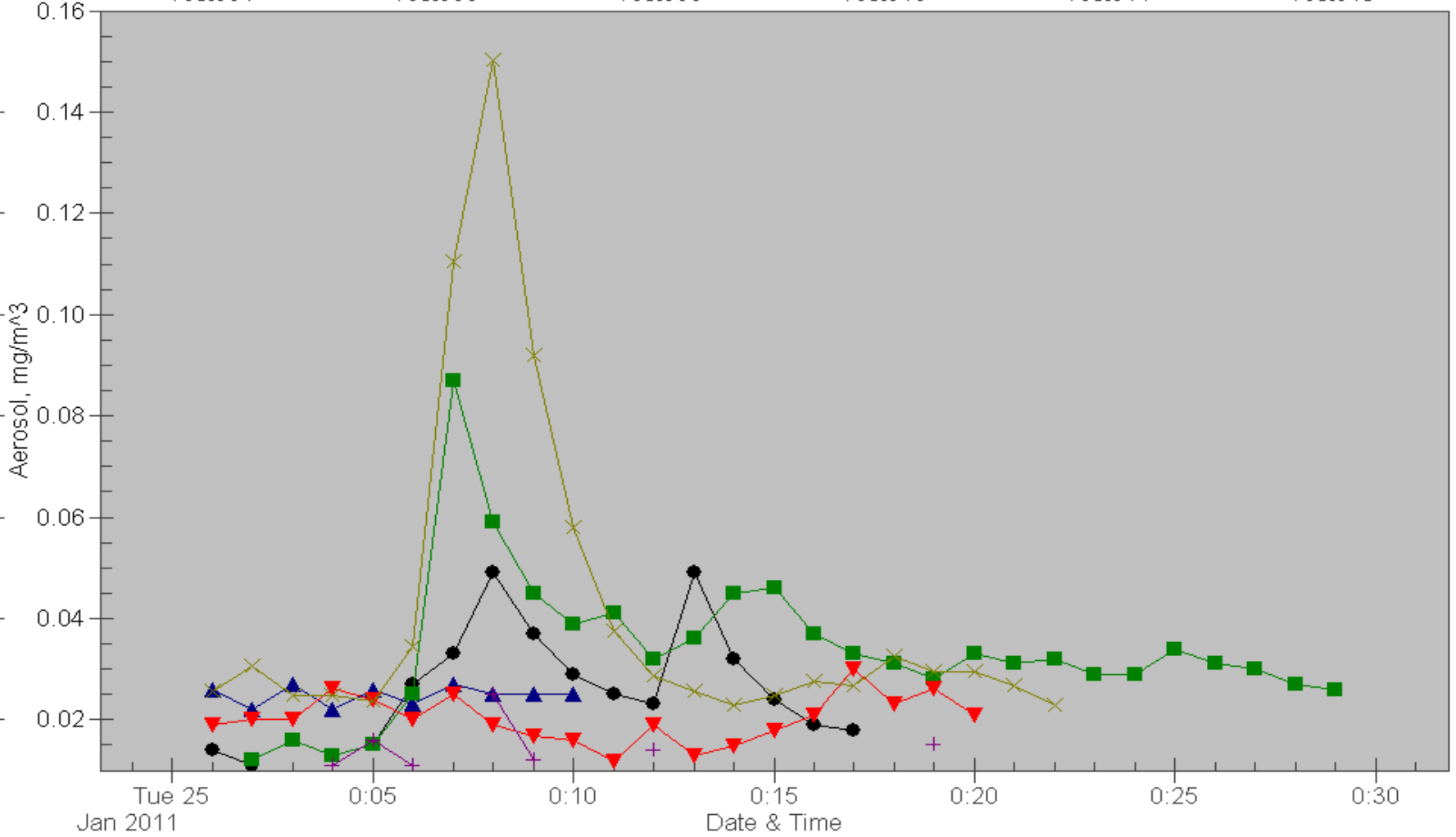
Test005

Test008

Test013

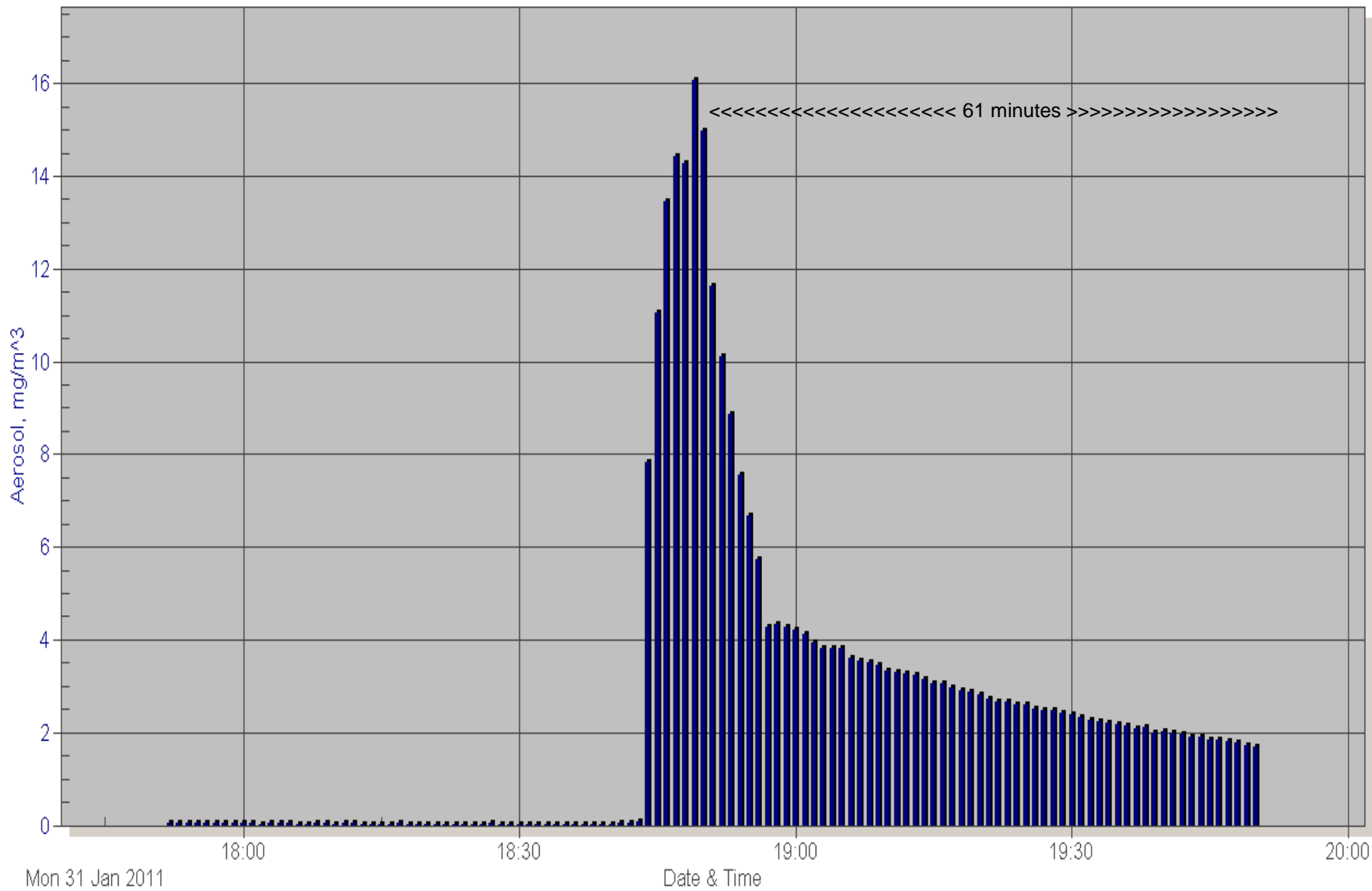
Test014

Test019



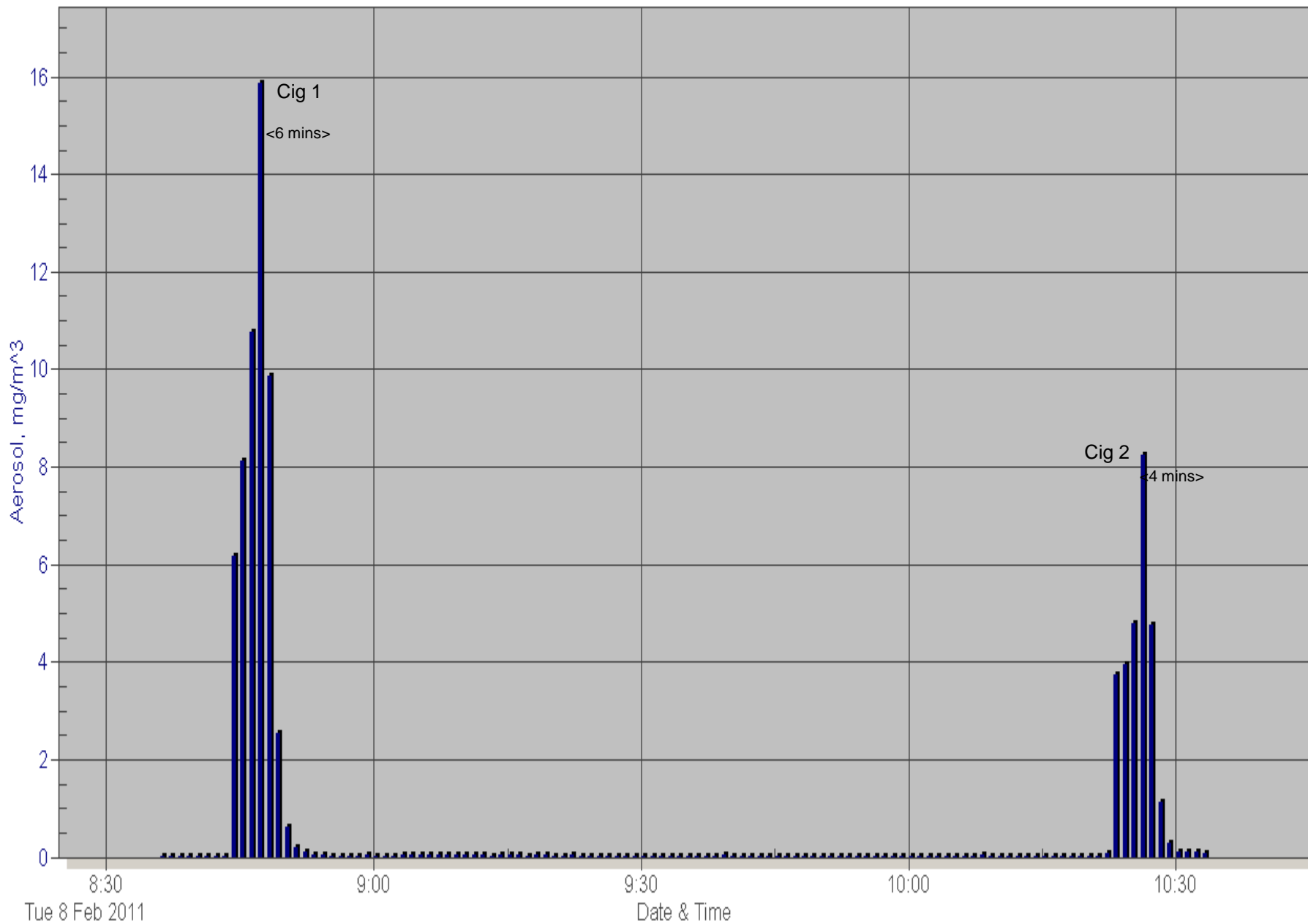
SMOKER 2 - Journey

Windows closed



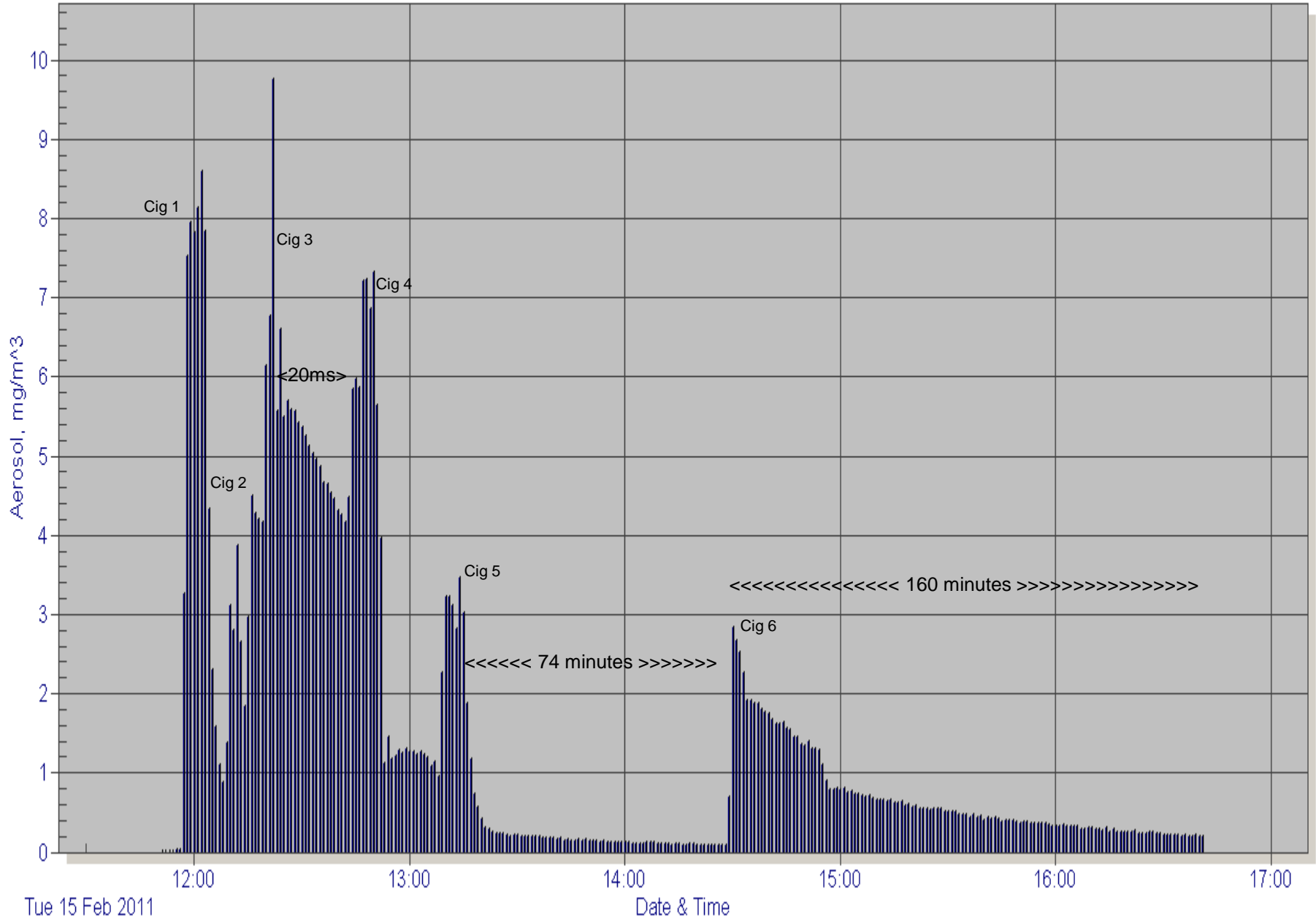
Smoker 4 - Journey

Windows closed



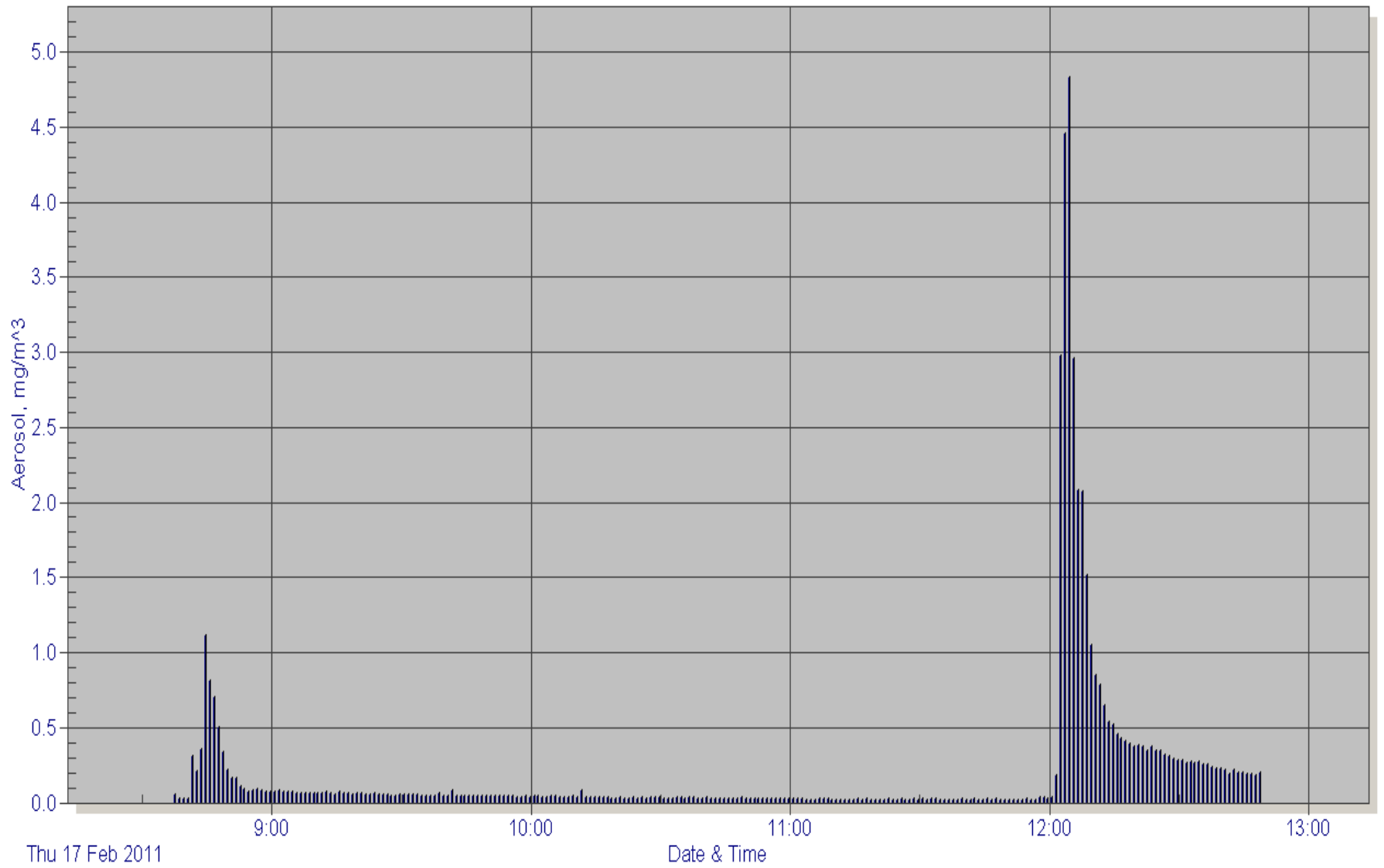
Smoker 5 – Journey

Windows closed



