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Foreword

In its Publication 65 published in 1993, the International Commission on Radiological Protection (ICRP) recommended the use of a single conversion factor, determined from uranium mining epidemiological studies, as the preferred method converting radon decay product (RDP) inhalation exposure to effective dose. This is the so-called RDP 'conversion convention'. In ICRP Publication 115, published in 2010, the ICRP revised upwards its assessment of risk detriment for inhalation of RDP and indicated its intention to replace the current dose conversion convention with a dose conversion coefficient derived from dosimetric modelling.

There is very little published data on RDP aerosol characteristics in modern uranium mines. Some measurements of this type were carried out at the Olympic Dam uranium mine at Roxby Downs, South Australia in 1992. Given the potential regulatory and operational impacts for assessment of doses from inhaled radon decay products in Australian uranium mines, it was determined that a study of the RDP aerosol characteristics in current Australia mines should be undertaken. This report summarises the measurements conducted at the Olympic Dam uranium mine in December 2013 to characterise the RDP parameters.

Contents

Acknowledgements

The preparation and conduct of the measurements involved a significant commitment of staff time and resources by BHP Billiton, as well as from the South Australian Environment Protection Authority (SA EPA) and ARPANSA. The contributions of the members of the Australian Particle Sizing Group in developing the measurement strategies are acknowledged. In addition, the significant efforts and hard work by Olympic Dam personnel together with SA EPA and ARPANSA staff, together with the work of the consultant (Southern Radiation Services), in undertaking these measurements are acknowledged.

The dosimetric model results (HPA 2012) used in the analysis in this report were kindly provided by Dr James Marsh of the UK Public Health England. The use of these dosimetric model results, together with the fruitful discussion on the ICRP approach to the assessment of doses from exposure to radon progeny is gratefully acknowledged.

Executive summary

The International Commission on Radiological Protection (ICRP) in ICRP Publication 65 (ICRP, 1993) recommended the use of a single conversion factor, determined from uranium mining epidemiological studies, as the preferred method for converting radon decay product inhalation exposure to effective dose. This is the so-called radon decay product 'conversion convention'. In ICRP Publication 115 (ICRP, 2010) the ICRP revised upwards its assessment of risk detriment for inhalation of RDP and indicated its intention to replace the current dose conversion convention with dose conversion coefficients (DCC) or dose conversion factors (DCF) derived from dosimetric modelling.

A key parameter used in the ICRP dosimetric modelling of inhalation of radionuclides is the aerosol size distribution of the RDP, particularly particle sizes in the range 0.6 nm to greater than 1 µm. There is very little published data on radon decay products aerosol characteristics in modern uranium mines. Some measurements of this type were carried out in 1992 at the Olympic Dam mine, currently operated by Broken Hill Proprietary (BHP) at Roxby Downs, South Australia. Given the potential regulatory and operational impacts for assessment of doses from inhaled RDP in Australian uranium mines, it was determined that a study of the RDP aerosol characteristics in current Australia mines should be undertaken.

In early 2013 the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) formed the Australian Particle Sizing Group (PSG) to advise government, regulatory authorities, industry and other stakeholders on the potential impacts of the proposed change to the dose conversion convention. The PSG included members of BHP (then BHP Billiton), Rio Tinto, the South Australian Environmental Protection Agency (SA EPA) and Western Australian Department of Health, Radiation Health Branch. The PSG established a project to conduct a limited set of measurements of the airborne RDP activity size distributions and other associated parameters in operating Australian uranium mines. This report summarises the measurements conducted at the BHP Olympic Dam uranium mine at Roxby Downs, South Australia in December 2013 to characterise the RDP parameters.

The measurement program at the Olympic Dam mine used manual grab sample measurements of the mine atmosphere at 31 representative locations within the mine, including a smaller number of more detailed measurements using an automated multi-stage wire screen diffusion battery at sites with access to power. The equipment required to conduct the measurements was primarily supplied by ARPANSA, the SA EPA, and BHP Billiton. The monitoring itself was conducted by BHP Billiton staff, assisted where possible by other members of the PSG.

The grab sample monitoring results for 24 sites within the Olympic Dam mine indicated a wide range of radon concentrations, Potential Alpha Energy Concentrations (PAEC) and condensation nuclei (CN) concentrations across the mine. The radon levels were in the range 8 to 2640 $Bq.m^{-3}$, PAEC values were in the range 5 to 4580 $nJ.m^{-3}$ and equilibrium ratios in the range 0.03 to 0.86. CN concentrations ranged from < 1000 cm^{-3} to > 100,000 cm^{-3}.

The single wire screen grab sampler had a 50% cut-point of 4nm ('wire screen fraction', f_{ws}). The mean of the fraction collected on the single wire screen across all grab sampling sites was 10.7% with a geometric mean of 5.3%. Further analysis of the results showed that sites with low equilibrium ratios ($F < 0.1$) had wire screen fraction values in the range 14% to 60%. Sites with medium equilibrium ratios ($0.2 < F < 0.7$) had wire screen fractions in the range 2% to 30%, dependent on the particle concentration. The mean value of wire screen fraction for these sites was 3.9% and the geometric mean was 2.7%. Sites with high

equilibrium ratios (F > 0.7) had wire screen fraction values in the range 0.4% to 5%. For those sites with PAEC > 1 $\mu J.m^{-3}$, the average wire screen fraction was ~2%.

For the full set of grab sample measurements there is little evidence of a correlation between wire screen fraction and CN concentration. However if the data for sites with very low equilibrium ratios (< 0.1) and/or low CN concentrations (< 20,000 cm^{-3}) are excluded, then the correlation is improved, with the data fitting a function of the form $f_{ws} \sim 2300 / Z$, where Z is the CN concentration (cm^{-3}).

