

APPENDIX H –SHS IN PRISONS PILOT STUDY

Second-Hand Smoke in Prisons: A Pilot Study to Test Methods for Measuring Exposure

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EXECUTIVE SUMMARY

This document provides a review of work carried out in a pilot study to quantify exposure of prison staff to second-hand smoke (SHS) in Cardiff prison. It is part of a wider study across the prison estate of England & Wales commissioned by the Ministry of Justice (MoJ). A mixture of devices to measure concentrations of fine particulate matter (either PM_{2.5} or Respirable dust) were employed with co-location of real-time direct reading instruments (Dylos DC1700 and Sidepak AM510 Personal Aerosol Monitor) across a range of prison locations and through personal sampling of a number of staff. Gravimetric methods were also used to determine appropriate correction factors for the direct reading instruments. Gravimetric methods also provided data to identify tobacco-specific fine particulate matter. Biological markers of SHS exposure including exhaled Carbon Monoxide and Salivary cotinine were also gathered. A small number of practical problems were encountered but, overall, the quality of data collected was high.

Comparison of gravimetric and photometric devices suggests that 0.295 is an appropriate correction value in these settings. There was clear evidence of SHS in many of the locations measured, while the personal exposure of the prison officers also indicates exposure across the work-shift. PM_{2.5} measurements in the main prison hall over the course of 7 days suggest that SHS levels are considerable within this setting. Cross-shift salivary cotinine measurements also provide data that are indicative of SHS exposure among this workforce. The Dylos DC1700, Sidepak AM510 Personal Aerosol Monitor and collection of saliva for analysis of cotinine provide practical, simple and inexpensive methods for characterising exposure to SHS in prison settings and these methods are recommended, for use on the remaining sites.

1 INTRODUCTION

1.1 Background

1.1.1 This document provides a review of work carried out in a pilot study to quantify exposure of prison staff to second-hand smoke (SHS) in Cardiff prison. It is part of a wider study to monitor exposure to SHS across the prison estate of England & Wales commissioned by the Ministry of Justice (MoJ).

1.1.2 The wider study aims to achieve the following objectives:

- Quantification of the extent that prison staff are exposed to SHS;
- Provide data on the patterns of SHS exposure of staff;
- Provide data on the variation of SHS concentrations across different types of prison buildings and prison categories;
- Provide data on the degree of SHS drift of into cells of non-smoking prisoners and to non-smoking areas within the prison;
- An evaluation of the impact on SHS concentrations of 'Canteen Day' (when inmates purchase tobacco).

1.2 Aims of Pilot Study

1.2.1 The pilot study aimed to test the practicalities of monitoring in prison environments and to collect gravimetric respirable dust samples for analysis of tobacco-smoke specific particulate matter using ultra violet (UV) and fluorescence methods. These data will be compared to results from co-located photometric devices designed to measure fine particle (Particulate Matter less than 2.5 microns in diameter (PM_{2.5})) concentrations. A TSI Sidepak AM510 Personal Aerosol Monitor (fitted with a PM_{2.5} impactor) and a Dylos DC1700 Air Quality Monitor were used to enable these devices to be calibrated to tobacco-specific SHS. The SHS-specific calibration factors for each instrument will be applied to the data collected in the main part of the study.

1.3 Methodology Overview

1.3.1 The monitoring campaign was implemented by two suitably qualified Parsons Brinckerhoff (PB) personnel.

1.3.2 The pilot study, conducted at Cardiff Prison, aimed to gather the following data using a sampling strategy (see Appendix A for full methodological detail):

- A static 24 hour gravimetric respirable dust sample within a cell containing smoking inmate(s) collected in accordance with MDHS14/4 (HSE, 2014). A co-located 24 hour Sidepak PM_{2.5} measurement and a co-located 24 hour Dylos DC1700 measurement will also be carried out.
- The above repeated in a cell containing non-smoking inmate(s).
- The above repeated in the main-hall area.
- Three personal exposure samples/measurements from non-smoking prison officers taken across as much of a full-shift as possible (at least ¾ of shift). These would involve the collection of a gravimetric respirable dust sample collected from the breathing zone of the worker according to MDHS14/4 (HSE, 2014) together with a co-located Sidepak PM_{2.5} measurement. Data on prison

officers' locations and activities within the prison would be collected through a mixture of observation, interview and personal record sheet as appropriate. These 3 prison officers will also be asked to provide saliva samples for the measurement of cotinine at the beginning and at the end of their shift together with exhaled breath Carbon Monoxide (CO) at both time points. A request for any other available non-smoking prison officers to provide saliva and exhaled CO will also be made.

- A series of short, 30 minute Dylos DC1700 fine particle number measurements will be made at 5-10 strategic locations where staff and inmates spend time. These are likely to include, but not be limited to, locations such as the gym, canteen, games room, library and others.
- A 7-day particle number concentration measurement will be made in the main hall area with a Dylos DC1700 instrument. This will be installed on the first day with data downloaded at regular intervals over the course of the week.

1.3.3

The planned timetable for the monitoring activity is set out below:

Table 1-1 Programme Tasks and Sampling duties carried out

| Phase of Sampling Campaign | Programme Tasks and Sampling duties carried out |
|-----------------------------------|---|
| <u>Day 0:</u> | Preliminary site visit to establish entry procedures for PB staff and the equipment / authorisations required. Discussions with site staff about the monitoring that will be carried out, timing of activities and staff shift, access to locations, PB staff safety, possible sites for monitoring and equipment safety. This visit will also provide prison staff with an opportunity to ask questions about the monitoring procedure and to raise any potential logistical difficulties. |
| <u>Day 1:</u> | Placement of a set of equipment (Sidepak, Dylos and Gravimetric sampling train) to carry out static monitoring within a smoking cell with another identical set placed in a non-smoking cell (ideally adjacent to the smoking cell being monitored). A third set of equipment will be placed in the main hall or atrium area – this instrument will be collected and data acquired at Day 7. |
| <u>Day 2:</u> | Collection of devices placed on day 1 (after 24 hours): download data where appropriate and replace batteries for further 24 hours data collection in a different location (smoking cell; non-smoking cell; main hall). |
| <u>Day 3:</u> | Collection of devices placed on day 2 (after 24 hours): download data where appropriate. Dylos located at main hall to be left in position. Additional Dylos to be used to make short 20-30 minute measurements at 5-10 strategic locations. |
| <u>Day 4:</u> | 3 self-reported non-smoking prison officers selected to wear gravimetric sampling train and a Sidepak device for duration of their shift. Instruments attached to prison officer by secure means, with Tygon® tubing positioned inside uniform to allow sampling within the breathing zone of the officer. Data on prison officers' locations and activity gathered by self-completion of diary (with 30 minute resolution) backed up by regular enquiry from PB team. Saliva sample and exhaled breath analysis carried out at beginning and end of shift. |

| | |
|----------------------|--|
| <u>Day 5:</u> | A further 3 non-smoking prison officers carry out personal sampling as described in day 4. |
| <u>Day 7:</u> | 7 days after initial placement of the Dylos device in the main hall this will be switched off and collected by a member of the PB team and downloaded. |

- 1.3.4 Data were collected by staff from PB using an agreed protocol (Appendix A) previously developed by the authors. Data collection was carried out between the 10th and 18th February 2015. Data were downloaded using Dylos Logger (v1.6.0.0) software and TSI TrackPro (v4.6.1.0), cleaned and provided to one of the authors (SS) for analysis. Dylos Logger files were exported to Microsoft Excel to enable calculation of mass concentrations from particle number concentrations as described in the scientific literature (Semple et al. 2013). Microsoft Excel was also used to generate real-time data in graphical format. Questionnaire data, results from exhaled Carbon Monoxide and salivary cotinine were also input to Microsoft Excel. Comparative statistics were generated using functions in Microsoft Excel.
- 1.3.5 While there is no occupational or workplace exposure limit for SHS a considerable proportion of the scientific literature describing SHS exposure uses the World Health Organisation 24-hour PM_{2.5} guidance value of 25 µg/m³ as a health-based comparator (WHO, 2010). Available evidence suggests that exposures to fine particulate above this concentration is associated with an increase in risk of cardiac and cardiopulmonary diseases (Pope, 2009). This value was used as a benchmark in the graphical presentations of the measured exposures and exposures are compared to this within the discussion of this report.

2 RESULTS

2.1 Practical considerations

Cell and Wing Sampling

2.1.1 Overall the sampling methods and monitoring plan posed no major logistical problems. PB staff were able to gather the required data generally as planned. There was a high level of co-operation from all levels of staff within the prison and identifying suitable sites for measurement was without major difficulty. A small number of unforeseen issues led to some minor changes to the timetabling of tasks or the type of data collected. These are summarised below.

Security

2.1.2 Due to security concerns and the paramount importance of protecting staff and prisoners from harm, all instruments were introduced into the cells within sealed tamper-proof containers (Figures 2-1 & 2-2) with care being taken to ensure that the sampling integrity of the devices was not compromised. .



Figure 2-1 Dylos & Apex Monitoring Device and tamper proof container



Figure 2-2 Sealed Tamper-proof container in-situ

Anti-Tampering of Cell and Wing Sampling

2.1.3 Concerns over sampling instruments being tampered by prisoners were also overcome by placing instruments within these sealed, tamper-proof containers. This restricted prisoners' access to the sampling instruments.

Instrument Damage

2.1.4 Cell samples were collected from prisoners who were identified by prison officers as being trustworthy, suitably responsible and resistant to outside influence of other prisoners.

2.2 Personal Sampling of Prison Officers

- 2.2.1 All self-reported non-smoking prison officers were invited to supply saliva samples and have personal monitoring equipment fitted prior to the start of their shift. Operational staff (wing staff) began their morning shifts from 07:15hr, requiring researchers to engage with all non-smoking prison operational staff as they entered prison at the gatehouse. This enabled data (including saliva samples and exhaled CO measurement) to be collected prior to any exposure to SHS on the wing and allowed researchers to set-up a temporary sampling station from where all participating staff were equipped with personal monitoring devices,.
- 2.2.2 Due to the personal samplers having a limit of 8 hour battery life, personal exposure monitoring ceased shortly after 16:00hr. The monitoring devices were switched off and removed from staff (wherever they were working at the time) and removed, and once again saliva samples were provided.

2.3 Exposure Data**Summary of data collected**

- 2.3.1 A total of 17 static/area-based measurements were taken using the Dylos. There were 11 short (approximately 15 minute) measurements made at various locations; 4 measurements within cells (2 smoking cells and 2 non-smoking cells) for a duration of approximately 24 hours; 1 measurement for a 24-hour period outside the office on the A wing; and 1 measurement for approximately 7 days gathered in the main atrium of A-wing. A summary of the sample ID, start and stop times, and PM_{2.5} concentrations of these measurements is given in Table 2-1.

Table 2-1 Data on Dylos Area Monitoring

| Sample Number | Location | Start Sample | | Stop Sample | | PM _{2.5} Concentration (µg/m ³) | | | Notes |
|--------------------|-------------------------------------|--------------|------------|-------------|------------|--|-----|-----|---|
| | | Time | Date | Time | Date | Mean | Min | Max | |
| Cardiff/ Dylos/001 | Smoker cell A-Wing | 14:07 | 10/02/2015 | 15:05 | 11/02/2015 | 201 | 6 | 825 | |
| Cardiff/ Dylos/002 | Non-Smoker Cell, C-Wing | 14:21 | 10/02/2015 | 14:35 | 11/02/2015 | 41 | 7 | 113 | Switched off 1904 -1048 (only 547 minutes of data) |
| Cardiff/ Dylos/003 | Outside Office Landing A-Wing | 14:33 | 10/02/2015 | 14:39 | 11/02/2015 | 48 | 21 | 165 | |
| Cardiff/ Dylos/004 | Level 2, A-Wing | 10:19 | 11/02/2015 | 10:34 | 11/02/2015 | 110 | 84 | 134 | |
| Cardiff/ Dylos/005 | Outside Cell 11 (non-smoker) C-Wing | 10:49 | 11/02/2015 | 11:04 | 11/02/2015 | 170 | 103 | 276 | |
| Cardiff/ Dylos/006 | Segregation landing | 11:13 | 11/02/2015 | 11:31 | 11/02/2015 | 62 | 43 | 122 | |
| Cardiff/ Dylos/007 | F1 Wing Association | 11:37 | 11/02/2015 | 11:52 | 11/02/2015 | 296 | 267 | 318 | |
| Cardiff/ Dylos/008 | IT Classroom | 13:52 | 11/02/2015 | 14:06 | 11/02/2015 | 28 | 21 | 42 | |
| Cardiff/ Dylos/010 | Builders Skills Classroom | 14:11 | 11/02/2015 | 14:24 | 11/02/2015 | 131 | 116 | 151 | |
| Cardiff/ Dylos/011 | Smoker Cell C-Wing | 17:02 | 11/02/2015 | 15:30 | 12/02/2015 | 77 | 6 | 654 | |
| Cardiff/ Dylos/012 | Reception Desk | 07:56 | 12/02/2015 | 08:11 | 12/02/2015 | 39 | 35 | 43 | |
| Cardiff/ Dylos/013 | Holding Cell Reception | 08:13 | 12/02/2015 | 08:28 | 12/02/2015 | 713 | 556 | 892 | |
| Cardiff/ Dylos/014 | F1 Wing Pool Table | 10:45 | 12/02/2015 | 11:00 | 12/02/2015 | 88 | 50 | 103 | |
| Cardiff/ Dylos/015 | Gatehouse | 11:05 | 12/02/2015 | 11:20 | 12/02/2015 | 21 | 18 | 25 | |
| Cardiff/ Dylos/016 | Non-Smoker Cell 12, C-Wing | 11:48 | 12/02/2015 | 08:25 | 13/02/2015 | 77 | 6 | 654 | Switched on/off several times between 1530-1633 |
| Cardiff/ Dylos/017 | F Wing Level 4 | 14:16 | 13/02/2015 | 14:32 | 13/02/2015 | 28 | 21 | 42 | |
| Cardiff/Dylos/018 | Outside Office Landing A-Wing | 03:28* | 11/02/2015 | 20:42 | 27/02/2015 | 69 | 0.8 | 892 | Switched off repeatedly on 11/02 and 12/02 until 1614 |

* Dylos only records the previous 6 days and 6 hours of data so although device was placed on the 10/02/2015 data is only available from this time on the 11/02/2015.

- 2.3.2 A total of 9 measurements were made using the Sidepak instrument, fitted with a PM_{2.5} impactor. These included two static /area 24 hour measurements made within cells alongside Dylos devices; one static /area 24-hour measurement made outside a staff office on A-wing; and six personal sampling measurements made by attaching the device to prison officers for a representative period of their work-shift. Table 2-2 summarises the collection times of data from these measurement periods. Data from the Sidepak instrument was corrected using a calibration factor of 0.295 to account for the lower density of combustion-derived PM_{2.5} compared with standard road test dust (Jiang et al., 2011).
- 2.3.3 A total of 11 filter based samples were also collected over the measurement campaign. These included five static /area 24-hour samples collected in smoking cells (2), static /area samples collected from non-smoking cells (2) and outside the office on A-wing (1). A further six personal sampling measurements were gathered by attaching to prison officers for the course of their work-shift. Table 2-3 summarises the collection times of data from these sampling periods.
- 2.3.4 In addition, ten prison staff agreed to provide pre and post-shift samples of saliva for the analysis of salivary cotinine. Five of these pre and post-shift samples were collected on 12/02/2015 with the remaining five pre and post shift samples gathered on the 13/02/2015.
- 2.3.5 The results of the monitoring of exhaled CO were all below <6ppm (the value reported in the literature as being indicative of SHS exposure) they are not reported here).
- 2.3.6 Questionnaire data were also gathered from all ten staff who consented to take part in the study in order to determine if they smoked, used nicotine replacement therapy or e-cigarettes, lived in a home where smoking took place or had travelled to work in a vehicle where someone smoked (all of which would increase their salivary cotinine concentrations from non-work sources). A summary of these data are provided in Appendix B. All participants were current non-smokers (7 never smokers and 3 ex-smokers). None reported current use of nicotine replacement products. None lived with a smoker or drove to work in a car with someone who smoked. Nine of the ten worked full-time (39 or 40 hours per week) in the prison service with one working approximately 19.5 hours. The duration of employment in the prison service ranged from 10 to 33 years. In terms of self-reported exposure to other people's tobacco smoke the prison officers estimated that between 10 and 100% of their working day involved exposure (mean 65%). The duration of the working day spent in prisoners' cells ranged from 5 to 50% (mean 20%).