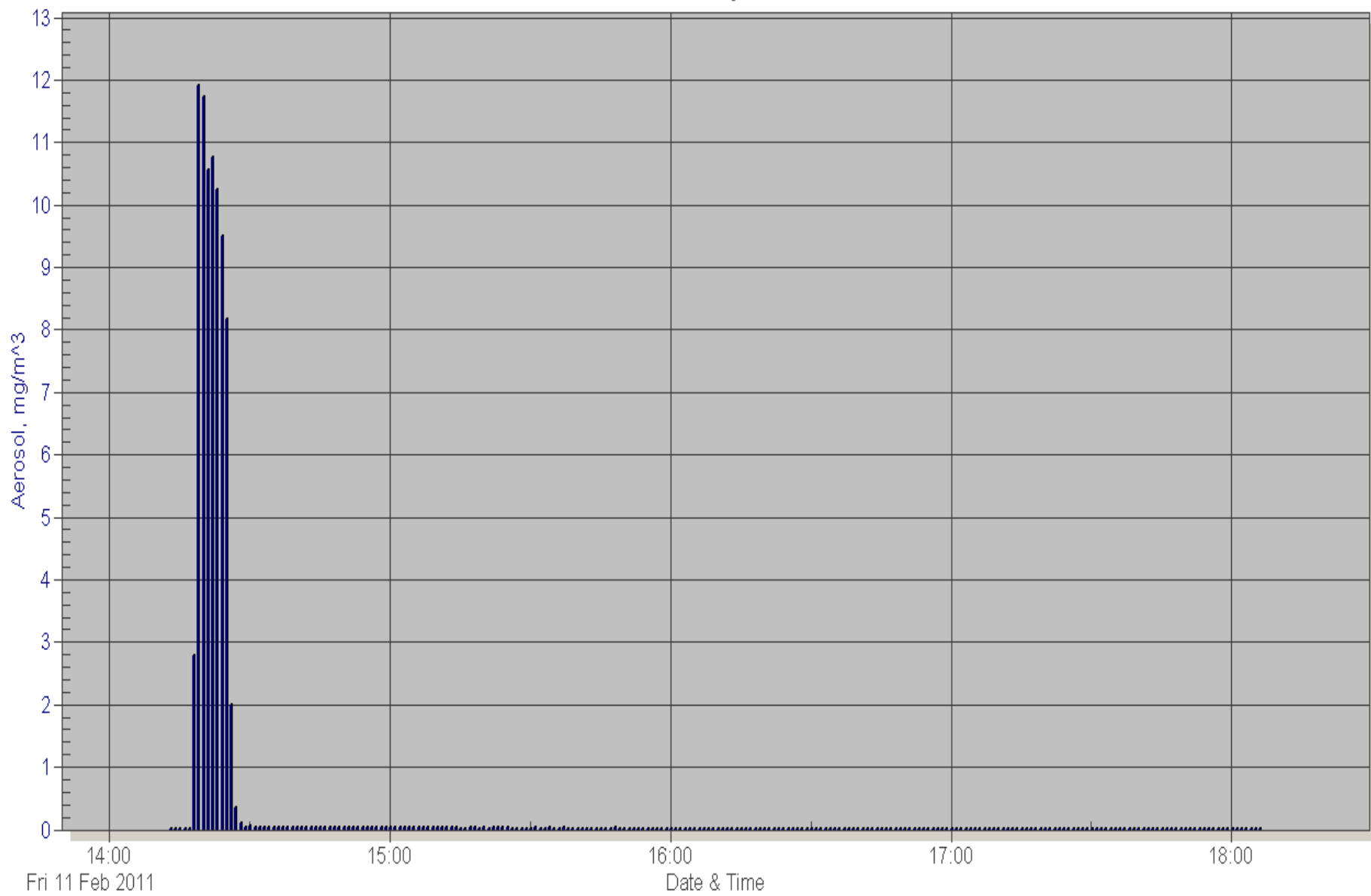
Smoker 1 - Journey

Window open



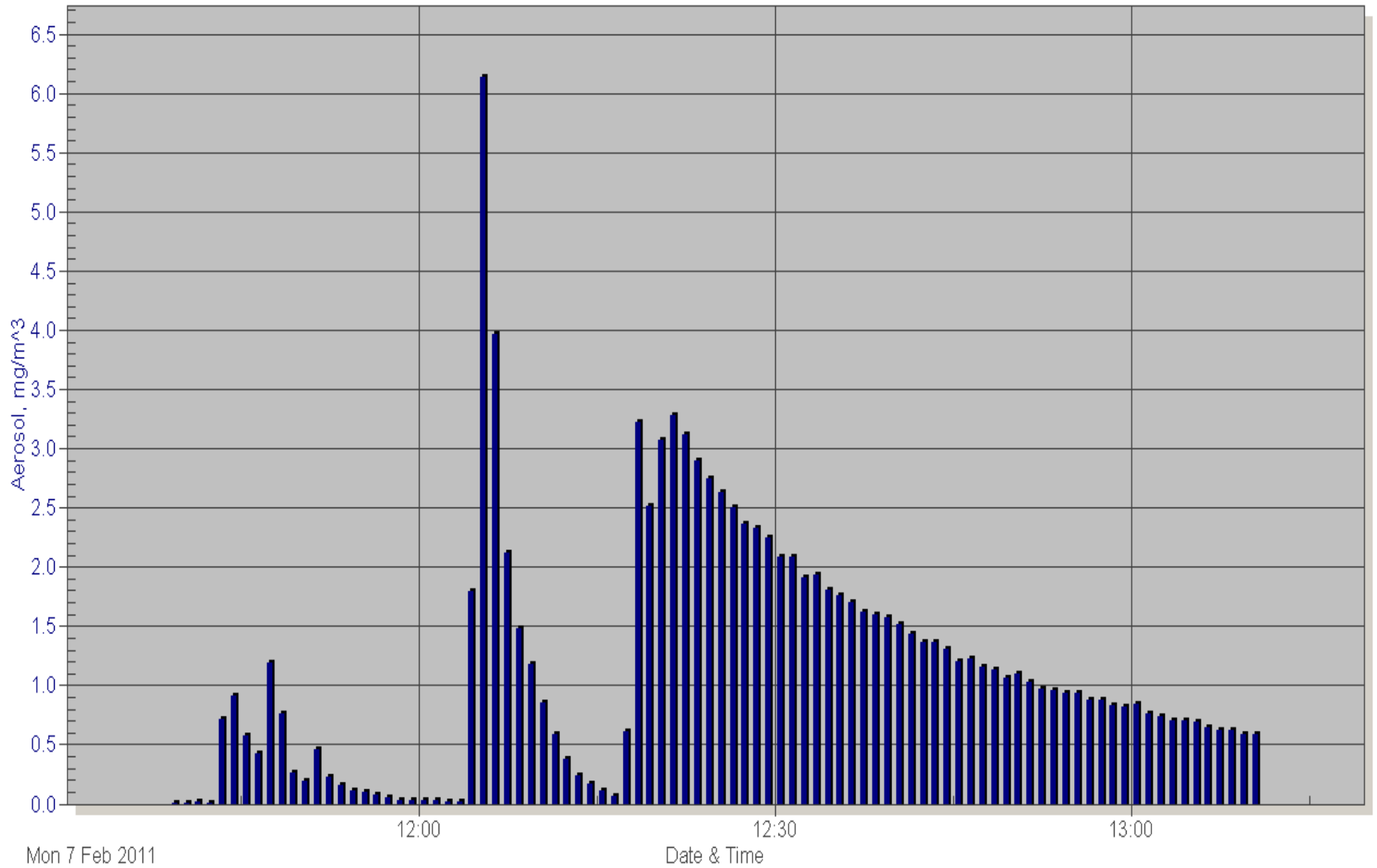
Smoker 3 - Journey

Window open



Smoker 5 - Journey

Window open

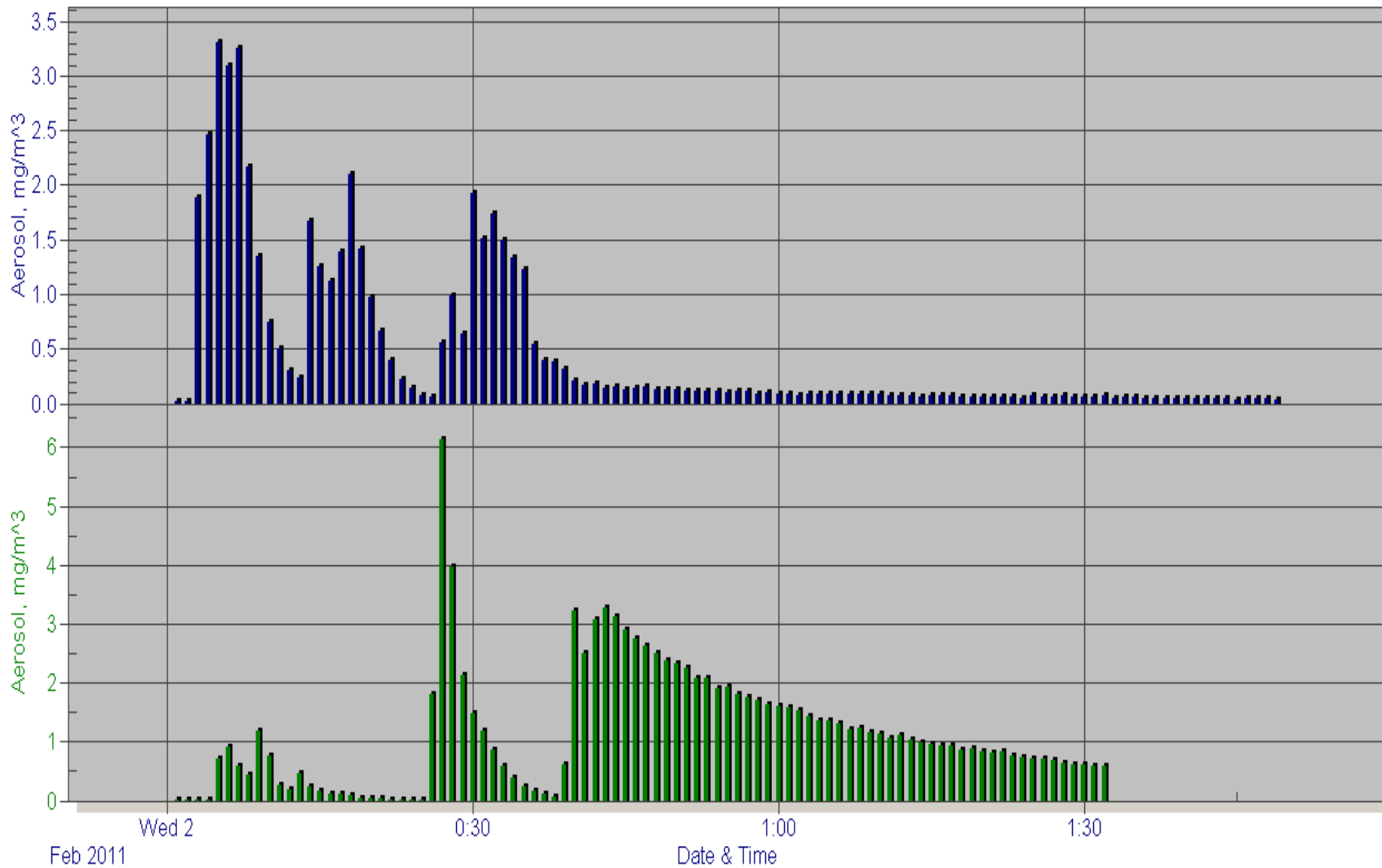


Smoker 5

Hand Rolled [22] v Branded cigarette [31]

Test022

Test031



Discussions

- Prior to 2009 there was very little monitoring of