The ARPANSA multi-screen Continuous Diffusion Battery (CDB) was operated at 8 powered sites in the underground mine. Grab sample measurements of RDP concentrations and PAEC were also carried out at 5 of these sites. The CDB results for wire screen fraction were also variable, but broadly correlated with the values obtained from the grab sample measurements. The range of CDB wire screen fraction values was 1.3% - 28%, with an average of 8.7%.

The CDB activity size distribution measurements at 6 of the 8 powered sites were assessed as having sufficient statistics to provide meaningful results. The two 420 Level Workshop sites had activity size distributions that were bimodal, one with an ultrafine mode and an accumulation mode, the other with a nucleation mode and an accumulation mode. The locations were characterised by low PAEC and low equilibrium factors, consistent with high ventilation rates.

The remaining 4 CDB sites were in locations within the operational portions of the mine, with higher levels of PAEC. Three of these sites had bimodal distributions with nucleation modes with average geometric means in the range 28 nm to 42 nm and accumulation modes with average geometric means in the range 180 nm to 270 nm. The fraction of the nucleation mode varied from 10% to 46% across these three sites. The fourth site, near the Whenan Crusher had a single accumulation mode at 114 nm. In general the ultrafine mode (and the unattached fraction f_p) were close to 0% in all cases except one.

For a restricted set of ventilation and aerosol conditions there was a good correlation between the CN concentration and the wire screen fraction. The predominance of a nucleation mode at many of the sampling locations means that inferring unattached fractions from single screen wire screen fraction results has to be done with some care. For the Olympic Dam mine sites, the fraction collected on a wire screen sampler with a Dp50 of 4 nm is not a good measure of the ultrafine mode (unattached fraction f_p) in the presence of a nucleation mode.

For this study, the dose conversion factors (DCF) (defined as the effective dose per unit intake of ^{222}Rn progeny) as a function of particle size were derived using two separate, but related RDP dosimetric models. The first approach used the computer program RADEP (Birchall and James, 1995), which implements the ICRP66 Human Respiratory Tract Model (HRTM) for exposure to short-lived radon progeny (ICRP66, 1994). The second approach uses dosimetric model results provided by the UK Public Health England, which are based on a modified form of RADEP that implements the revised HRTM with the new reference absorption parameter values for radon progeny (Marsh and Bailey, 2013).

The RDP activity weighted dose conversion factors were calculated from the CDB results using both the RADEP and the HPA2012 derived dose conversion factors, for those measurement results where the distributions were assessed as meaningful.

The derived DCF values from the RADEP dosimetric model were in the range 4100 $mSv/(J.h.m^{-3})$ to 7550 $mSv/(J.h.m^{-3})$ (14.4 mSv/WLM to 24.8 mSv/WLM).

The derived DCF values from the HPA2012 dosimetric model were in the range 3880 mSv/(J.h.m^{-3}) to 7350 mSv/(J.h.m^{-3}) (13.6 mSv/WLM to 23.4 mSv/WLM).

For comparison, the ICRP65 Conversion Convention values is 1425 mSv/(J.h.m^{-3})) or 5 mSv/WLM.

In ICRP Publication 126 (ICRP, 2014), a dose coefficient of 11 mSv/WLM was quoted for exposures in mines using the dosimetric approach, essentially twice the current value of the ICRP 65 dose conversion convention. The ratio of these measurement-derived DCF values to the Reference Mine DCF value are consistent between the two dosimetric approaches and range from 1.3 to 2.4, depending on the work activity and the ventilation conditions.

For the operational areas of the mine the average DCF ratio is about 1.5 relative to the Reference Mine DCF and about 3.3 relative to the ICRP65 Conversion Convention. For work locations with high ventilation and/or low CN concentrations the average DCF ratio was about 2.3 relative to the Reference Mine DCF and about 5, relative to the ICRP65 Conversion Convention.

Over the period July 20 to July 30, 1992, measurements were carried out in the mine at Olympic Dam by the Australian Radiation Laboratory (now ARPANSA). At the time of the original 1992 measurements analysis, the results were interpreted in terms of the 'diesel' and 'non-diesel' areas of the mine. A re-evaluation of the measurement results, undertaken as part of this present work, determined that four of the sites were away from the actual working mine areas. For these sites, the distributions show ultrafine and accumulation modes. The average DCF ratios at these sites was 2.3, comparable to the values measured at the Workshop sites in the present 2013 Olympic Dam mine measurements. The three remaining 1992 sites were close to operating areas of the mine and had the higher PAEC values. The activity size distributions at one of these sites show a nucleation and an accumulation mode. The average DCF ratios at these sites was 1.4, comparable to the values measured at the operational sites in the 2013 Olympic Dam measurements.

The second stage of the diffusion battery consisted of a 2-screen sampler that has a collection efficiency optimised to match the particle size dependence of the DCF, which is calculated from the ICRP 66 Respiratory Tract Model, as implemented in the RADEP computer code. The ratio of the PAEC collected on the second screen, relative to the PAEC on the filter of the first stage with no screens, designated as f_{HE} can be used to provide a measure of the size-weighted dose conversion factor using the methodology in Solomon (1997).

For the present measurements, the 2-screen sampler provided estimates of the RDP DCF values that were in good agreement with the size weighted DCF values based on the measured RDP activity size distributions. While the 2-screen sampler does not provide information on the actual activity size distribution, the 2-screen sampler does provide a good measure of the aerosol size dependency of the DCF values for all of the conditions in the Olympic Dam mine.

1. Introduction

1.1 Inhalation doses from exposure to radon decay products

When radon gas decays, a series of radionuclides are produced and it is inhalation of the short half-life radon decay products (RDP) that are of concern to health. Two of the short-lived radionuclides are ^{218}Po and ^{214}Po, and each emits an alpha particle as they decay. It is the alpha energy delivered by these two radionuclides that produces the relatively high dose to the lung.