Table 2-2 Data on Sidepak PM_{2.5} monitoring

| Sample Number | Location/Staff Member | Start Sample | | Stop Sample | | PM _{2.5} (µg/m ³) | | | Notes |
|----------------------|--|--------------|------------|-------------|------------|--|-----|------|-------------------------------|
| | | Time | Date | Time | Date | Mean | Min | Max | |
| Cardiff/ Sidepak/001 | Static - Smoker cell A-Wing | 14:07 | 10/02/2015 | 15:05 | 11/02/2015 | 30 | 20 | 106 | Switched off after 45 minutes |
| Cardiff/ Sidepak/002 | Static - Non-Smoker Cell, C-Wing | 14:21 | 10/02/2015 | 14:35 | 11/02/2015 | 317 | 26 | 1579 | |
| Cardiff/ Sidepak/003 | Static - Outside Office Landing A-Wing | 14:34 | 10/02/2015 | 14:39 | 11/02/2015 | 64 | 26 | 148 | |
| Cardiff/ Sidepak/005 | Personal - TM Prison Officer | 07:15 | 12/02/2015 | 13:10 | 12/02/2015 | 36 | 16 | 71 | Switched off after 40 minutes |
| Cardiff/ Sidepak/006 | Personal - LF Prison Officer | 07:25 | 12/02/2015 | 16:28 | 12/02/2015 | 37 | 1 | 386 | |
| Cardiff/ Sidepak/007 | Personal - MS Prison Officer | 07:32 | 12/02/2015 | 16:15 | 12/02/2015 | 84 | 7 | 342 | |
| Cardiff/ Sidepak/009 | Personal - MO 213 | 07:11 | 13/02/2015 | 15:33 | 13/02/2015 | 67 | 15 | 1027 | |
| Cardiff/ Sidepak/010 | Personal - PB 094 | 07:25 | 13/02/2015 | 15:42 | 13/02/2015 | 27 | 0 | 452 | |
| Cardiff/ Sidepak/011 | Personal - LF 112 | 07:35 | 13/02/2015 | 16:19 | 13/02/2015 | 42 | 1 | 425 | |

Table 2-3 Data on gravimetric (Respirable PM) monitoring

| Sample Number | Location/Staff Member | Start Sample | | Stop Sample | | Respirable PM ($\mu\text{g}/\text{m}^3$) | Notes |
|-------------------|--|--------------|------------|-------------|------------|--|-------|
| | | Time | Date | Time | Date | | |
| Cardiff/ APEX/001 | Static - Smoker cell A-Wing | 14:07 | 10/02/2015 | 15:05 | 11/02/2015 | 214 | |
| Cardiff/ APEX/002 | Static - Non-Smoker Cell, C-Wing | 14:21 | 10/02/2015 | 14:35 | 11/02/2015 | 23 | |
| Cardiff/ APEX/003 | Static - Outside Office Landing A-Wing | 14:34 | 10/02/2015 | 14:39 | 11/02/2015 | 56 | |
| Cardiff/ APEX/004 | Static - Smoker cell C-Wing | 17:02 | 11/02/2015 | 15:30 | 12/02/2015 | 210 | |
| Cardiff/ APEX/005 | Personal -TM Prison Officer | 07:15 | 12/02/2015 | 13:10 | 12/02/2015 | 108 | |
| Cardiff/ APEX/006 | Personal -LF Prison Officer | 07:25 | 12/02/2015 | 16:28 | 12/02/2015 | 59 | |
| Cardiff/ APEX/007 | Personal -MS Prison Officer | 07:32 | 12/02/2015 | 16:15 | 12/02/2015 | 53 | |
| Cardiff/ APEX/008 | Static - Non-Smoker Cell 12, C-Wing | 11:48 | 12/02/2015 | 08:25 | 13/02/2015 | 22 | |
| Cardiff/ APEX/009 | Personal -MO 213 | 07:11 | 13/02/2015 | 15:33 | 13/02/2015 | 66 | |
| Cardiff/ APEX/010 | Personal -PB 094 | 07:25 | 13/02/2015 | 15:42 | 13/02/2015 | 40 | |
| Cardiff/ APEX/011 | Personal -LF 112 | 07:35 | 13/02/2015 | 16:19 | 13/02/2015 | 58 | |

- 2.3.7 From the static cell sample measurements using both Dylos and Sidepak devices, it can be seen that 1-minute averaged $PM_{2.5}$ monitored concentrations ranged between 6 to $1579 \mu\text{g}/\text{m}^3$, with whole-period averaged concentrations ranging from 21 and $713 \mu\text{g}/\text{m}^3$.
- 2.3.8 Figure 2-3 below illustrates the pattern of $PM_{2.5}$ concentrations within a cell of a smoking prisoner across a 24 hr monitoring period.
- 2.3.9 It can be seen that there are multiple peaks of elevated $PM_{2.5}$ concentrations across the monitoring period. The majority of these peaks are considered to be directly associated with tobacco smoke, with the drop in $PM_{2.5}$ concentrations occurring between 03:00hr and 05:00hr representing the last cigarette smoke of the night. Accumulation of $PM_{2.5}$ concentrations within the smokers cell is observed to occur between 19:00hr in the evening through to 3:00hr the following morning. This period of $PM_{2.5}$ accumulation corresponds with the evening lock-up of prisoners in their cells on A-wing at 19:00hr and the morning opening of cells at 08:00hr.
- 2.3.10 Figure 2-4 below illustrates the pattern of $PM_{2.5}$ concentrations within a cell of a non-smoking prisoner across a 24 hr monitoring period. $PM_{2.5}$ concentrations within this sampling period are observed to be an order of magnitude below those for the smokers cell (note different scales used in Figures 2-3 and 2-4). Interruption of the cell sample between 19:04hr and 10:48hr the following day, excludes any measurement of night-time concentrations. In addition few peaks were observed in $PM_{2.5}$ concentrations observed across the 24hr period, implying that there are few, if any, sources of $PM_{2.5}$ particulate matter within non-smoking Cardiff prison cells. Therefore, it can be concluded that any distinct and significant peaks in $PM_{2.5}$ concentrations within cells of prisoners who smoke can almost certainly attributed to tobacco smoke.

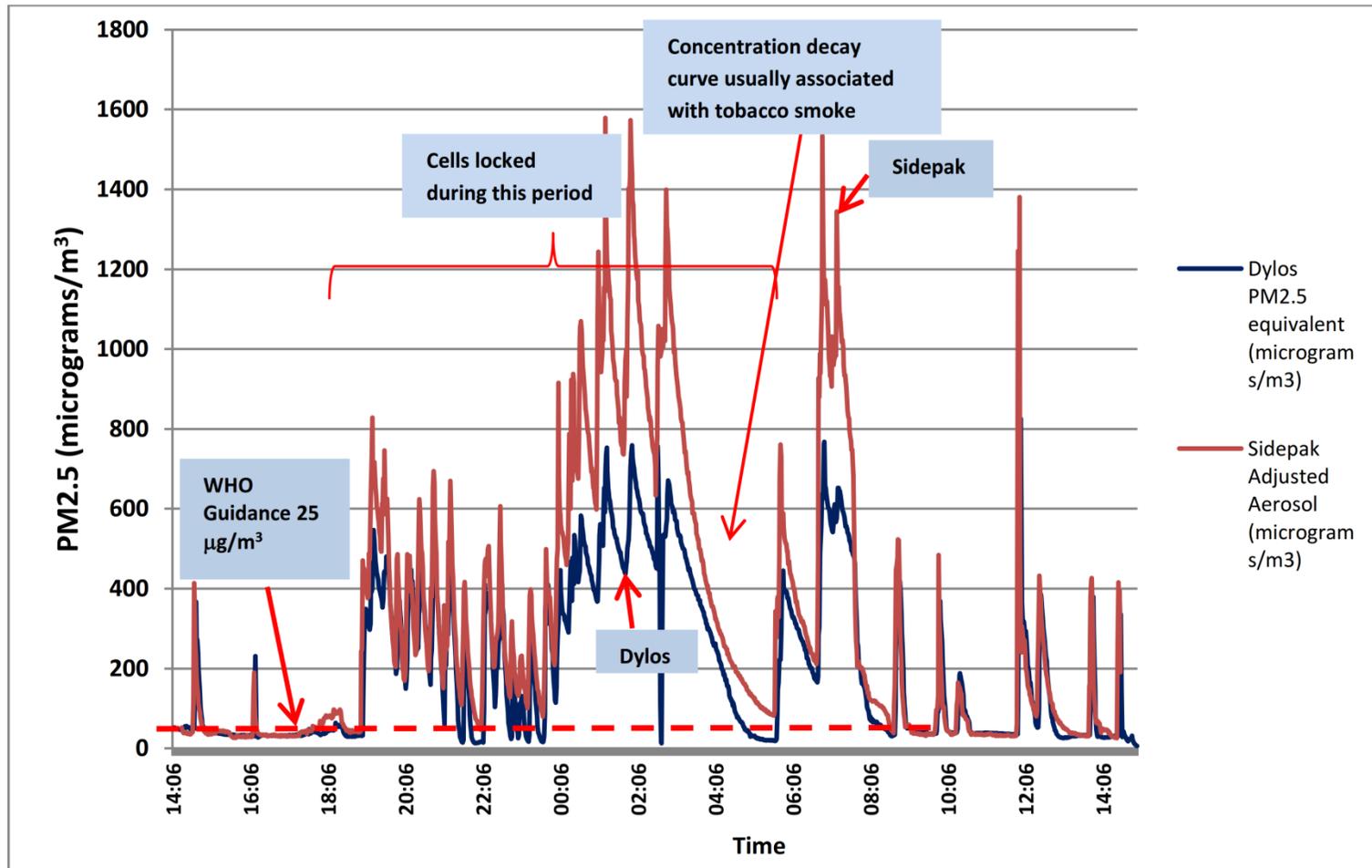


Figure 2-3 Static - Cardiff/ Dylos/001 Smoker cell A-wing

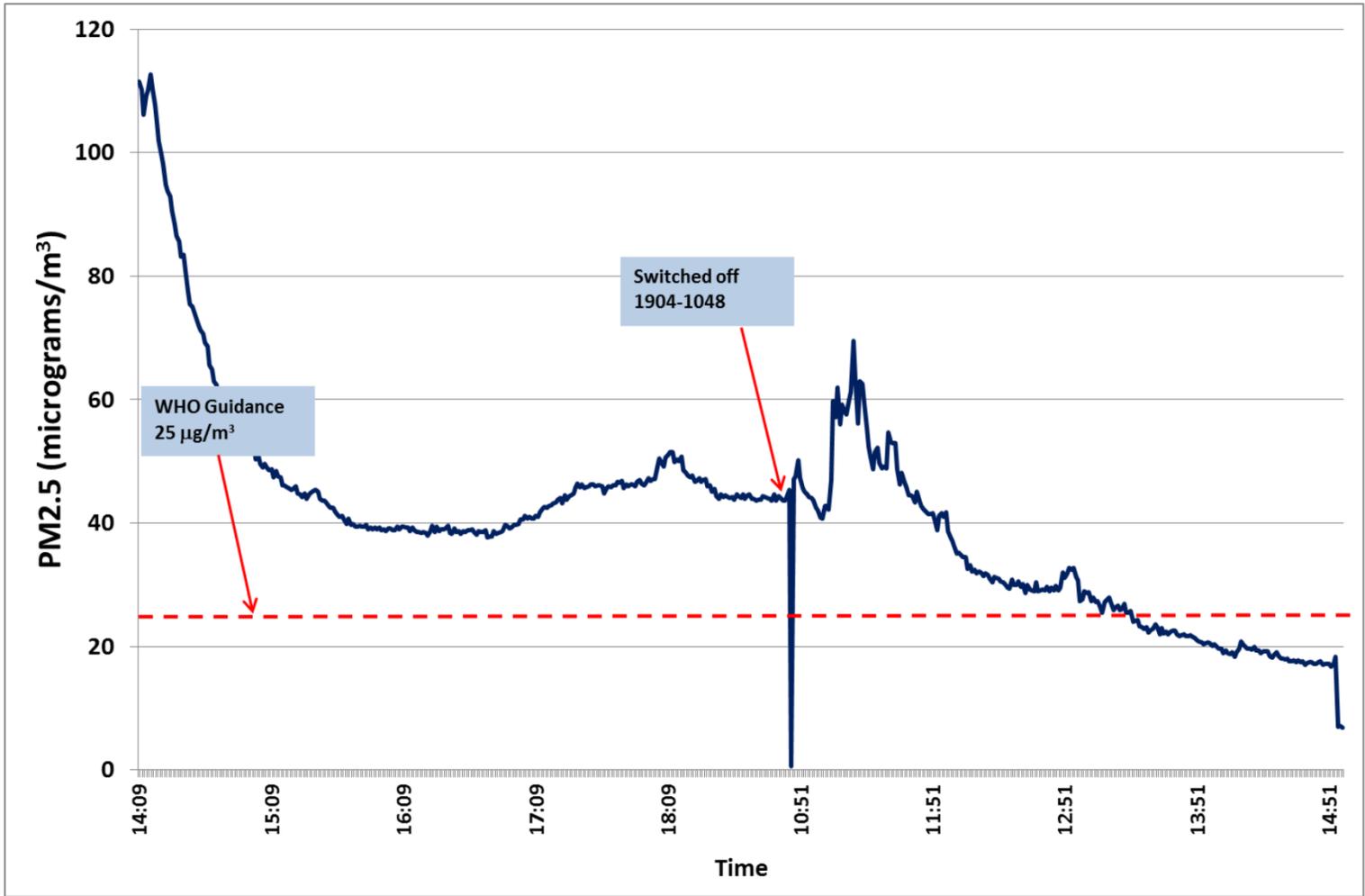


Figure 2-4 Static - Cardiff/ Dylos/002 Non-smoker cell C-wing

2.4 Area-based (static) measurements of fine particle concentrations

- 2.4.1 Twenty-five area-based measurements were made to gather data on fine particle concentrations with the prison. There were 17 Dylos measurements of PM_{2.5}, three Sidepak measurements of PM_{2.5} and five filter-based gravimetric samples. It should be noted that the five filter-based results are expressed as respirable fraction concentrations (broadly equivalent to PM₄) rather than PM_{2.5}. All results are expressed as arithmetic means for the sampling duration and expressed as micrograms per cubic metre of air sampled ($\mu\text{g}/\text{m}^3$). Graphs of real-time concentrations are provided in Appendix C (for measurements >360 minutes duration).
- 2.4.2 The results of these measurements are presented in Tables 1-3. Measurement durations ranged from 14 minutes through to over 8000 minutes and the data show that measured (averaged over the sampling period for that location) fine particle concentrations ranged from 21 to 713 $\mu\text{g}/\text{m}^3$. Concentrations were, as anticipated, higher in smoking cells compared to smoking-restricted areas and where devices were co-located (and left switched on for comparable times) the results were broadly similar for the three different measurement methods (see table 2.4).
- 2.4.3 The only case where agreement between sampling methods was poor occurred for the results for the co-located devices in the non-smoking cell on C-wing. The Sidepak recorded a 24-hour concentration of 317 $\mu\text{g}/\text{m}^3$ while the gravimetric sample returned an average value of 23 $\mu\text{g}/\text{m}^3$ (the Dylos was switched off for most of the night and so the results are not comparable). Examining the real-time plot from the Sidepak device used in this cell indicates repeated and regular peaks that are suggestive of smoking activity. Given the fact that the Dylos was switched off it may also be the case that the Apex pump and gravimetric device was in some way restricted from sampling the air.