concentrations of particulate matter. At this time an expansion in the UK monitoring programme occurred in order to meet the requirements of the EU Clean Air for Europe Directive.
- It is recognised that exposure to airborne particulate matter can give rise to significant health impacts and that there is no evident “safe” level of exposure. Attention was initially directed towards PM of less than 10 mm diameter $PM_{(10)}$, but epidemiological evidence regarding the health impacts of smaller particles has now changed the focus to smaller particles less than 2.5 mm diameter $PM_{(2.5)}$.

- Currently there is no recognised threshold below which negative health effects are known to be absent. The current regime focuses on limiting long term exposure through the use of annual mean standards. This exposure reduction approach has been introduced for $PM_{2.5}$ in recognition of the absence of a safe level for exposure to $PM_{2.5}$. However, there is no clear evidence as to which $PM_{2.5}$ components produce harmful effects therefore all components must be treated as potentially harmful.

Improvements to Future Studies

- More details required regarding real-time measurements. Timed recordings should be taken of when a cigarette was lit, how long the smoking occurred for and time vehicle was parked. In order to carry out this an observer will need to be within the vehicle to record the necessary details.
- Detailed recordings should also be taken of any external events that may influence a rise in levels monitored such as time static in stationary traffic, whether positioned adjacent to a potential pollution source ie smokey exhaust from neighbouring vehicles.

- In order to make a comparative study with relation to potential health effects measurements should be taken that can be compared to 24hour or annual mean concentrations.
- Although there is no recognised threshold at which adverse health effects are known to occur the US Environmental Protection Agency air quality index rates 24 hour exposure to PM_{2.5} concentrations as follows:.
Rates of 40 µg/m³ or less are deemed as “unhealthy for sensitive groups” with levels of more than 250 µg/m³ being “hazardous” for all individuals.