Airborne concentrations of RDP can be quantified in terms of the potential alpha energy concentration (PAEC), measured in terms of J.m^{-3}. Exposure to RDP is measured in terms of the product of PAEC, the breathing rate and the exposure time. A historical unit still used in some countries, is the Working Level Month (WLM). Both units will be used in this report to enable comparisons with other studies (1 WLM = 3.54 mJ.h.m^{-3}).

The decay of radon produces charged ions (initially ^{218}Po), which combine rapidly ($time_{1/2}$ < 1 s) with gases and vapours by cluster formation to form particles of a few nanometres (nm) in size. These particles exhibiting relatively large diffusion velocities, form the so-called 'unattached faction'. As these particles continue to combine with other aerosol particles ($time_{1/2}$ ~1-100s), such as sub-micron aerosol particles, particularly diesel fume in mines, the RDP are said to have become 'attached'. The attached particles have larger sizes, with lower diffusion velocities. As the attached ^{218}Po decays to the other radionuclides in the Uranium decay chain (^{214}Pb, ^{214}Bi, ^{214}Po), they generally remain attached. The unattached fraction f_p is the fraction of RDP that is not attached to aerosol particles.

The International Commission on Radiological Protection (ICRP) In ICRP Publication 65 (ICRP, 1993) recommended the use of the 'conversion convention' (1425 mSv/(J.h.m^{-3}) or 5 mSv/WLM), determined from uranium mining epidemiological studies, as the preferred method for converting radon progeny exposure to effective dose. In ICRP Publication 115 (ICRP, 2010) the ICRP revised upwards its assessment of risk detriment for inhalation of RDP and indicated its intention to replace the current dose conversion convention with a dose conversion coefficient derived from dosimetric modelling that takes account of the ICRP respiratory tract model in ICRP Publication 66 (ICRP, 1994).

A key parameter used in the ICRP dosimetric modelling of inhalation of radon progeny is the aerosol size distribution of the radon decay products, particularly particle sizes in the range 0.6 nm to greater than 1 µm. Aerosol sizing systems, such as wire screen diffusion batteries, measure the Activity Median Thermodynamic Diameter (AMTD). (Compared with inertial impactors, which measure the Activity Median Aerodynamic Diameter (AMAD)). The modes in size distributions are typically fitted by log-normal functions, described in terms of their geometric means and geometric standard deviation. These modes include:

- an ultrafine mode with AMTD typically <2nm
- a cluster mode with AMTD in range 2–10 nm
- a nucleation mode with AMTD typically 10–100 nm
- an accumulation mode AMTD typically 100–400 nm
- a coarse mode with an AMAD >1000 nm.

The portion of the distribution in the ultrafine and cluster modes are usually termed ‘unattached’, while the remaining modes are termed ‘attached’.

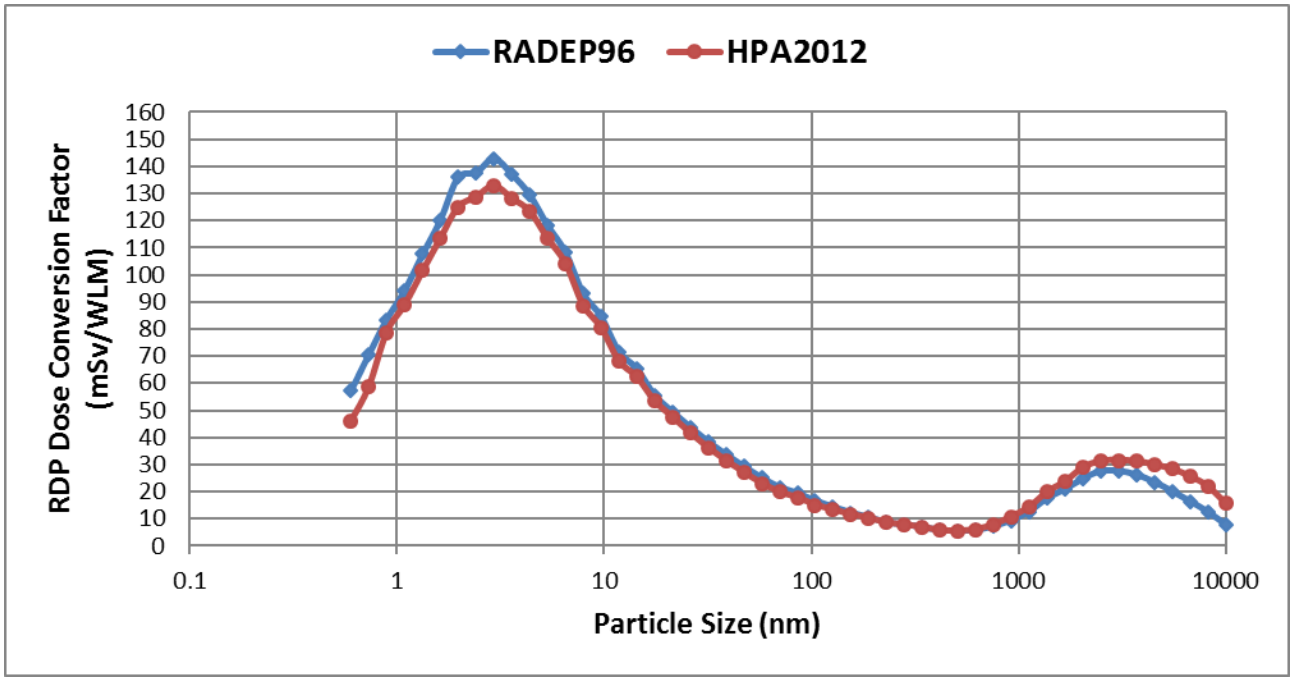
1.2 Radon decay product dosimetric models

At the time of the preparation of this present work, the ICRP had not published the results for its own radon progeny dosimetric modelling. For this study, the effective dose per unit intake of ^{222}Rn progeny as a function of particle size were derived using two separate, but related RDP dosimetric models. The first approach used the computer program RADEP (Birchall and James, 1995), which implements the ICRP Publication 66 Human Respiratory Tract Model (HRTM) for exposure to short-lived radon progeny (ICRP, 1994). The second approach uses dosimetric model results provided by the UK Public Health England, which are based on a modified form of RADEP that implements the revised HRTM with the new reference absorption parameter values for radon progeny (Marsh and Bailey, 2013).