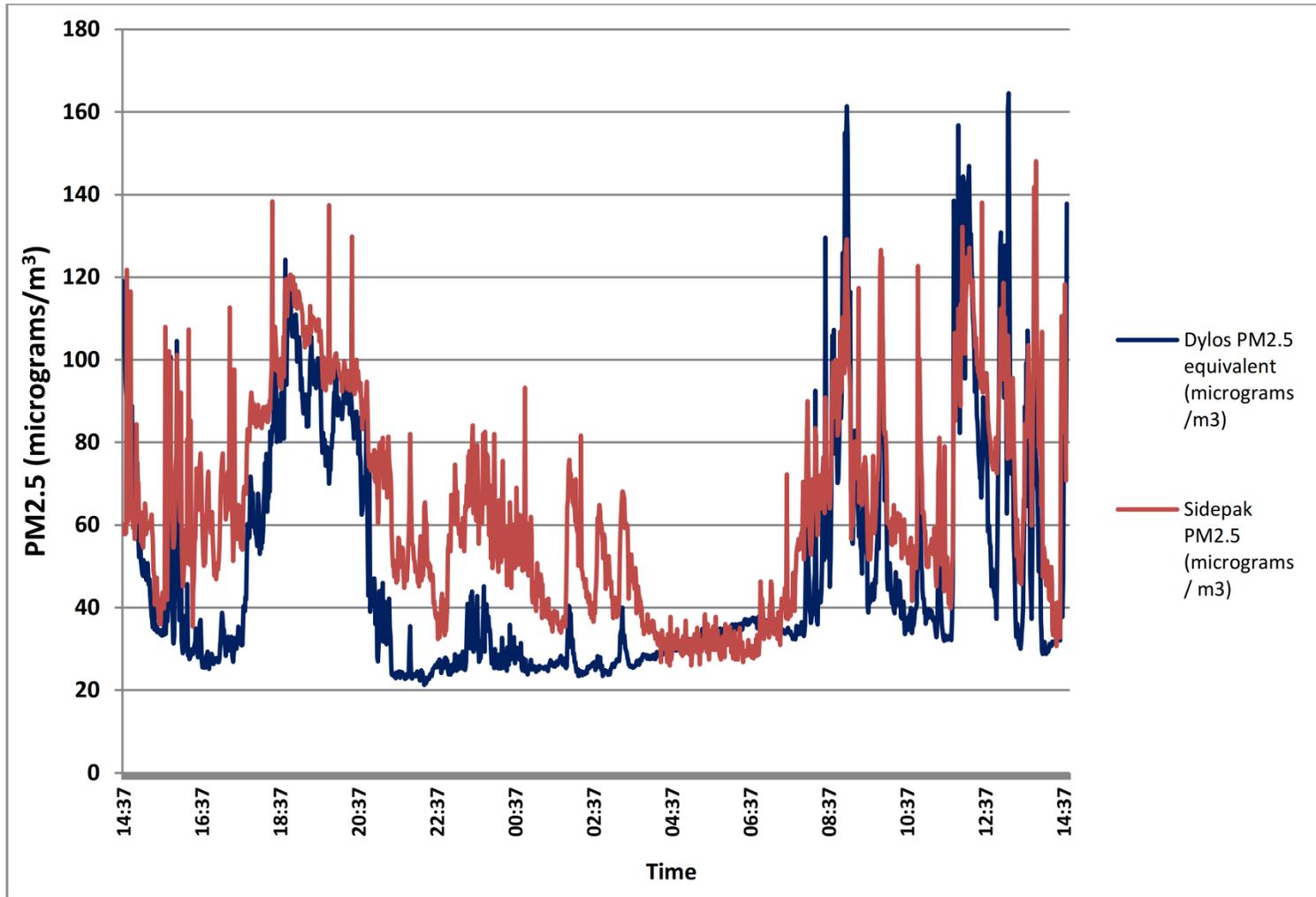


Figure 2-5 Comparison between Sidepak and Dylos Static Landing measurement A Wing 10/02/2015 to 11/02/2015

- 2.4.4 Particulate (PM_{2.5}) concentration data gathered from the atrium of A-wing area using both a Dylos and a Sidepak for the first 24hrs (Figure 2-5), and then using a Dylos alone for the whole week (Figure 2-6) is particularly instructive. PM_{2.5} concentrations reach considerable peaks each of between 120 to 140 micrograms /m³ for the 24hr sample (Figure 2-5) and over 250 micrograms /m³ at time during the weekly sample (Figure 2-6).
- 2.4.5 The average value is 67 µg/m³ (this is after excluding the data prior to 16:14hr on the 12/02/15, when the device was repeatedly switched off/on). Figure 2-6 also provides a red horizontal line at the 25 µg/m³ concentration. This is the World Health Organisation (WHO) guidance level for 24-hour average exposure to PM_{2.5}. The graph in Figure 2-6 illustrates the daily peaks in PM_{2.5} concentrations during periods when cell doors are opened and during periods of prisoner association.
- 2.4.6 The magnitude and duration of PM_{2.5} concentrations varies across the weekly sample. With high levels of PM_{2.5} being detected for greater durations by the static sampling device based at A-wing over weekend than during the week.

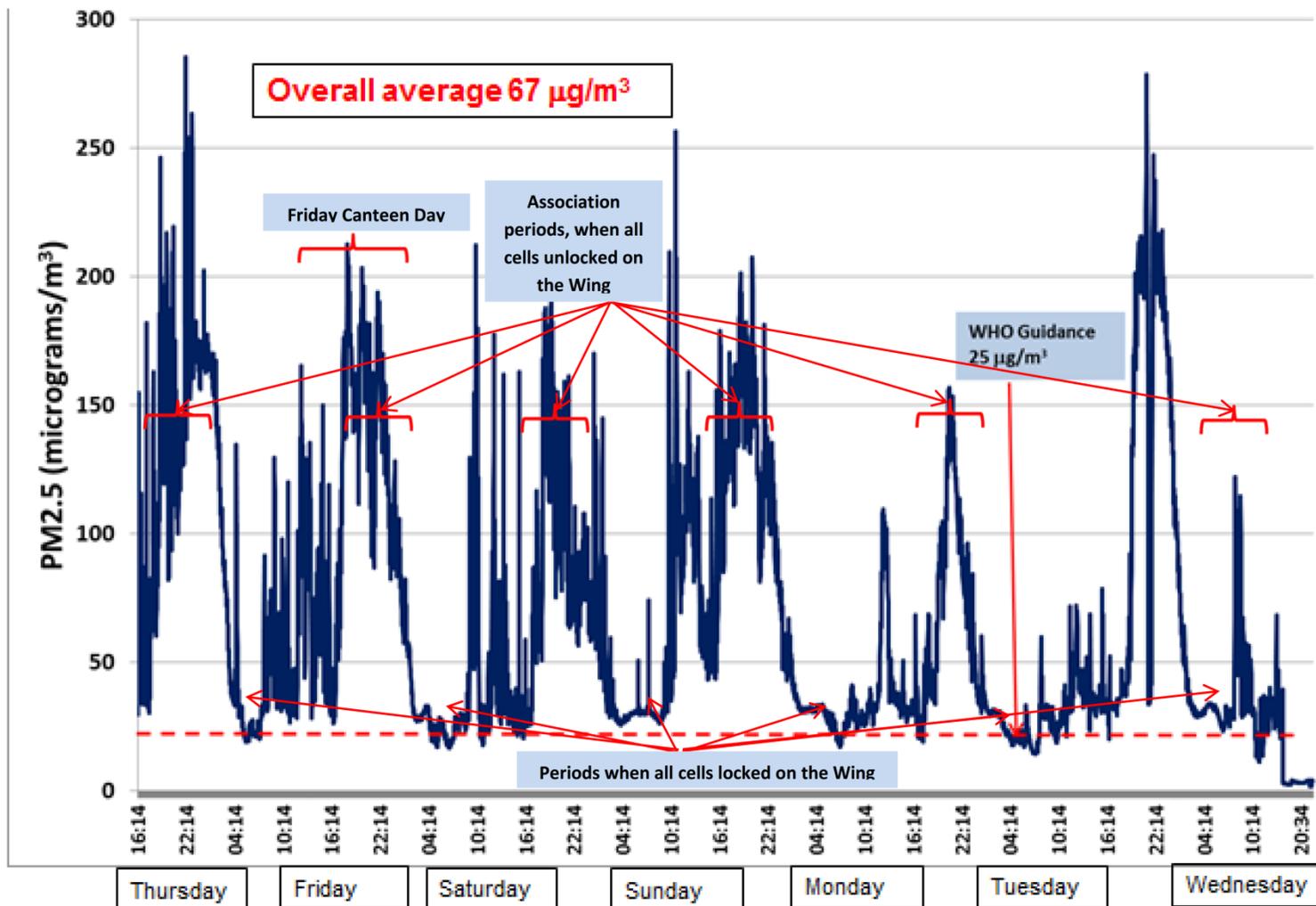


Figure 2-6 Dylos PM_{2.5} concentrations from A-wing landing over the whole week (12 – 18/02/2015)

2.5 Personal measurements of fine particle exposures

- 2.5.1 Six prison officers wore both Sidepak and gravimetric respirable sampling devices for their full shift. These data are presented in Tables 2 and 3. One device – a Sidepak - did not record data after the first 40 minutes of sampling and so there are five pairs of comparable data (see section 2.2.4).
- 2.5.2 The full shift mean exposures range from 27 to 84 $\mu\text{g}/\text{m}^3$ (as measured by the Sidepak device) and 40 to 108 $\mu\text{g}/\text{m}^3$ (as measured gravimetrically).

2.6 Comparison of results by measurement method

- 2.6.1 One of the aims of this pilot was to determine how comparable the results were when measured by different methods within this environment. During the 24-hour measurements within A-wing the Dylos, Sidepak and gravimetric methods were located side-by-side in: one non-smoking cell; one smoking cell; and the A-wing Landing.
- 2.6.2 Due to devices being switched off in the two cells there is only data from 2 devices (Dylos and Apex in one smoking cell; Sidepak and Apex in the non-smoking cell). All 3 devices provided data of similar duration when co-located on the A-wing landing.
- 2.6.3 A Dylos and an Apex/gravimetric device were co-located for 24-hour in a smoking and a non-smoking cell in C-wing. Due to the Dylos being switched off in the non-smoking cell there was only comparable data in the smoking cell in C-wing.
- 2.6.4 The Sidepak and gravimetric devices were co-located on all six prison officers who agreed to wear the instruments for a full working shift. The data gathered provided 5 pairs of readings of similar duration.
- 2.6.5 A comparison of the data gathered with co-located instruments is provided in Table 2-4. The data are arithmetic mean values of the concentrations measured with the final two columns providing information on the ratio between Dylos and Gravimetric or Sidepak and Gravimetric measurements. A value of 1.0 indicates that the average measurements taken by both instruments within that scenario are identical.
- 2.6.6 The comparable data gathered with co-located Dylos and gravimetric measurement methods indicate good agreement with ratio of concentrations ranging from 0.86 to 1.21 (arithmetic mean for the three pairs of measurements is 1.00). This suggests the current method (Semple et al., 2013) for converting the Dylos particle number concentration to a $\text{PM}_{2.5}$ mass concentration equivalent is appropriate for this environment.
- 2.6.7 Excluding the Sidepak: Gravimetric ratio of 13.8 from the non-smoking cell (as previously discussed), the ratio for the Sidepak and Gravimetric data is more variable but still lies within a range of 0.63 to 1.58 (with an arithmetic mean for the six pairs of 0.96). It should be remembered that the gravimetric measurement is based on respirable fraction data rather than $\text{PM}_{2.5}$ data. This slightly larger size fraction of PM (PM_4 rather than $\text{PM}_{2.5}$) may account for some of this discrepancy. However, given that the majority of SHS is $<1 \mu\text{m}$ in diameter this effect is likely to be minimal. The results suggest that, on average, the Sidepak density correction value in this environment was 0.31. This is very close to the 0.295 as applied. Given the literature available for correcting SHS-related aerosol in indoor environments (Jiang et al., 2011) it is justifiable to continue to use the 0.295 correction factor with Sidepak data gathered in prisons.

Table 2-4 Comparison of data gathered from co-located instruments

| Sample Location/ Personal | Dylos $\mu\text{g}/\text{m}^3$ | Sidepak $\mu\text{g}/\text{m}^3$ | Gravimetric $\mu\text{g}/\text{m}^3$ | Dylos: Gravimetric | Sidepak: Gravimetric |
|------------------------------------|--------------------------------|----------------------------------|--------------------------------------|--------------------|----------------------|
| Static - Smoker cell A wing | 201 | CDNC | 214 | 0.94 | |
| Static - Non-smoker cell C wing | CDNC | 317 | 23 | | 13.8 |
| Static - Landing A wing | 48 | 64 | 56 | 0.86 | 1.14 |
| Static - Smoker cell C wing | 255 | | 210 | 1.21 | |
| Static - Non-smoker cell 12 C wing | CDNC | | 22 | | |
| Personal - TM Prison Officer | | CDNC | 108 | | |
| Personal - LF Prison Officer | | 37 | 59 | | 0.63 |
| Personal - MS Prison Officer | | 84 | 53 | | 1.58 |
| Personal - MO213 | | 67 | 66 | | 1.02 |
| Personal - PB094 | | 27 | 40 | | 0.68 |
| Personal - LF112 | | 42 | 58 | | 0.72 |

CDNC – Comparable Data Not Collected

2.7 Tobacco-smoke specific particulate matter

2.7.1 The gravimetric samples were also analysed for UV-absorbing PM (UVPM) and Fluorescent PM (FPM) to provide an indication as to whether the PM in these samples were primarily from tobacco-specific sources. The results are presented in Table 2-5 and Table 2-6. Data generally indicate higher proportions of UVPM and FPM in smoking areas (average UVPM 36.5 $\mu\text{g}/\text{mg}$ and average FPM 644 $\mu\text{g}/\text{mg}$) than non-smoking areas (UVPM 6.8 $\mu\text{g}/\text{mg}$ and FPM 149 $\mu\text{g}/\text{mg}$), with the A-wing landing and personal exposure of staff giving values that lie between these two environments (average UVPM 18.4 $\mu\text{g}/\text{mg}$ and PFM 277 $\mu\text{g}/\text{mg}$).

Table 2-5 Data on tobacco-specific PM from gravimetric/filter samples collected from static cell sampling

| Sample Number | Location/Staff Member | UVPM $\mu\text{g}/\text{m}^3$ | FPM $\mu\text{g}/\text{m}^3$ | UVPM per gravimetric ($\mu\text{g}/\text{mg}$) | FPM per gravimetric ($\mu\text{g}/\text{mg}$) |
|-----------------------------|--|-------------------------------|------------------------------|--|---|
| Cardiff/ APEX/001 | Static- Smoker cell A-Wing | 7.9 | 135 | 37 | 631 |
| Cardiff/ APEX/002 | Static - Non-Smoker Cell, C-Wing | 0.16 | 3.5 | 6.8 | 149 |
| Cardiff/ APEX/003 | Static - Outside Office Landing A-Wing | 1.1 | 18 | 19.5 | 320 |
| Cardiff/ APEX/004 | Static - Smoker cell C-Wing | 7.58 | 140 | 36.1 | 666 |
| Cardiff/ APEX/008 | Static - Non-Smoker Cell 12, C-Wing | 0.2 | 3.26 | 8.9 | 147 |
| Smoker Cell Mean | | 7.75 | 138 | 36.6 | 649 |
| Non-Smoker Cell Mean | | 0.18 | 3.38 | 7.85 | 148 |

2.7.2 Tobacco specific PM has been detected in significantly higher concentrations within smoking cells (UVPM 7.75 $\mu\text{g}/\text{m}^3$ and FPM 138 $\mu\text{g}/\text{m}^3$) over non-smoking cells (UVPM 0.18 $\mu\text{g}/\text{m}^3$ and FPM 3.38 $\mu\text{g}/\text{m}^3$) suggesting that the additional PM_{2.5} detected in smoking cells is largely derived from tobacco smoke. The concentration of tobacco specific PM from the static wing sample can be seen to be mid-range between the smoking cell sample and the non-smoking cell sample. This suggests

that tobacco derived PM detected by the static sample on A-Wing is as a result of emissions of tobacco smoke from the cells of prisoners who have recently smoked.