Figure 1.1 shows the response functions for the dose conversion factor (DCF) for RADEP (labelled RADEP96) and for the Public Health England model (labelled HPA2012). The curves show the effective dose per working level month (WLM) as a function of particle size of a monodispersed aerosol for a reference worker with an average breathing rate of 1.2 m^3 h^{-1} following exposure to radon progeny. Unit density and unit shape factor were assumed and hygroscopic growth was not taken into account.

In January 2018 ICRP Publication 137, Occupational Intakes of Radionuclides Part 3 (ICRP, 2017) was published. The Public Health England dosimetric model is identical the radon progeny dosimetric model used in ICRP Publication 137 and the curve matches that shown in Figure A.5 (ICRP, 2017).

Figure 1.1 Dose conversion factor (DCF) as a function of particle size for RADEP96 and HPA2012 models



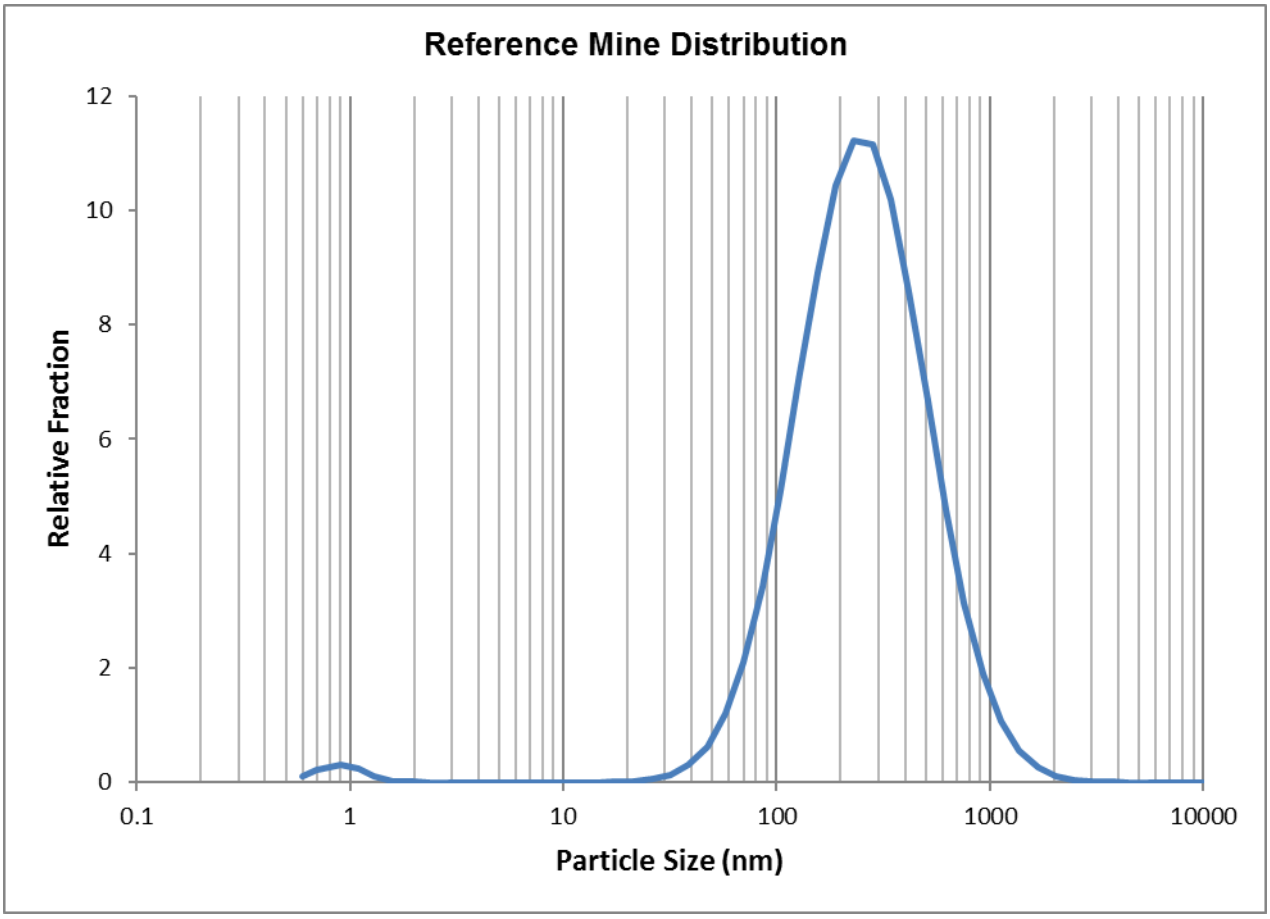
The results from these dosimetric models demonstrate the strong size dependence of the dose per unit exposure. The DCF values for ultrafine (unattached) radon progeny with activity diameters ~1 to 3 nm, are up to 20 times higher than for attached radon progeny, with diameters in the range 100 to 300 nm. This is mainly due to the size of the particle affecting the site of deposition in the respiratory tract, and the different radiological sensitivities of tissues at different parts of the respiratory tract. The reduction in the

DCF values below 4 nm is mostly due to the deposition of the nanometre sized particles in the nasal passages.

1.3 Reference Uranium Mine Conditions

The ICRP Conversion Convention (ICRP, 1993) was based partly on the data from the uranium miner epidemiological studies of the 1970's. Previous studies (BEIR VI, 1999) have defined so-called 'Reference Mine' conditions, based on the published data from a limited number of size distribution measurements in uranium mines from this period. The 'Reference Mine' conditions are taken to be a 1% ultrafine mode at 0.9 nm and geometric standard deviation (GSD) of 1.3, and a 99% accumulation mode with an AMTD of 250 nm and GSD of 2.0. This Reference Mine size distribution is shown in Figure 1.2.