Table 2-6 Data on tobacco-specific PM from gravimetric/filter sample collected from static sampling of A-Wing

| Sample Number | Location/Staff Member | UVPM µg/m ³ | FPM µg/m ³ | UVPM per gravimetric (µg/mg) | FPM per gravimetric (µg/mg) |
|-------------------|---|---------------------------|--------------------------|------------------------------------|-----------------------------------|
| Cardiff/ APEX/003 | Static - Outside Office Landing A-Wing | 1.1 | 18 | 19.5 | 320 |

2.7.3 Tobacco specific PM detected by personal samplers worn by prison officer staff was similar in concentration to that detected in the A- wing sample, with all personal samples indicating comparable concentrations across a narrow range. The proportion of tobacco specific PM as UVPM and FPM per gravimetric sample was approximately double that detected in non-smoking cells, implying that operational prison staff are being exposed to tobacco smoke during the course of their shift.

Table 2-7 Data on tobacco-specific PM from gravimetric/filter samples collected as part of Prison Officer personal sampling

| Sample Number | Location/Staff Member | UVPM µg/m ³ | FPM µg/m ³ | UVPM per gravimetric (µg/mg) | FPM per gravimetric (µg/mg) |
|---|---------------------------------|---------------------------|--------------------------|------------------------------------|-----------------------------------|
| Cardiff/ APEX/005 | Personal - TM Prison Officer | 0.78 | 12.8 | 7.22 | 119 |
| Cardiff/ APEX/006 | Personal - LF Prison Officer | 0.69 | 11.0 | 11.7 | 187 |
| Cardiff/ APEX/007 | Personal - MS Prison Officer | 1.09 | 16.9 | 20.5 | 318 |
| Cardiff/ APEX/009 | Personal - MO 213 | 1.52 | 22.3 | 23.0 | 338 |
| Cardiff/ APEX/010 | Personal - PB 094 | 0.76 | 10.0 | 18.8 | 248 |
| Cardiff/ APEX/011 | Personal - LF 112 | 1.11 | 15.4 | 19.1 | 265 |
| Personal Sampling Tobacco Specific PM Mean | | 0.99 | 14.7 | 16.7 | 246 |

2.8 Biological monitoring results (Salivary cotinine)

2.8.1 Saliva samples were collected (using protocol detailed in Appendix 1) from twelve non-smoking prison officers at the beginning and end of their shifts. Pre and post-shift samples from two staff were of insufficient sample volume for analysis, leaving ten pairs of samples with valid data.

2.8.2 Values ranged from <LOD (0.1ng/ml) to 0.63ng/ml. The three samples (two from the start of the shift and one from the end of the shift) that were <0.1ng/ml were assigned values of one-half the LOD (0.05 ng/ml) to allow data analysis. Data were log-normally distributed and a geometric mean (GM) was calculated for the pre-shift and post-shift samples.

2.8.3 The salivary cotinine values recorded are presented in Table 2.8. The geometric mean for the 10 pre-shift values is 0.14 ng/ml, increasing to 0.24 ng/ml by the end of the shift. Nine of the ten prison officers show an increase in their salivary cotinine concentration at the end of their shift.

2.8.4 Using pharmacokinetic modelling and data on the average metabolic half-life (or elimination) of cotinine from the body it is possible to calculate the post-shift value if no further nicotine intake occurred over the course of the shift (Repace, 2006). From a 0.14 ng/ml pre-shift level a post-shift of 0.09 ng/ml would be expected if there was zero exposure. This translates in to a 0.15 ng/ml (0.24-0.09) exposure decrease when averaged across the sampled population. Using Repace's Rosetta Stone (Repace, 2006) equations to provide comparison between salivary cotinine and SHS-PM_{2.5} equivalent exposures this suggests a working shift exposure to about 27 µg/m³ for the prison officers sampled .

Table 2-8 Prison officers' salivary cotinine concentrations

| Sample ID | Pre-shift (ng/ml) | Post-shift (ng/ml) | Change (ng/ml) |
|-----------------------|----------------------|-----------------------|-------------------|
| CF/001a | 0.05 | 0.18 | 0.13 |
| CF/002a | 0.10 | 0.05 | -0.05 |
| CF/003a | 0.12 | 0.25 | 0.13 |
| CF/004a | 0.34 | 0.38 | 0.04 |
| CF/005a | 0.10 | 0.33 | 0.23 |
| CF/007a | 0.18 | 0.30 | 0.12 |
| CF/008a | 0.05 | 0.12 | 0.07 |
| CF/009a | 0.23 | 0.32 | 0.08 |
| CF/010a | 0.20 | 0.37 | 0.16 |
| CF/011a | 0.25 | 0.63 | 0.38 |
| Geometric Mean | 0.14 | 0.24 | 0.10 |

3

DISCUSSION

- 3.1.1 This pilot study set out to test the practicalities of quantifying workers' exposure to SHS in prison environments and to compare results from a variety of co-located devices designed to measure fine particle concentrations. This was to inform the main sampling campaign and to allow any necessary changes to the sampling strategy and its implementation to be identified and implemented. The pilot study sought to validate whether the detection of elevated PM_{2.5} concentrations in prisoner cells and on prison wings could be clearly correlated with the presence of tobacco derived PM and therefore directly attributable to the presence of SHS.
- 3.1.2 There were a small number of practical problems particularly in relation to sampling or measuring devices not operating for the full duration. These are typical when gathering data from volunteers or workers and the noise of the devices may have been a particular nuisance for prisoner when located in the confined environment of a cell overnight. Overall a large quantity of static air quality data was gathered, with considerable data also obtained to quantify the personal exposure of prison officers. There was a generally high level of co-operation from prison officers and prisoners. The main practical issue experienced involved the 15 minute data collection at various locations – it was often difficult to keep staff members located for 15 minutes at a single location.
- 3.1.3 Overall there was good agreement between the various methods used to assess SHS and the data gathered are broadly comparable to those reported from other studies in prison settings. Proescholdbel et al (2008) reported PM_{2.5} measurements gathered using the TSI Sidepak AM510 device in 22 areas across 6 prisons in the USA before/after implementation of a smoking ban. Prior to any restrictions being put in place that study reported average levels of 93 µg/m³ in settings where smoking was permitted. Similar concentrations of PM₁₀ were reported in a prison in Switzerland using the TSI Sidepak AM510 where average levels were 110 µg/m³ (Ritter et al., 2012).
- 3.1.4 This study also used a cross-shift cotinine method to generate shift estimates of SHS-PM_{2.5} exposure. At a population level across the workforce sampled these values also broadly agree with the measured airborne PM concentrations.

4

CONCLUSION

- 4.1.1 The Dylos DC1700, Sidepak AM510 Personal Aerosol Monitor and collection of saliva for analysis of cotinine provide practical, simple and cheap methods for characterising exposure to SHS in prison settings and these methods are recommended for the remaining sites. Use of CO sampling was useful for screening purposes only (i.e. to provide immediate confirmation that participating subjects were non-smokers).
- 4.1.2 As a result of the pilot study no major changes were made to the main study. The sampling principle applied across all main study sites followed the combination of both static and personal sampling, using Sidepak and Dylos samplers. In addition saliva samples were collected from prison officers for determination of cotinine concentrations.
- 4.1.3 Personal exposure measurements of PM_{2.5} or respirable dust show that prison officers are exposed to SHS regularly and repeatedly across their work-shift. Personal full shift SHS levels ranged from 27-108 µg/m³.
- 4.1.4 Real-time personal exposure data clearly show much lower concentrations of SHS exposure during breaks and lunch periods compared to time spent on the wings and in cells.
- 4.1.5 The 7-day Dylos results on the wing show PM_{2.5} levels are, on average, nearly three times higher than WHO 24-hour guidance of 25 µg/m³ (WHO, 2010). Given that these concentrations are likely to be typical exposures in this setting they may also be compared with the WHO annual guidance limit (10 µg/m³) (WHO, 2010) and are thus, more than seven times greater than that value.
- 4.1.6 Tobacco is routinely distributed on Friday across A-wing, when prisoners receive their 'Canteen purchases'. It was observed that the concentration of PM_{2.5} detected at the beginning of the week was lower than that the PM_{2.5} concentration detected across the days following the distribution of tobacco. This is often described as the 'Canteen day' effect and will be explored in the main study.
- 4.1.7 The decay curve of PM_{2.5} concentrations after the last cigarette of the day is smoked within a cell suggests that SHS levels remain high for 3-4 hours. This is similar to household data (Semple et al., 2014) and is broadly similar to the current Scottish Government message of SHS lingering for 'up to 5 hours' within home settings (<http://www.rightoutside.org>).
- 4.1.8 The salivary cotinine of non-smoking prison officers (0.24 ng/ml) at the end of their shift is much lower than those reported for bar workers in Scotland prior to smoke-free legislation in 2006 (2.9 ng/ml) (Semple et al., 2007) and broadly similar to the general non-smoking adult population in Scotland (0.26 ng/ml) (Haw et al., 2007). However the salivary cotinine increases observed over the course of the work-shift in 9 out of 10 workers indicates that SHS exposure occurs. Pharmacokinetic modelling methods suggest that, on average, prison officers inhale approximately 27 µg/m³ of SHS-PM_{2.5}
- 4.1.9 It is likely that higher quantities of tobacco are consumed by prisoners over the weekend, than during week days, as fresh supplies of tobacco are issued each Friday (canteen day), combined with the high level of day time cell occupancy, due to the fact that prisoners are not required to work from Friday afternoon, Saturday and Sunday, leads to an increase in SHS concentrations across A-wing as a whole. The high concentrations of SHS detected on Friday afternoon correspond with this distribution of fresh tobacco to prisoners and greater quantities of tobacco being smoked immediately after this than at any other time.
- 4.1.10 Detection of high concentrations of SHS continued throughout the weekend (including Friday afternoon, which is a non-working period). In contrast, a marked reduction in

SHS concentrations detected can be seen on Monday morning as a result of lower cell occupancy during the day, due to prisoners being out at work or in training sessions

- 4.1.11 This report demonstrates that: SHS concentrations in Cardiff Prison are considerable; prison officers have repeated and regular exposure to SHS; and that the protocol described provides practical, simple and relatively inexpensive methods for characterising that exposure.

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APPENDIX A – PROTOCOL USED TO GATHER DATA SAMPLING METHODOLOGY AND MONITORING PLAN

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Background

This document provides detail of an agreed approach to gather data that will enable quantification and characterisation of the occupational exposure to second-hand tobacco smoke (SHS) of prison officers working within prisons in England & Wales. The proposed methodology takes into consideration the available project budget, manpower and logistical constraints and has been developed as a result of a meeting between Dr Sean Semple (University of Aberdeen) and Dr Karen Galea (Institute of Occupational Medicine (IOM)) on 12th January 2015 followed by a one-day project kick-off meeting (16th January 2015) involving Drs Semple and Galea and representatives from Parsons Brinckerhoff (PB), Peter Walsh and Bethan Tuckett-Jones. Dr Martie van Tongeren of the IOM also contributed to part of the meeting.

The proposed methods build on previous experience of the IOM/University of Aberdeen team in measuring SHS in a variety of occupational and non-occupational settings [e.g. 1-2] with particular reference to a project to measure SHS exposure of prison officers in a prison on the Isle of Man carried out in 2008 [3].

Previous work has been published on SHS exposure within prison settings [4-8]. These studies have used mixed methods to quantify SHS exposure in prisons in Ireland, the USA, Switzerland and New Zealand. Methods have included measurement of fine Particulate Matter (PM_{2.5}) or nicotine in prison air or levels of Carbon Monoxide (CO) in exhaled breath of prison officers. Some have examined changes in SHS concentrations after implementation of new rules limiting or prohibiting smoking within the prison setting. None of these studies have attempted to quantify personal exposure of prison officers to SHS during their work-shift.

The work proposed here aims to achieve the following:

- Quantification of the extent that prison staff are exposed to SHS;
- Provide data on the patterns of SHS exposure of staff;
- Provide data on the variation of SHS concentrations across different types of prison buildings and prison categories;
- Provide data on the degree of SHS drift of into cells of non-smoking prisoners and to non-smoking areas within the prison;
- An evaluation of the impact on SHS concentrations of 'Canteen Day' (when inmates purchase tobacco).

Sampling overview

The sampling campaign will be divided in to two phases. The first, a pilot study, will be carried out over a period of seven days at Cardiff prison (a Category B Local/Training prison). On completion and after a short period for data analysis and assimilation the second phase will commence. The second phase will involve visits to five prisons (Leyhill, Long Larten, Winchester, Gartree and Risley) that span Category A to Category C. Seven days of monitoring activity is planned in each.

Pilot study

The pilot study will test the practicalities of monitoring in prison environments and will collect gravimetric respirable dust samples to be analysed for tobacco-smoke specific particulate matter using UV and fluorescence analysis, following BS 15593:2001 [9]. These data will be compared to results from co-located photometric devices (TSI Sidepak AM510 Personal Aerosol Monitor, fitted with a PM_{2.5} impactor) and Dylos DC1700 Air Quality Monitor) to enable these devices to be calibrated to tobacco-specific SHS. The SHS-specific calibration factors for each instrument will be applied to the second phase data collection.

The pilot study will gather the following data:

- A static 24 hour gravimetric respirable dust sample within a cell containing smoking inmate(s). This will be collected in accordance with MDHS14/4 [10]. A co-located 24 hour Sidepak PM_{2.5} measurement and a co-located 24 hour Dyllos DC1700 measurement will also be carried out.
- The above repeated in a cell containing non-smoking inmate(s).
- The above repeated in the main-hall area.
- Three personal exposure monitoring/samples from non-smoking prison officers taken across as much of a full-shift as possible (ideally $\frac{3}{4}$ of the shift where possible). These would involve the collection of a gravimetric respirable dust sample collected according to MDHS14/4 together with a co-located Sidepak PM_{2.5} measurement. Data on prison officers' locations and activities within the prison would be collected through a mixture of observation, interview and personal record sheet as appropriate. These 3 prison officers will also be asked to provide saliva samples for the measurement of cotinine at the beginning and at the end of their shift together with exhaled breath CO at both time points. A request for any other available non-smoking prison officers to provide saliva and exhaled CO will also be made.
- A series of short, 30 minute Dyllos DC1700 particle number measurements will be made at 5-10 strategic locations where staff and inmates spend time. These are likely to include, but not be limited to, venues such as the gym, canteen, games room, library and others.
- A 7-day particle number concentration measurement will be made in the main hall area with a Dyllos DC1700 instrument. This will be installed on the first day with data downloaded at regular intervals over the course of the week.

The monitoring activities at the pilot study will broadly follow the timetable set out below:

Day 0: Preliminary site visit to establish entry procedures for PB staff and the equipment / authorisations required. Discussions with site staff about the monitoring that will be carried out, timing of activities and staff shift, access to locations, PB staff safety, possible sites for monitoring and equipment safety. This visit will also provide prison staff with an opportunity to ask questions about the monitoring procedure and to raise any potential logistical difficulties.

Day 1: Placement of a set of equipment (Sidepak, Dyllos and Gravimetric sampling train) to carry out static monitoring within a smoking cell with another identical set placed in a non-smoking cell (ideally adjacent to the smoking cell being monitored). A third set of equipment will be placed in the main hall or atrium area.

Day 2: Collection of devices placed on day 1 (after 24 hours): download data where appropriate and replace batteries for further 24 hours data collection in a similar location (smoking cell; non-smoking cell; main hall).

Day 3: Collection of devices placed on day 2 (after 24 hours): download data where appropriate. Dyllos located at main hall to be left in position. Additional Dyllos to be used to make short 20-30 minute measurements at 5-10 strategic locations.

Day 4: 3 self-reported non-smoking prison officers selected to wear gravimetric sampling train and a Sidepak device for duration of their shift. Instruments attached to prison officer by secure means with Tygon tubing positioned inside uniform to allow sampling within the breathing zone of the officer. Data on prison officers' locations and activity gathered by self-completion of diary (with 30 minute resolution) backed up by regular enquiry from PB team. Saliva sample and exhaled breath analysis carried out at beginning and end of shift.

Day 5: A further 3 non-smoking prison officers carry out personal sampling as described in day 4.

Day 7: Fully 7 days after initial placement of the Dyllos device in the main hall this will be switched off and collected by a member of the PB team.

Second phase

The following outline may be updated following review of the results and the experience gained in the pilot phase. It is anticipated that a similar approach will be taken to the data collection in the remaining 5 prisons with the aim of collecting in each establishment personal exposure data for 6 prison officers, a 24 hour static measurement in a smoking and non-smoking cell, static, 20-30min measurements in strategic locations and a 7 day static measurement in the main hall. Pre and post-shift salivary cotinine and exhaled CO will also be measured for participating prison officers. Gravimetric samples

will not be collected during the second phase with values gained from co-location of instrument in the pilot study used to calibrate the photometric devices to SHS-specific PM_{2.5}.

The timetable for second phase visits will be as follows:

Day 0: Preliminary site visit to establish entry procedures for PB staff and the equipment / authorisations required. Discussions with site staff about the monitoring that will be carried out, timing of activities and staff shift, access to locations, PB staff safety, possible sites for monitoring and equipment safety. This visit will also provide prison staff with an opportunity to ask questions about the monitoring procedure and to raise any potential logistical difficulties.

Day 1: Placement of Dylos DC1700 devices to carry out static monitoring within a smoking cell with another Dylos device placed in a non-smoking cell (ideally adjacent to the smoking cell being monitored). A third Dylos will be placed in the main hall or atrium area.

Day 2: 3 non-smoking prison officers selected to wear a Sidepak device for duration of their shift. Instruments attached to prison officer by secure means with Tygon tubing positioned inside uniform to allow sampling within the breathing zone of the officer. Data on prison officers' locations and activity gathered by self-completion of diary (with 30 minute resolution) backed up by regular enquiry from PB team. Saliva sample and exhaled breath analysis carried out at beginning and end of shift. Collection of Dylos devices placed on day 1 (after 24 hours): download data where appropriate. Dylos located at main hall to be left in position. Additional Dylos to be used to make short-term 30-minute measurements at 5-10 strategic locations (can also be carried out on day 3).

Day 3: A further 3 non-smoking prison officers carry out personal sampling as described in day 2.

Day 7: Fully 7 days after initial placement of the Dylos device in the main hall this will be switched off and collected by a member of the PB team or sent back to PB by postal arrangement.

An equipment summary with details of measurement locations is provided in the Excel document 'MoJ device timetable'.

Monitoring protocols/supporting guidance notes

Static monitoring with Dylos DC1700

The Dylos DC1700 counts particle numbers using photometric methods [11]. The device measures particle numbers in two size bins (>0.5 microns and >2.5 microns) every second and logs the average every 1 minute. Devices require mains electricity to run for periods beyond the 6-8 hour internal battery life. Devices should be checked that they are set to the correct date and time in accordance with the instructions available in the Dylos DC1700 manual, and placed within a secure environment while ensuring adequate air flow to and within any enclosure. Devices should then be switched on, the memory cleared of any residual data and they will then automatically log particle number concentrations for a period of approximately 6 days and 6 hours. For the device located in the main hall for 7 days data should be downloaded at least once during the time the team is within the prison – this will ensure that a complete 7 day period is collected.

For devices located in cells data should be downloaded at the end of the 24 hour measurement period. Contextual data about the cell, (size/volume, number of inmates, smoking activity, the presence of any other fine particulate emissions sources) should be gathered. A similar process should be followed for the 20-30 minute measurements made at strategic locations. Strategic locations should be visited at times when the area is in typical use and this should broadly match the time of day that prison officers would tend to be present in those areas.

Static/personal monitoring with Sidepak AM510 Personal Aerosol Monitors

Devices will be cleaned, greased and zero calibrated prior to each use. Flow rates will be set at 1.7 l/min using a TSI flowmeter as indicated in the device manual. For 24 hour monitoring Sidepaks will operate from mains electricity. Devices should be set to measure every 1 second and to log every 1 minute with a calibration factor of 1.0. Care should be taken to set the devices to 'Logging mode' rather than 'Survey mode'. The keypad can be locked by following instructions from the manual and when used in cells the Sidepak should be further secured inside a small lockable box –with the additional benefit of sound insulating material. A short piece of Tygon tubing will be attached from the

PM_{2.5} inlet to the outside of this box. For personal exposure monitoring a similar procedure will be followed but with the device attached to a belt or pocket of the officer wearing the instrument. For safety reasons this should be secure and/or inside the officers' clothing. A short length of Tygon tubing would be attached from the PM_{2.5} inlet to be attached to the breathing zone of the officer. Again this should be inside the officers' uniforms and present no mechanism for intentional injury.

Static/personal gravimetric monitoring

A sampling train consisting of a Casella Apex personal sampling pump, a short length of Tygon tubing and a Higgins-Dewell type cyclone sampling head containing a 37mm filter suitable for UVPM analysis, will be required. A flow rate of 2.2 litres per minute will be set using a calibrated rotameter. Sampling will be carried out in accordance with MDHS14/4 [10]. For a 24-hour sample it is recommended that replaceable AA battery packs are used with these pumps: with high quality lithium batteries 20-24h can be achieved. When using these for 24h measurement in prison cells it will be important to check these pumps first thing every morning to determine if replacement batteries are required to achieve the 24h sample. As with the Sidepak device the Apex pumps should be located inside a secure, noise reducing box when used in cells. The sampling head will be located outside the box and attached to the pump by a short piece of Tygon tubing. When used to collect personal samples on prison officers the pumps should be attached in a similar way to that described for the Sidepak devices.

Saliva samples

The following protocol is based on that used for the Bar Workers' Health and Exposure to Environmental Tobacco Smoke (BHETSE) study [1].

- Salivettes (2 per prison officer) and a matching number of zip-lock plastic bags will be provided. The salivettes have three parts: an inner tube with stopper; an outer tube; and a cotton wool roll.
- DO NOT OPEN THESE TUBES as you could contaminate the swabs.
- Each tube has a label on it with a serial number. Please put each tube into a separate zip-lock plastic.
- When you are keeping the tubes at home before you use them in the field survey, please store the tubes in an area where they will not be exposed to tobacco smoke to avoid contamination.
- Please make sure you are wearing a watch for the interview (preferably one with a second hand) as you will need to time the 3 minutes that the respondent keeps the swab in their mouth.

How to introduce the saliva collection to prison officers:

- "We are interested in measuring exposure to cigarette smoke amongst prison officers. In order to do this, we need to carry out some tests on people's saliva. This involves putting a piece of cotton wool in your mouth and leaving it there for 3 minutes and then spitting it out into a tube.
- Would you be willing to help us with this? As I said, it would just involve you putting a cotton wool swab in your mouth between your gum and your cheek, and leaving it there for 3 minutes. This is what the swab looks like."
- (SHOW TUBE CONTAINING SWAB TO PRISON OFFICER)
- If you agree to do this, the results will be kept fully confidential. Are you happy to help us with this now?
- If they are not willing to do this then continue with the questionnaire administration. Make a note on the cover sheet that they were not willing to provide a saliva sample. "Can I just check, as far as you know, are you allergic to cotton wool?"
- If they are allergic, explain that it is best not to take part in this part of the survey after all and complete the rest of the survey as normal.

- In order to ensure that the correct swabs are assigned to respondents attach an ID label to the outside of the salivette. This should be the duplicate of the label that has been attached to the participant cover sheet. Please take care to carry this out accurately.

How to administer the swab:

- If the respondent agrees to take part, you should hand them the tube without opening it – please do NOT touch the swab.
- “I’ll just explain to you what I would like you to do. Firstly, remove the stopper from the inner tube and tip the cotton wool roll into the stopper. Now put the cotton wool roll into your mouth without touching it, and rest it between your cheek and gum. “
- “I would now like you to leave the cotton wool in your mouth for 3 minutes, but please DO NOT chew it. I will let you know when the 3 minutes is over. If your mouth feels really dry at any point you can move the swab around inside your mouth and then put it back between your cheek and gum, but please DO NOT chew it.”
- You should time 3 minutes and let the respondent know when they should stop. They should return the cotton wool to the stopper and put it back in the inner tube, then place the tube in the plastic bag and hand it back to you.
- If the respondent finds the cotton wool roll particularly uncomfortable or unpleasant, and wants to remove the swab early, allow them to stop and get them to put the cotton wool back in the tube as described above.
- Record on the cover sheet whether the respondent kept the swab in their mouth for the full three minutes, or removed it earlier.
- Don’t forget to take the plastic bag with the tube in it away from the interview with you.

After swabs have been collected, please take care to store them away from smoky environments. You should store the samples (in their sealed jiffy bag) in a cool box for transport or fridge for no more than 7 days before batching them up and sending them in a jiffy bag to ABS Labs for analysis. These samples will be analysed by ABS Labs Ltd using a previously published methodology [12] for salivary cotinine. Saliva samples will be collected at the beginning and end of the prison officers’ work shift.

Exhaled CO measurement

A Bedmont Scientific Micro EC50 Smokerlyzer will be used to monitor CO concentration in exhaled breath of prison staff. Measurements, in accordance with the device manual, will be taken at the beginning and end of shift periods. Readings are given in ppm.

Time-activity data

Time activity data should be acquired for those prison officers wearing Sidepak devices in order to allow the interpretation of real-time SHS exposure information. Methods of collecting prison officers’ time-activity from swipe cards or CCTV resources should be explored on site but in the absence of this a paper-based recording method similar to the one in the attached Word file (MoJ Time activity diary) should be used. PB will need to adapt this document to reflect the various locations and activities that prison officers will spend their time. Self-completion of such forms is notoriously poor and it is recommended that PB staff ‘check-in’ as frequently as possible with staff during the course of the day.

Informed consent

While this work is seeking to characterise prison officers’ occupational exposure to a hazardous agent (tobacco smoke) and, as such is covered by occupational hygiene monitoring under the COSHH regulations and the Health and Safety at Work Act, it would be prudent to (a) provide participants with an Information Sheet describing the nature of the work and (b) to gain informed consent from the prison officers that take part. No personal exposure data is being gathered from prison inmates and data about their environment is being gathered in much the same way as thermostatic temperature

data is gathered to ensure that prisons are sufficiently heated. An example participant information sheet and a consent form are provided for modification and use by PB staff.

Data entry and review

Data from the Sidepak and Dylos devices should be stored as TSI Trackpro files or .txt files with summary exposure data (average, maximum, minimum and sampling times) entered to an Excel database containing location identity and contextual information. Where possible, and when timing permits, data will be reviewed at the end of Day 2 of each site visit. This review will be performed by Dr Sean Semple of the University of Aberdeen and will seek to identify any potential problems with the data and to advise on corrective action on the final day of site activity for that particular prison. A final database containing exposure data and associated contextual data will be delivered to the IOM/University of Aberdeen team on conclusion of the pilot phase for to allow determination of calibration factors for photometric devices and to enable consideration of potential problems that may require modification of the planned second phase protocol. On completion of the second phase a similar structured database will be delivered, together with the original raw instrument outputs from the Sidepak and Dylos devices, to allow appropriate analysis and preparation of a final report.

Protocol References

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APPENDIX B – QUESTIONNAIRE RESULTS

Table B-1 Summary of prison officer questionnaire responses

| Section A – Details | | | | | | Section B - Sample Results | | | Section BC- Self Description | | Section D – Exposure | | | Section E - Work as prison officer | | |
|---------------------|---------------------|--------------|-----------|-------------|-----|----------------------------|------------------|-------------------|--|----------------------------------|----------------------|-------------------------|---------------------------------|---|---|---|
| Sample Date | Time Initial Sample | Staff Number | Job Title | Wing Code | Sex | CO result AM (ppm) | Personal Monitor | Describe yourself | Do you use Nicotine replacement therapy? | Do you use electronic cigarette? | Living with a smoker | Sharing car with smoker | Average Hours Worked Week (hrs) | How long have you worked in prison sector (yrs) | Approximate exposure in working day to other peoples smoke (prisoners and colleagues) (%) | Approximate percentage of working day in prison cells (%) |
| 13/02/2015 | 07:20 | CF094 | PO | C | M | 3 | Y | NS | N | N | N | N | 39 | 23 | 80 | 5 |
| 13/02/2015 | 07:05 | CF213 | PO | A | M | 5 | Y | NS | N | N | N | N | 40 | 20 | 90 | 10 |
| 13/02/2015 | 07:35 | CF112 | PO | F | M | 4 | Y | NS | N | N | N | N | 39 | 10 | 90 | 10 |
| 12/02/2015 | 07:15 | TM | PO | C | M | 2 | Y | NS | N | N | N | N | 39 | 28 | 60 | 10 |
| 12/02/2015 | 07:25 | LF | PO | D | F | 3 | Y | NS | N | N | N | N | 39 | 15 | 60 | 15 |
| 12/02/2015 | 07:25 | MS | SPO | Missin g | M | 7 | Y | NS | N | N | N | N | 39 | 10 | 35 | 10 |
| 13/02/2015 | 07:10 | CF299 | PO | B | M | 3 | N | ES | N | N | N | N | 39 | 20 | 100 | 30 |
| 13/02/2015 | 07:40 | CF153 | PO | A | M | 2 | N | NS | N | N | N | N | 40 | 22 | 75 | 50 |
| 12/02/2015 | 07:10 | KJ | PO | Missin g | M | | N | ES | N | N | N | N | 39 | 24 | 10 | 10 |
| 12/02/2015 | 07:30 | CF030 | SPO | C,D,E | M | 4 | N | ES | N | N | N | N | 19.5 | 33 | 50 | 50 |
| 13/02/2015 | 07:15 | CF286 | PO | E | M | | N | NS | N | N | N | N | 39 | 14 | 75 | 50 |

SOP – Senior Prison Officer; PO – Prison Officer
ES - Ex-Smoker; NS- Never Smoked

APPENDIX C – GRAPHS OF REAL-TIME MEASUREMENTS (MEASUREMENTS >360 MINUTES OF DATA).