Figure 1.2 Reference Mine size distribution



1.4 The Australia RDP Particle Sizing Project

The derivation of RDP DCF values based on the dosimetric approach is dependent on the use of representative RDP activity size distributions. There are very few studies of the representative RDP particle size distributions in modern operating mines. ARPANSA made measurements at the Olympic Dam uranium mine in South Australia in the early 1990's (Solomon, 1993) and there is some published data for mines overseas. However, it is possible that more modern mining methods and improvements in underground ventilation may have changed the aerosol characteristics.

In early 2013 ARPANSA formed the Australian Particle Sizing Group (PSG) to advise government, regulatory authorities, industry and other stakeholders, on the radiation protection implications from the proposed

ICRP changes in RDP dose conversion factors. The PSG was coordinated by Stephen Solomon (ARPANSA), and consisted of Paul Martin (ARPANSA), Ches Mason (BHP Billiton), Frank Harris (RioTinto), Duncan Surin (WA Health), and Artem Borysenko (EPA SA).

The PSG had two main aims:

- To develop a programme for the measurement of RDP in operating Australian uranium mines that might inform the future monitoring and control of radon progeny. These measurements include the assessment of representative values for parameters such as the potential alpha energy concentration, unattached fraction, equilibrium ratio, aerosol concentration, temperature, humidity, pressure. This project is referred to as the 'RDP Particle Sizing Project'.
- To advise on a coordinated approach to the regulation of radon progeny exposures and its monitoring in mining in Australia, taking into account the ICRP recommendations on conversion factors for RDP.

In 2013 the PSG commenced the RDP Particle Sizing Project to conduct a limited set of measurements of the airborne RDP activity size distributions and other associated parameters in operating Australian uranium mines. Measurements were conducted at the BHP Olympic Dam uranium mine at Roxby Downs, South Australia in December 2013 to characterise the radon decay products parameters. The detailed measurement results are reported in the BHP Billiton report Measurements of Radon Progeny Particle Size and Unattached Fraction in the Underground Uranium Mine at Olympic Dam (BHP-Billiton, 2014).

This ARPANSA report details an assessment of radon progeny dose conversion factors based on the December 2013 measurement results at the Olympic Dam mine.

1.5 Measurements at the BHP Olympic Dam uranium mine

Measurements of RDP particle size distributions and other parameters were carried out at the BHP Olympic Dam uranium mine at Roxby Downs, South Australia over the period 2 December to 12 December 2013.

Undertaking particle sizing and unattached fraction measurements in a working underground mine is technically difficult. There is little commercially available equipment for assessing submicron activity size distributions of radon progeny in mine air. ARPANSA provided specialised equipment for making measurements of unattached fraction, RDP activity size distributions, and radon and RDP concentration, together with optical particle counters. In particular, ARPANSA has refurbished some of its original equipment used in the 1990's survey at Olympic Dam.

The logistical support for the investigation was provided by the Olympic Dam Radiation and Occupational Hygiene team who also provided most of the human resources for making the measurements. In addition, BHP Billiton engaged a consultant (Andrew Johnston, Southern Radiation Services) to provide a project management role, and to assist in data acquisition, analysis, and reporting of the results. The SA EPA Radiation Protection Branch provided staff and calibration support, and additional monitoring equipment, and assisted with underground measurements.

2. Methods

2.1 Outline of the Olympic Dam measurement program

The primary objectives of the Olympic Dam measurement program were to:

- determine radon decay products activity size distributions and principal modes in representative locations within the Olympic Dam underground mine at Roxby Downs, South Australia
- determine the RDP unattached fraction of PAEC (f_p) at representative locations in the mine air, together with the concentration of aerosol particles and other parameters to evaluate the correlation, if any, between unattached fraction and mine conditions.

This current report aims to estimate site specific RDP dose conversion factors for the Olympic Dam underground mine based on the measured activity size distributions and the dosimetric models. The measurements at a range of representative underground sites at the Olympic Dam mine in December 2013 used short duration 'grab sample' measurements, made using filter and wire screen collectors. The collected alpha particle activity was analysed using the modified-Tsivoglou method (Thomas, 1970) to assess PAEC and where possible the wire screen fraction (f_{ws}). Longer duration air sampling using the ARPANSA Continuous Diffusion Battery (CDB) (see Appendix 1) was conducted at a smaller number of mains powered sites to measure PAEC, f_{ws}, f_p and AMTD.

Additional measurements were conducted at each site to determine other factors that may influence, the PAEC, f_p, and AMTD, including the concentration of aerosol particles (CN), the equilibrium factor (F), air temperature, humidity, and ventilation rate. The measurements were carried out for a representative set of underground workplace environments in the Olympic Dam mine over a two week period at the end of 2013. The details are provided in the BHP Billiton Report *Measurements of radon progeny particle size and unattached fraction in the underground Uranium Mine at Olympic Dam* (BHP-Billiton, 2014).