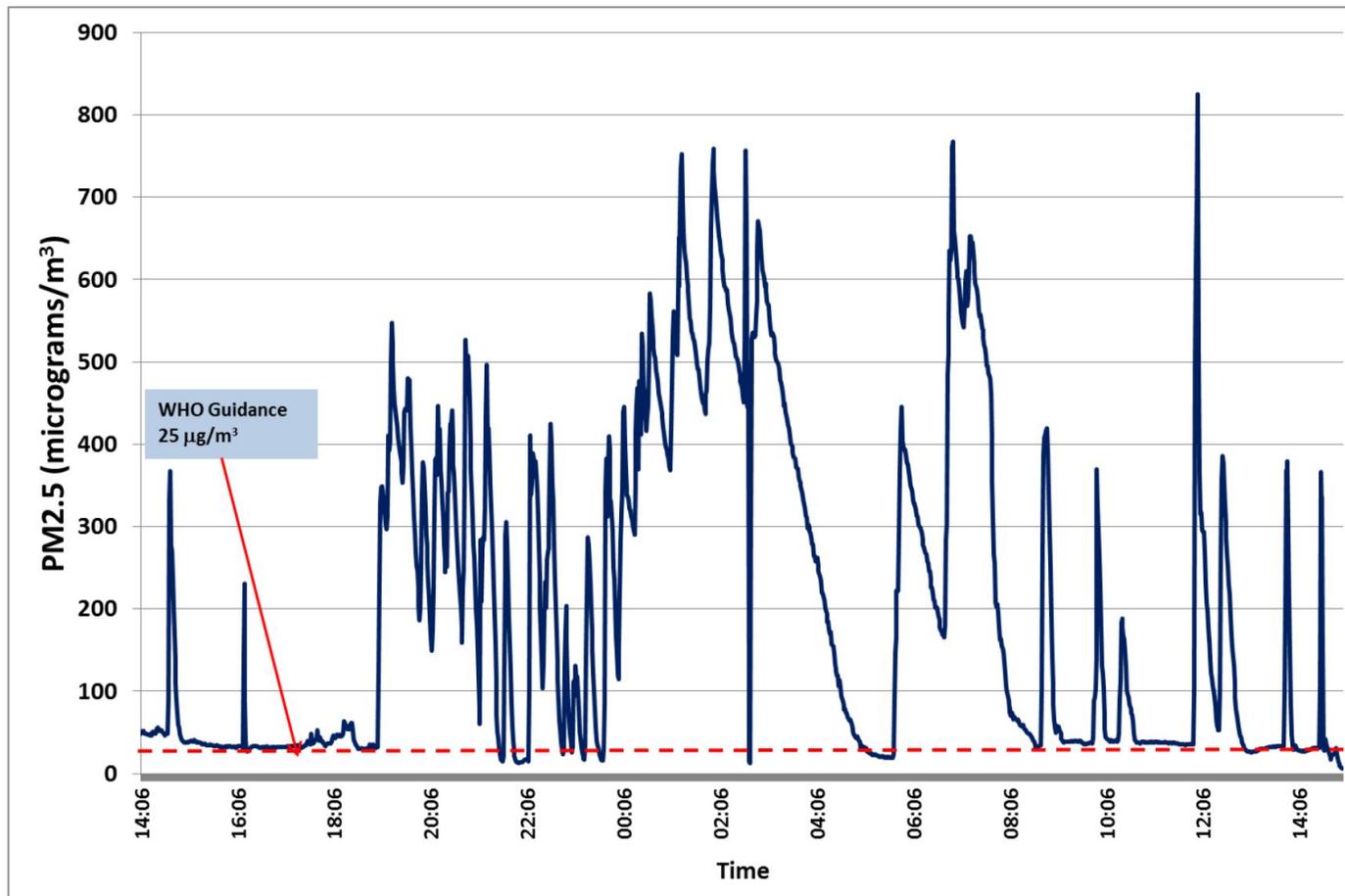


Figure C-1 Static - Cardiff/ Dylos/001 Smoker cell A-wing

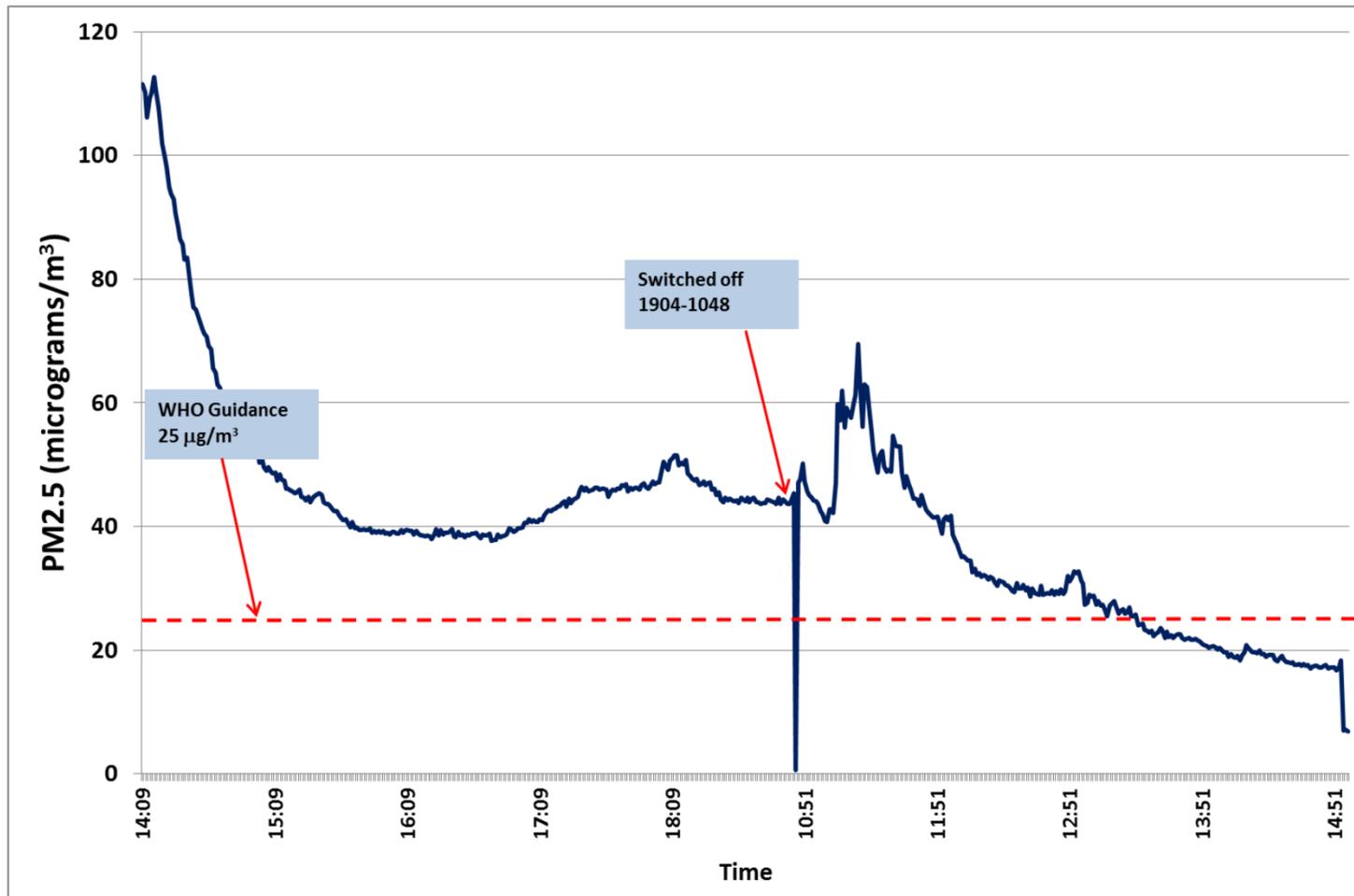


Figure C-2 Static -Cardiff/ Dylos/002 Non-smoker cell C-wing

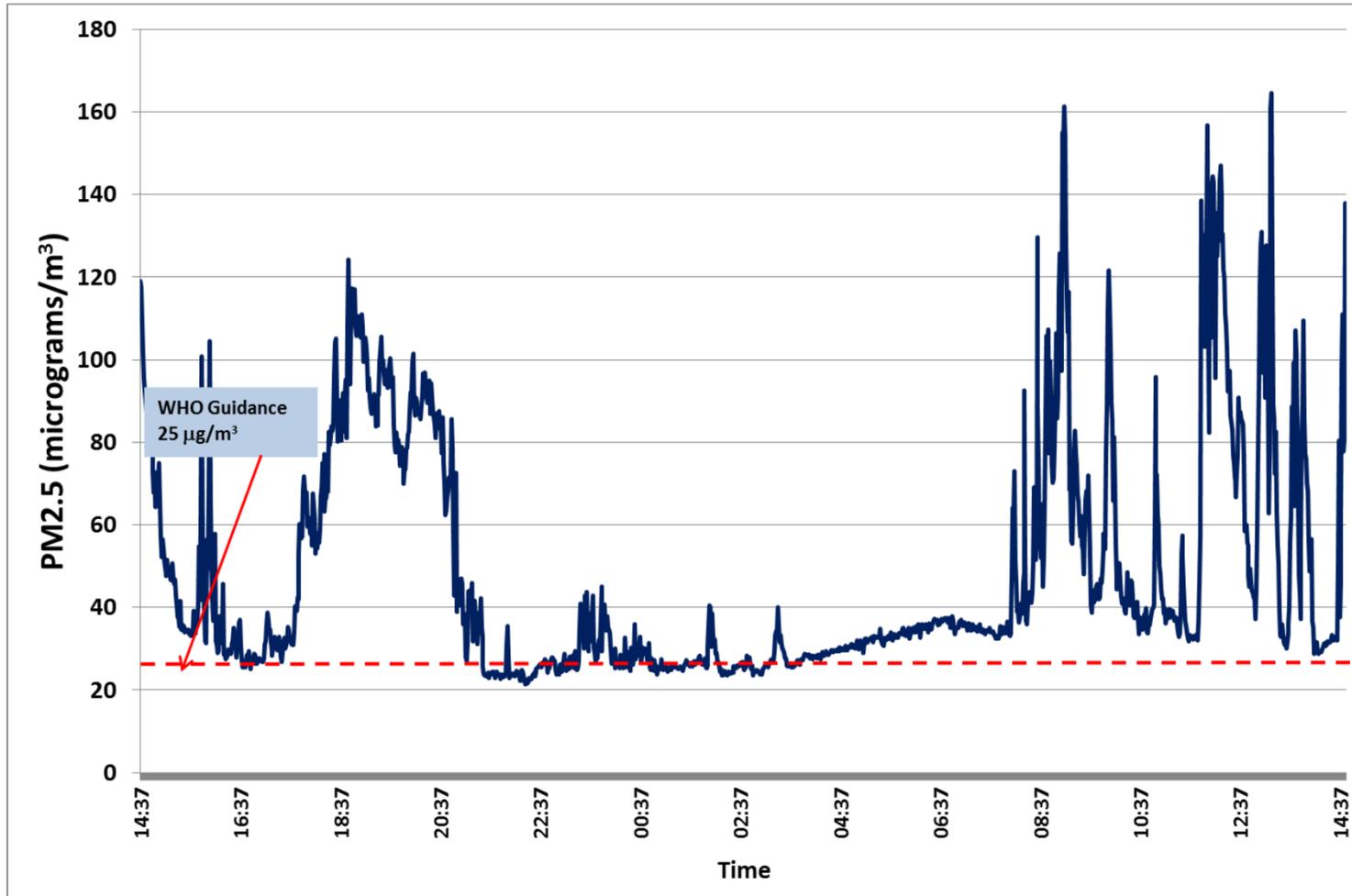


Figure C-3 Static -Cardiff/ Dylos/003 Outside office landing A-wing

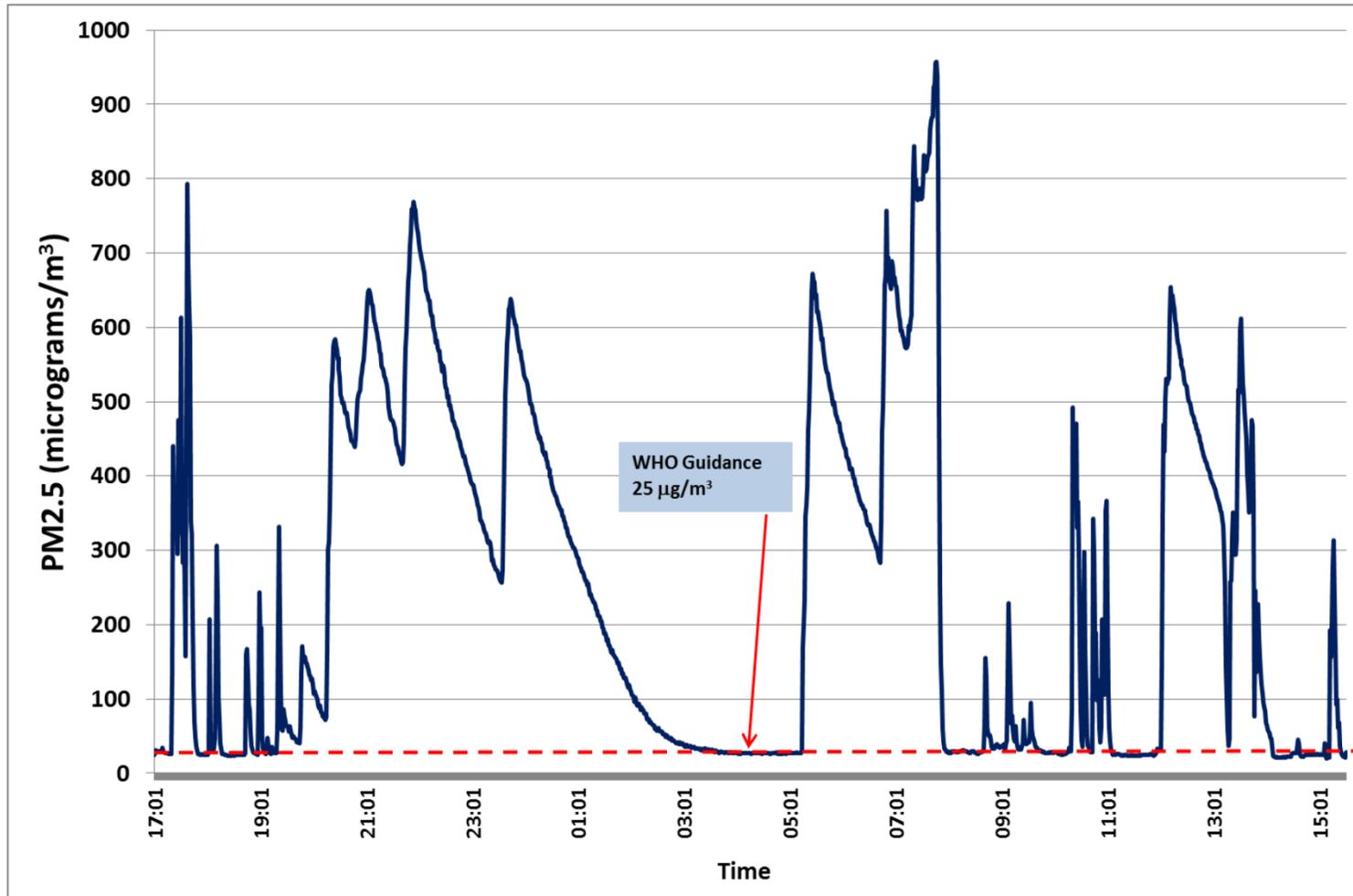


Figure C-4 Static -Cardiff/ Dylos/011 Smoking cell C-wing

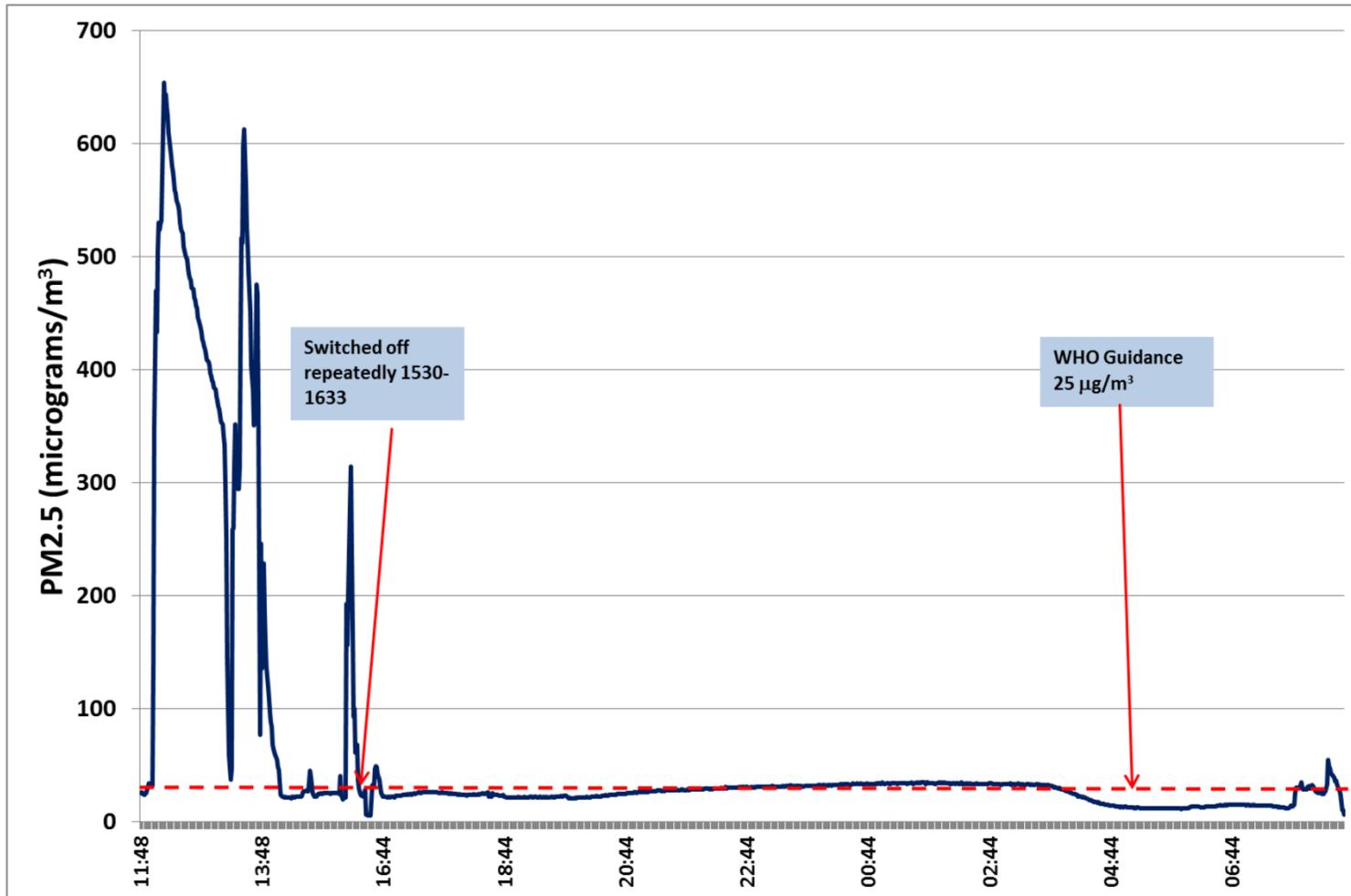


Figure C-5 Static -Cardiff/ Dylos/016 Non-smoking cell C-wing

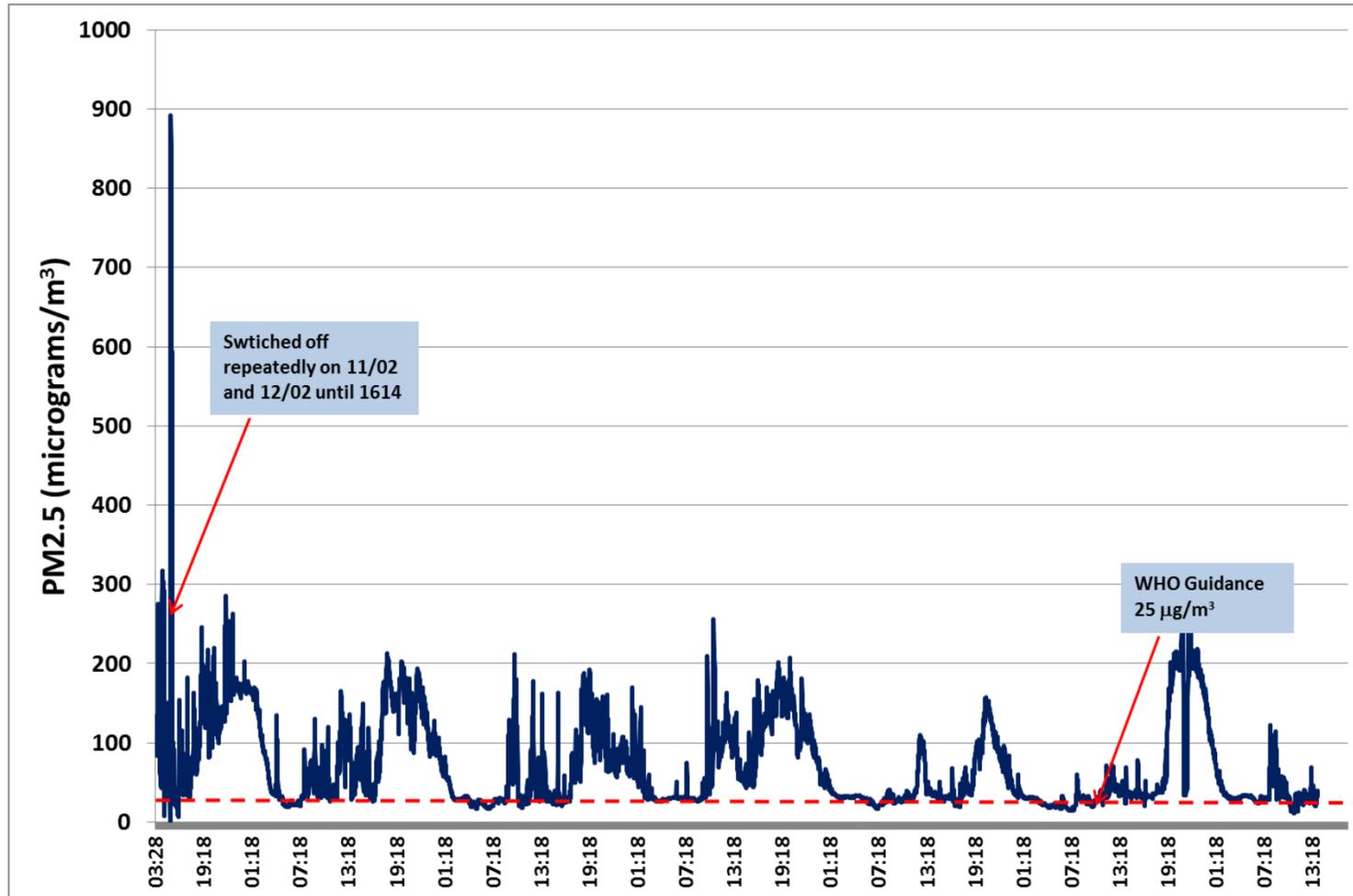


Figure C-6 Static -Cardiff/Dylos/018 A-wing landing

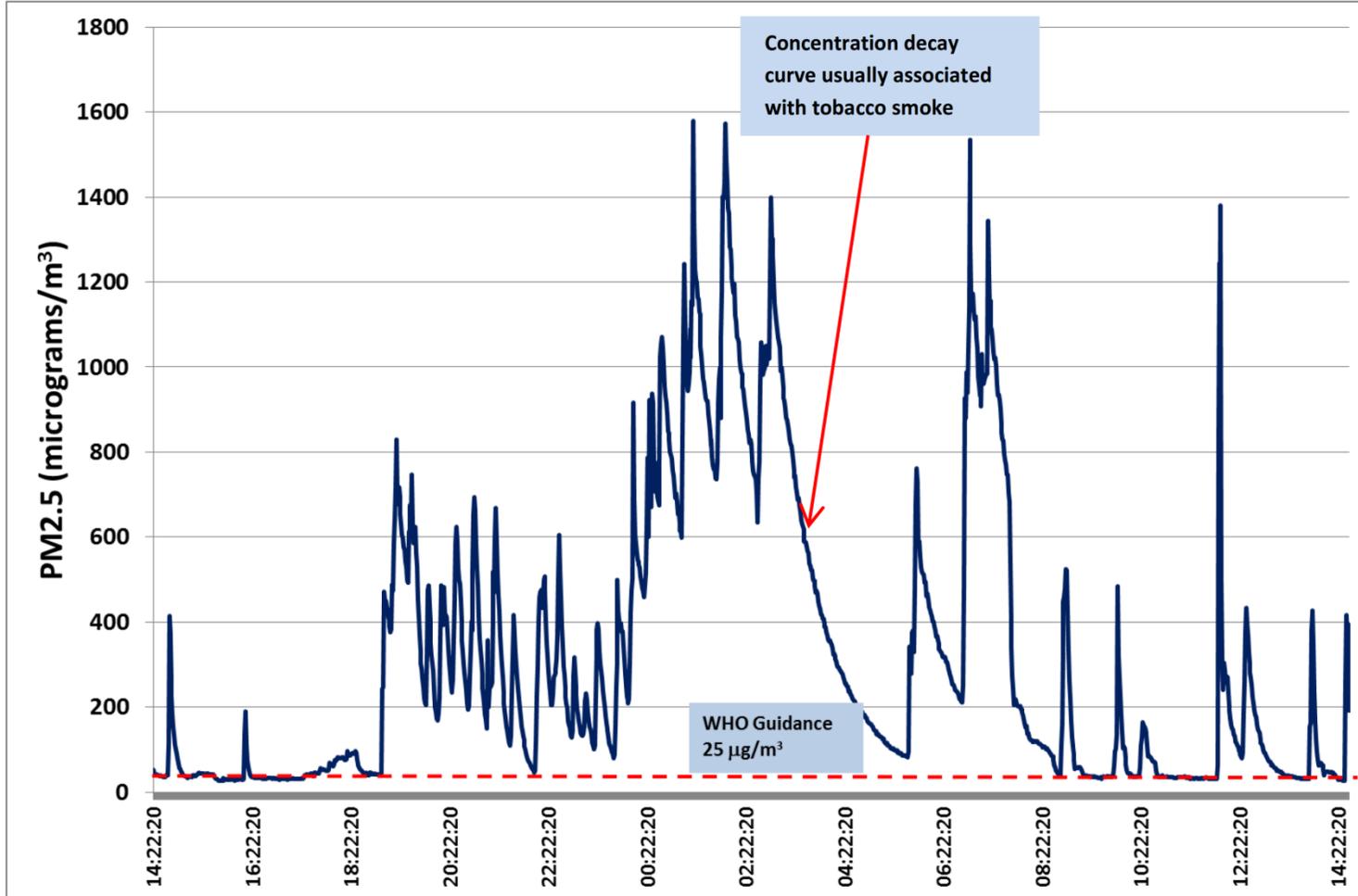


Figure C-7 Static -Cardiff/Sidepak/002 Smoking cell A-Wing

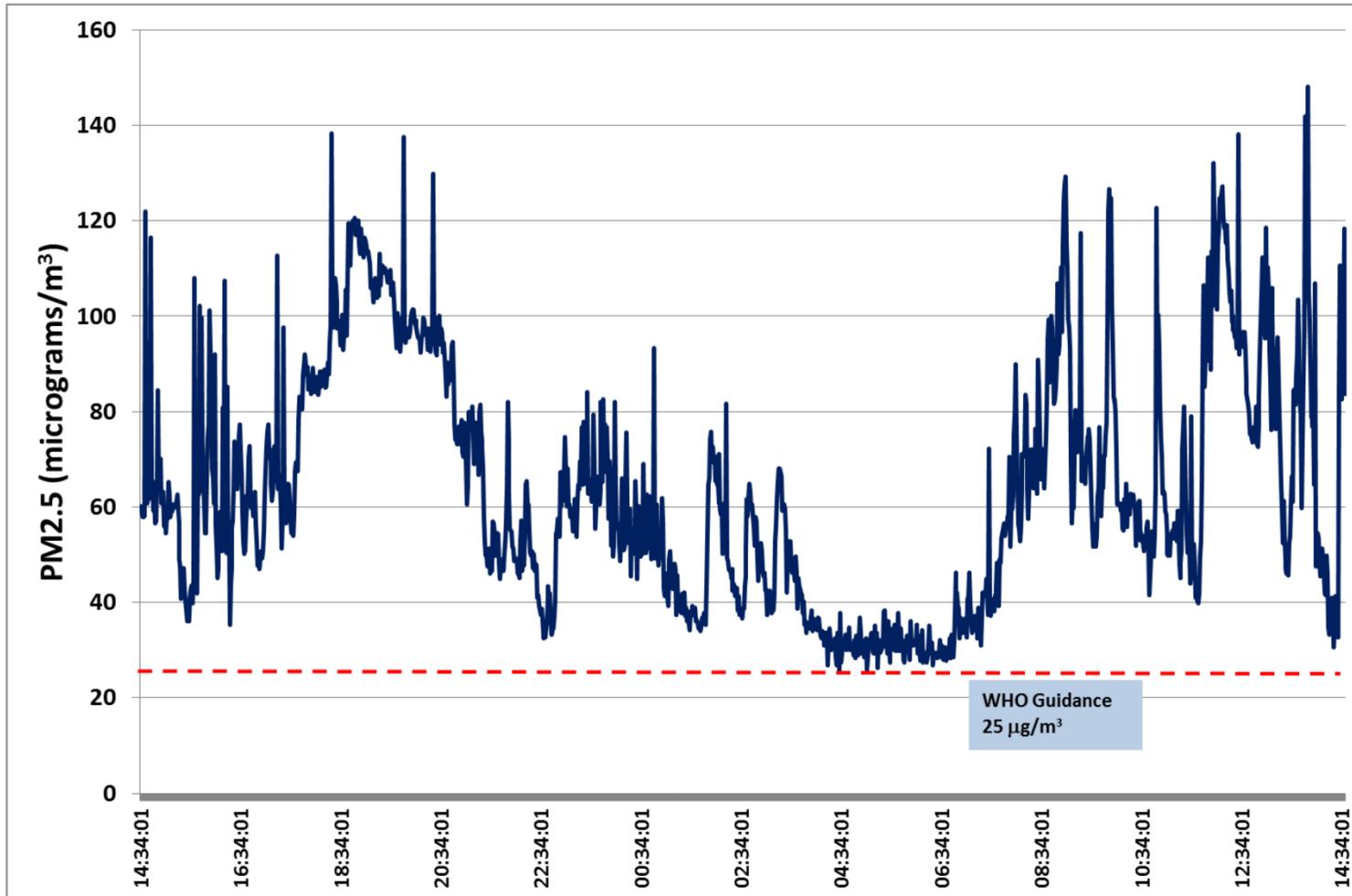


Figure C-8 Static - Cardiff/Sidepak/003 Outside Office Landing A-Wing

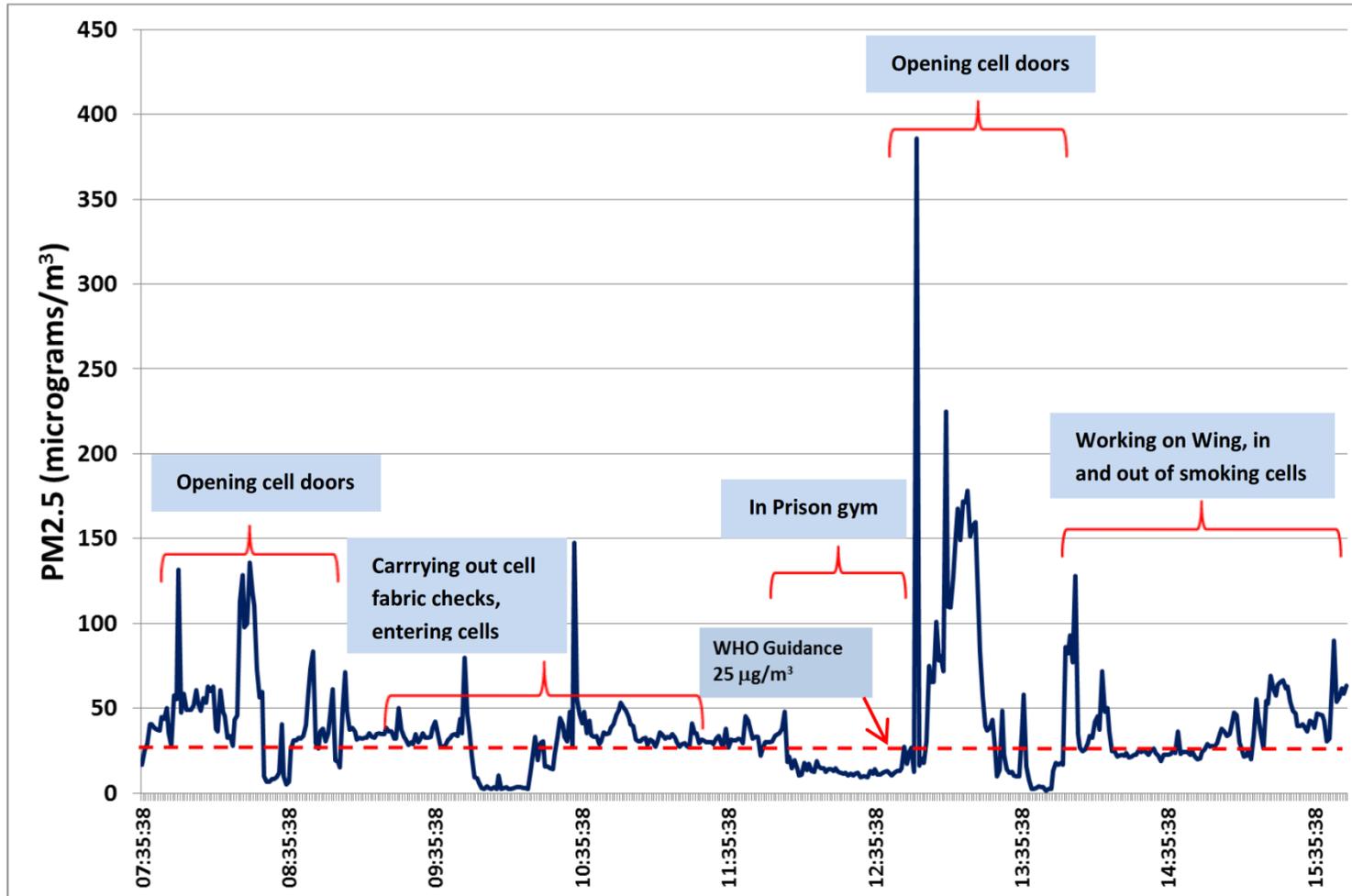