2.2 Description of Measurements

2.2.1 Single screen determination of PAEC and unattached fraction.

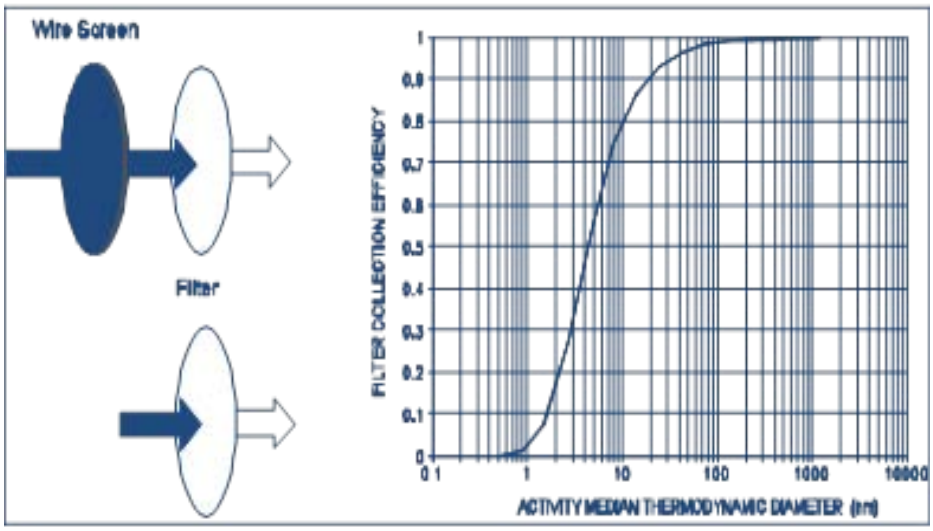
A total of 36 grab sample measurements were conducted at 31 sites using both an open face sampler and a single wire screen sampler, with the alpha activity analysed using the modified Tsivoglou method (Thomas, 1970) to determine total PAEC for each sample and the wire screen fraction of PAEC. The single screen sampler contained a single 105 mesh wire screen with a backing filter. The wire screen has a higher efficiency for collecting the unattached particles than for the attached RDP and the resultant $PAEC_{WS}$ is principally due to the unattached RDP. The second filter holder had an open face filter which collected both the attached and unattached components ($PAEC_F$). The screen parameters and sampling rates were selected to produce a 50% cut-point for the mesh screen of 4 nm as shown in Figure 2.1.

A fraction of the unattached RDP also attaches to the rear of the mesh. Based on the work of Solomon and Ren (1992) the fraction of RDP collected on the rear of the mesh screen was estimated to be 33%. The fraction collected by the single screen system, f_{ws} were estimated by the equation;

$$f_{ws} = \frac{1.5 \times PAEC_{WS}}{PAEC_F}$$

For RDP with an ultrafine mode at ~1 nm and no nucleation mode, then $f_p \sim f_{ws}$.

Figure 2.1 Single Screen Sampler configuration and wire screen penetration



2.2.2 Continuous Diffusion Battery assessment of PAEC, f_p and AMTD

2.2.2.1 Measurement of RDP Size Distribution

The potential alpha energy concentration (PAEC), the unattached fraction of PAEC (f_p) and the PAEC activity size distributions were measured using a five-stage wire screen diffusion battery and single stage impactor. The ARPANSA Continuous Diffusion Battery (CDB) shown in Figure 2.2 was used at a series of powered sites in the mine to determine values of PAEC, f_p and AMTD at 60 minute intervals. The diffusion battery parameters are summarised in Table 2.1 and the stage configuration and the calculated stage collection efficiencies are shown in Fig. 2.3.

Figure 2.2 ARPANSA 6-Stage Continuous Diffusion Battery (ORANGEDB)

The diffusion battery used in-situ counting of alpha particles from the radon progeny activity deposited on the collector (filter or screen) in each stage. The mode of operation of the diffusion battery has been

described previously (Solomon et. al., 1994). The collection efficiencies for each stage were calculated using the fan filtration penetration theory applied to wire screens (Cheng and Yeh, 1980, Cheng et al., 1980), with a semi empirical diffusion coefficient equation in the molecular cluster size range (Ramamurthi and Hopke, 1989). The activity collected on the wire screen collector were corrected for alpha particle losses in the screens and for the fraction of activity on the front of the screen (front to total ratio) using the functions in Solomon and Ren (1992).

Continuous in-situ alpha counting was conducted on the open face filter and the filter behind each set of wire screens and on the impactor stage. The collection and analysis of the diffusion battery data were carried out automatically using a purpose-written computer program running on a portable computer. For each 60 minute integration period, the set of six alpha activities were converted to PAEC and deconvoluted using both the Twomey (Twomey, 1975) and the Expectation Maximisation algorithms (Maher and Laird, 1985) to derive two independent particle sizes for each sample. The measured radon progeny size distributions were combined with the particle size dependent DCF values, calculated from the RADEP & HPA2012 dosimetric model, to derive size-weighted dose conversion factors. Further details on the basis for the analysis is provided in Appendix 1.

The second stage of the diffusion battery consists of a 2-screen sampler that has a collection efficiency optimised to match the particle size dependence of the DCF, which is calculated from the ICRP Publication 66 Respiratory Tract Model (ICRP, 1994) as implemented in the RADEP computer code. The ratio of the PAEC collected on the second screen relative to the PAEC on the filter of the first stage with no screens, designated as f_{HE} can be used to provide a measure of the size-weighted dose conversion factor using the methodology in Solomon (1997).