Figure C-9 Personal -Cardiff/Sidepak/006 LF Prison Officer

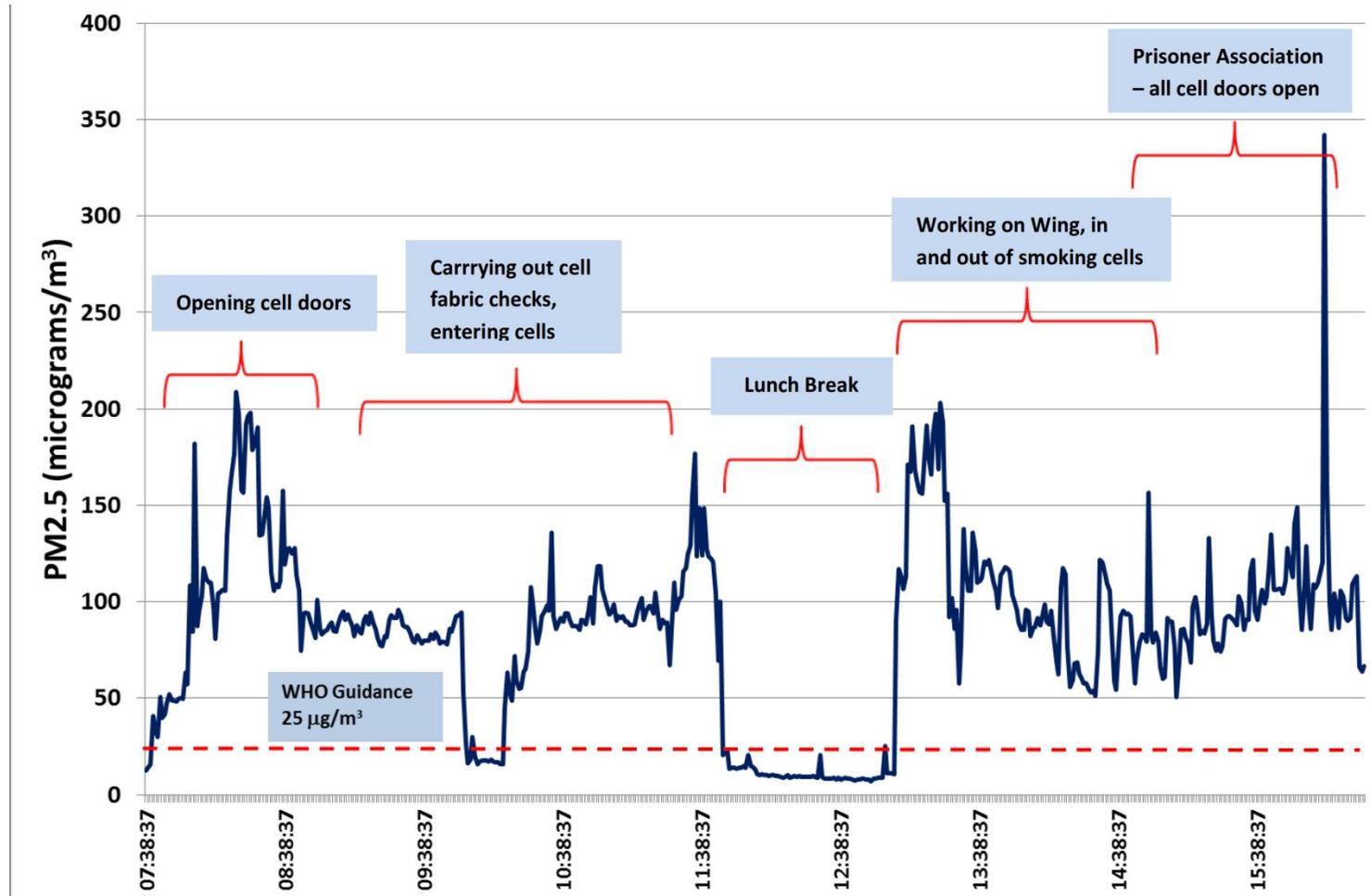


Figure C-10 Personal Cardiff/Sidepak/007 MS Prison Officer

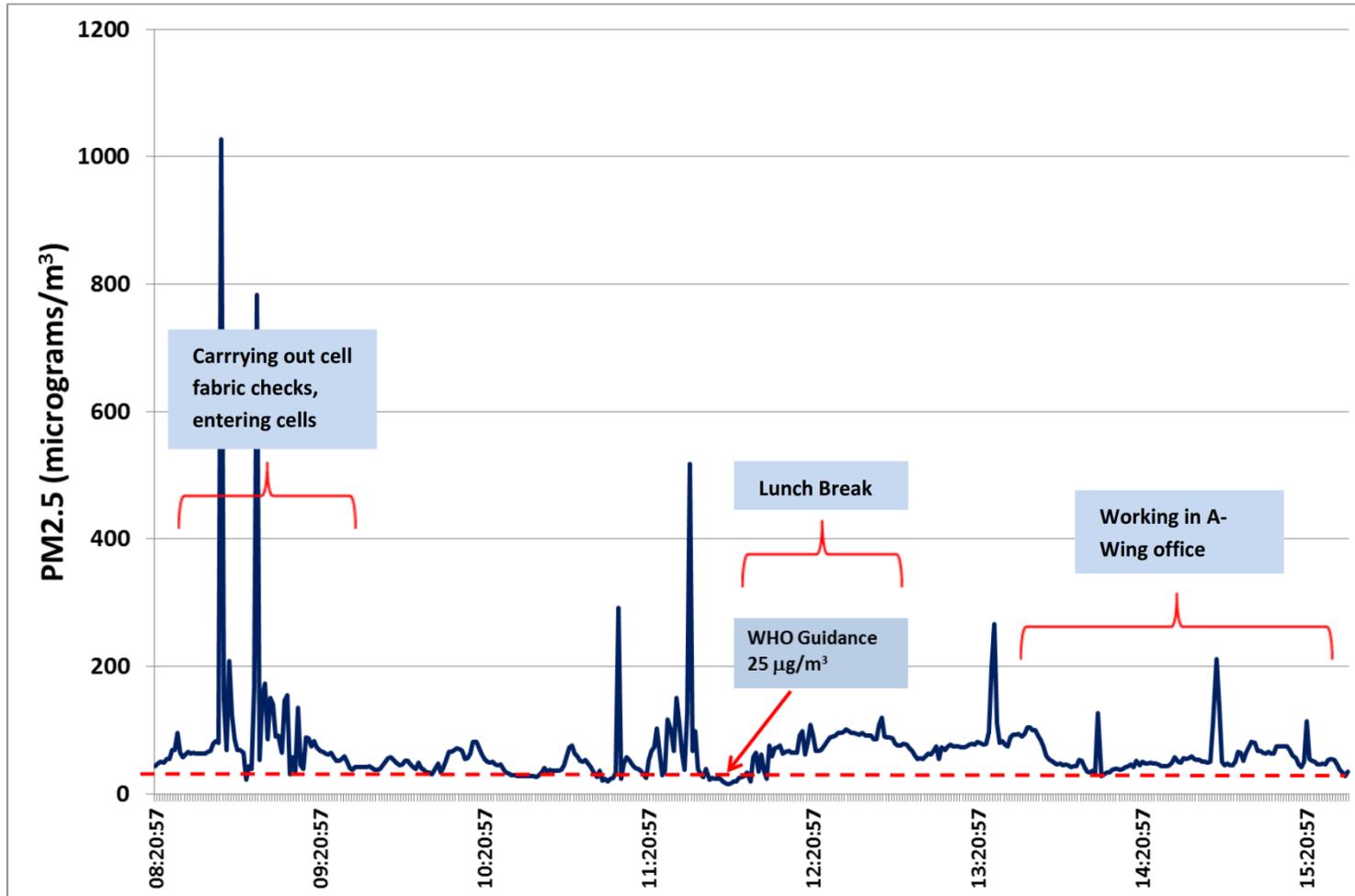


Figure C-11 Personal Cardiff/Sidepak/009 MO 213 Prison Officer

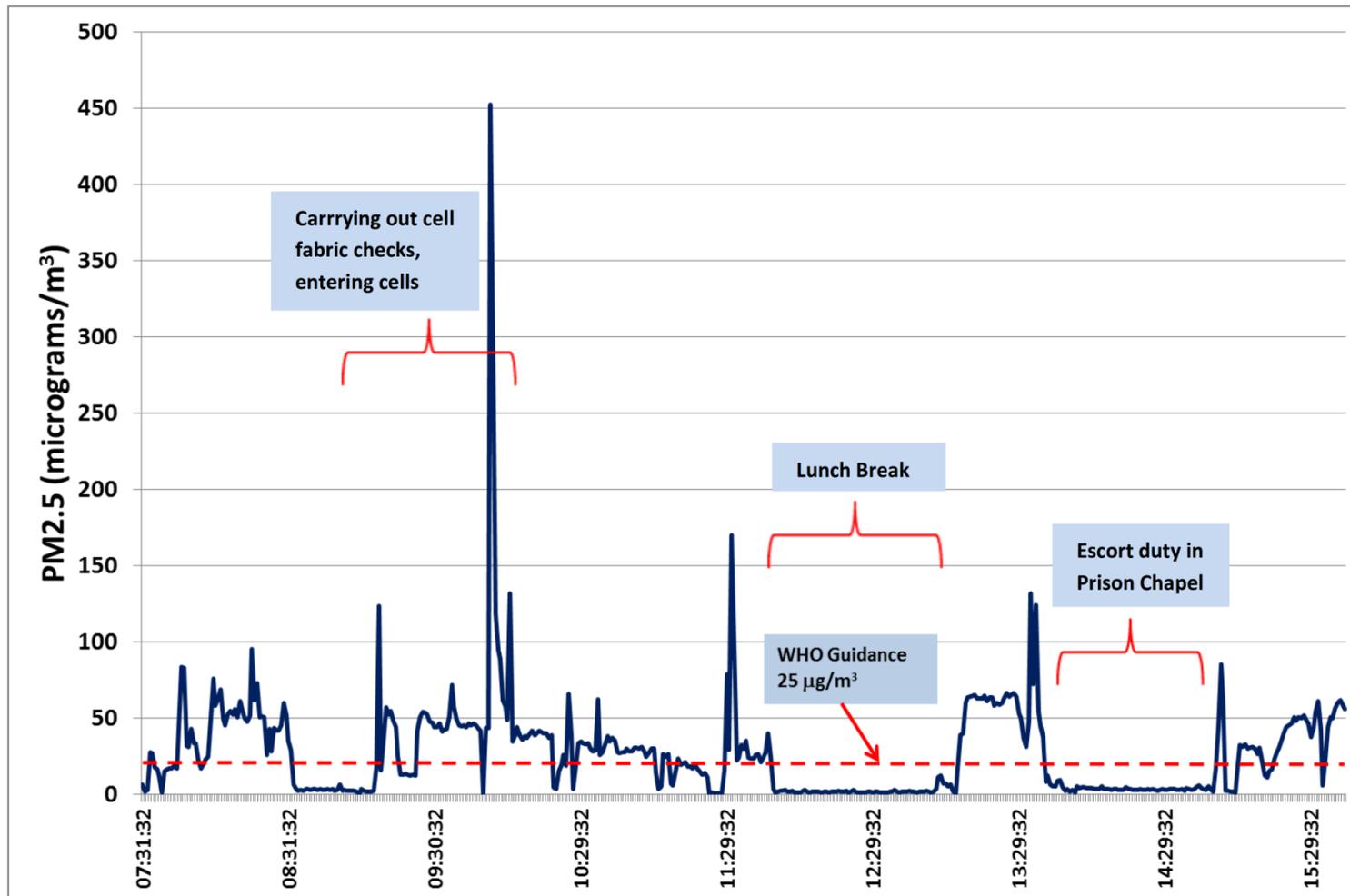


Figure C-12 Personal Cardiff/Sidepak/010 PB 094 Prison Officer

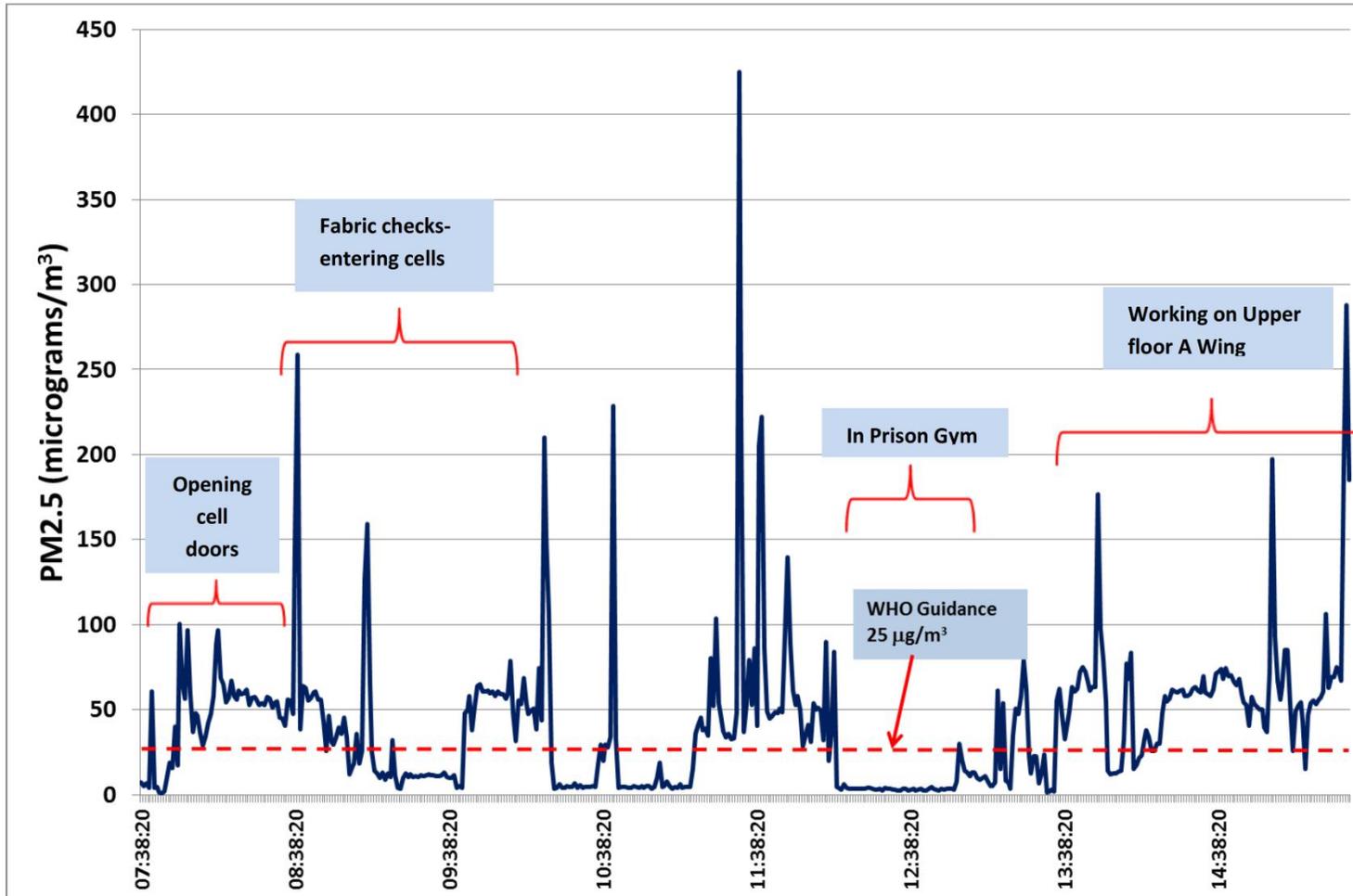


Figure C-13 Personal Cardiff/Sidepak/011 LB112 Prison Officer