Table 2.1 The ARPANSA CDB parameters

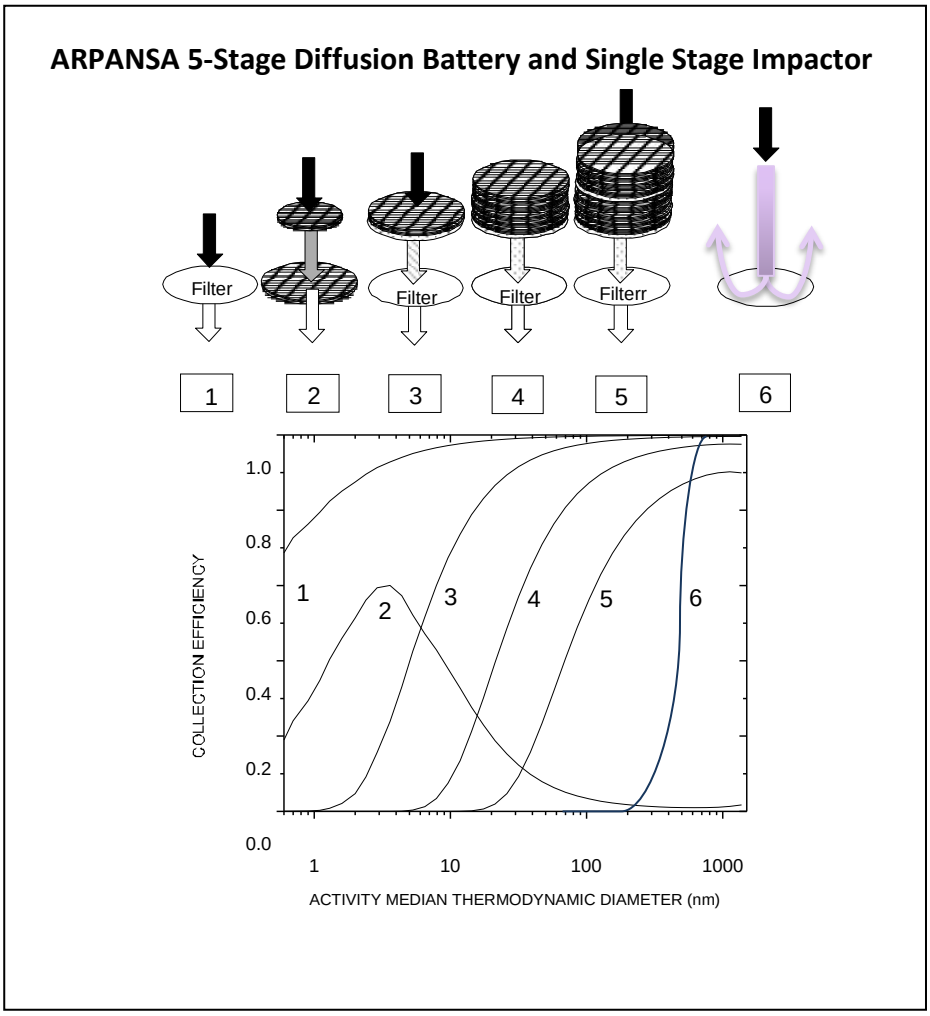
Stage	No/screens	Mesh (note 1)	Screen Diam. (cm)	Flow (lpm)	Effic.	Dp50 (nm)
1	0	Filter	3.8	0.8	0.127	0
2	2	100	0.7	0.8	0.108	(note 2)
3	1	100	3.8	0.8	0.13	4.0
4	10	100	3.8	0.8	0.13	
5	80	100	3.8	0.8	0.13	
6	0	(note 3)	-	0.7	0.22	500

Note 1: 100 Mesh wire screen, Wire Diameter 112 µm, Screen Thickness 215 µm, Solid Fraction 31.3%

Note 2 Stage 2-screen sampler (Solomon, 1997).

Note 3: Stage 6 is a single stage inertial impactor designed with a 50% efficiency collection of 500nm (AMAD).

Figure 2.3 ARPANSA 5 stage wire screen diffusion battery and single stage impactor (see Appendix 1)



2.3 Site Selection

A total of 31 sites were selected for inclusion in the monitoring program. The Continuous Diffusion Battery (CDB) was operated at 8 sites for periods of up to 24 hours. The CDB monitoring sites were chosen on the basis that they were representative of the range of working atmospheres underground, had power available, and equipment could be left unattended in safety over a 24-hour measurement cycle. These sites were not always occupied at the time of monitoring. Modified Tsivoglou analysis (Thomas, 1970) of the alpha activity from grab sample measurements were conducted at 6 of these CDB measurement sites and at 24 other sites. Modified Tsivoglou site selection allowed for a little more flexibility as the measurement cycle could be relatively short (~3 hours/site).

3. Grab Sampling Measurement Results

3.1 Modified Tsivoglou PDP Measurements

RDP grab samples were collected at 30 of the 31 measurement sites, and the alpha activities on the filter and wire screen analysed using the modified-Tsivoglou method (Thomas, 1970) to assess the individual RDP concentrations, the PAEC and the wire screen fraction of PAEC, for each site. A total of 26 RDP grab samples from 24 sites were considered to be technically valid measurements and to have sufficient sensitivity for inclusion in this study. The results for measured PAEC, radon concentration, collected fraction on wire screen (f_{ws}), equilibrium factor (F) and particle concentration (CN) for the 26 valid grab samples are summarised in Table 3.1, together with the estimated standard deviation (1 SD). The PAEC values were in the range 5 to 4600 $nJ.m^{-3}$, radon levels 8 to 2600 $Bq.m^{-3}$ and equilibrium ratio in the range 0.03 to 0.86. The results for single wire screen fraction of PAEC ranged from 0.4% to 60%. (The f_{ws} value of 150% at location #26 was excluded from the analysis because of poor measurement statistics at the very low PAEC).

Table 3.1 Summary of modified Tsivoglou results

ID	Location	PAEC	1SD	Radon	1SD	f_{ws}	1SD	F	1SD	CN	1 SD
		$nJ.m^{-3}$		$Bq.m^{-3}$		%				cm^{-3}	
8	39 Blue 102	2 800	50	1 500	200	3.4	0.3	0.32	0.05	71 000	6 000
9	420 Auto Workshop	33	7	53	12	60	21	0.11	0.05	17 000	3 000
10	32 Purple 253	360	17	290	100	9.1	1.8	0.22	0.08	23 000	7 000
11	45 Olive 103	1 600	40	470	100	0.4	0.2	0.60	0.10	310 000	18 000
12	52 Purple 245	4 600	70	2 600	140	2.0	0.2	0.31	0.03	120 000	4 000
13	39 DCI Ore Pass	54	6	160	50	23	9	0.06	0.03	63 000	17 000
14	39Blue7 Access 1Dec	47	6	100	20	17	7	0.09	0.03	72 000	32 000
14	39Blue7 Access 2Dec	30	5	100	25	32	14	0.05	0.03	75 000	21 000
15	Whenan Crusher	560	25	290	70	5.7	1.0	0.35	0.10	63 000	16 000
16	420 Tyre Bay	180	12	140	50	1.8	1.8	0.21	0.09	91 000	35 000
17	52 Amber 305_1	780	30	220	50	5.0	0.9	0.63	0.16	39 000	27 000
17	52 Amber 305_2	860	30	370	120	3.1	0.7	0.42	0.10	62 000	31 000
18	45 Jade 325	860	30	180	100	0.5	0.3	0.86	0.50	85 000	28 000
19	37 Jade 117	670	25	400	130	2.1	0.5	0.30	0.10	210 000	49 000
20	27 Amber 385	2 000	50	830	150	2.4	0.3	0.44	0.10	69 000	46 000
21	65 Rail Workshop	120	10	60	30	12	4	0.34	0.18	20 000	3 000

ID	Location	PAEC	1SD	Radon	1SD	f_{ws}	1SD	F	1SD	CN	1 SD
22	58LG64 Decline	670	30	200	120	4.3	0.9	0.59	0.30	58 000	5 000
23	52 Cyan 114	830	30	340	150	2.0	0.5	0.44	0.22	160 000	12 000
24	52F2 Ore Pass	120	10	70	30	6.7	3.5	0.30	0.17	280 000	39 000
25	32RB5	14	4	8	4	15	18	0.30	0.23	500	45
26	54LK 57	5	2	30	16			0.03	0.03	1 100	360
27	54 Workshop	37	6	30	20	33	13	0.22	0.20	8 400	2 600
28	36 Yellow 419	1 700	40	670	150	1.4	0.3	0.44	0.11	220 000	34 000
29	39 Workshop	84	9	230	70	14	5	0.07	0.03	40 000	6 000
30	68 Transfer	280	15	280	90	2.4	1.2	0.18	0.08	14 000	2 000
31	65LK 62	210	14	1 200	60	10	3	0.19	0.07	14 000	2 000

4. Diffusion Battery Results

4.1 Measurement Locations and Sampling Dates

The ARPANSA Continuous Diffusion Battery (CDB) was operated at 8 powered sites in the underground mine during the period from 2 to 12 December 2013. These locations are listed in Table 4.1. Valid modified Tsivoglou grab sample measurements of PAEC were also carried out at 5 of these sites and form part of the data set described in Section 3.1 above. In addition, continuous Radon, PAEC, CN, humidity and temperature measurements were made during the measurement period. Figure 4.1 shows the ARPANSA DB operating at the 49MB52 Exploration Drive sampling site.

Table 4.1 Diffusion Battery Locations

Location ID No	Location Name	Sample Date
1	420 Drill Maintenance Workshop	02/12/13
5	49 MB52 Exploration Drive	03/12/13
9	420 Auto Workshop	04/12/13
8	39 Blue 102	06/12/13
15	Whenan Crusher	09/12/13
21	65 Rail Workshop	10/12/13
25	32RB5	11/12/13
28	36 Yellow 419	12/12/13

Figure 4.1 Diffusion Battery operating at 49MB52 Exploration Drive

4.2 Activity Size Distribution Measurement Results

The detailed CDB results for activity size distributions are provided in Section 4.2.1 to 4.2.8 and average results are summarised in Table 4.2. The f_p value was determined from the fraction in the ultrafine mode of each size distribution. The f_{HE} value is the fraction on the second stage of the CDB system.

The average results for site #25 (32RB5) and site 21 (65 Rail Workshop) are not reported in the Table 4.2 summary because it was assessed that the stage activities were too low to provide a meaningful result from the deconvolution procedure. The RDP PAEC at the 32RB5 site was very low (12 $nJ.m^{-3}$), as was the CN concentration (~1300 cm^{-3}) indicating clean, fresh air. Measured activity size distributions at the 65 Rail Workshop site were very variable with modes changing significantly each hour. The average CN concentration at this site was ~16 600 cm^{-3} and the PAEC was low during the sample period (85 $nJ.m^{-3}$).

Table 4.2 Site Averages

ID	Location	PAEC		Radon	f_{HE}(%)	f_p(%)	f_{ws} (%)	CN
		$nJ.m^{-3}$	mWL	$Bq.m^{-3}$	DB	DB	DB	cm^{-3}
1	420 Drill Workshop	134	6.5		6.4	0.8	3.7	14 417
5	49MB52 Exploration	1 349	64.8		2.9	0	1.3	74 420
9	420 Auto Workshop	53	2.5	160	8.5	28	28.1	34 326
8	39Blue 102	2 286	110	844	4.6	0	1.8	69 000
15	Whenan Crusher	539	26	287	3.1	0	1.3	70 876
28	36Yellow419	534	26	175	5.6	0	1.7	145 075

Therefore, of the 8 CDB measurements sites, only 6 had activity levels with sufficient stability and adequate counting statistics to ensure meaningful results for the deconvolution analysis. Each of the measured activity size distributions was fitted by multiple log-normal distributions. As shown in Table 4.3, most of the distributions were bi-modal, however the size of the lower mode was found to be dependent on the type of work activity at the sampling site.

Table 4.3 summarises the results of fitting multiple log-normal distributions to each of the modes in the activity size distribution measurements at the eight sites. For the two 420 level workshop sites the distributions were bimodal, one with an ultrafine mode and an accumulation mode, the other with a nucleation and an accumulation mode. The locations were characterised by low PAEC and low equilibrium factors (high ventilation rates). The remaining four sites were in locations within the operational portions of the mine, with higher levels of PAEC. Three of these sites had bimodal distributions with nucleation modes with average geometric means in the range 28 nm to 42 nm and accumulation modes with average geometric means in the range 180 nm to 270 nm. The fraction of the nucleation mode varied from 10% to 46% across these three sites. The fourth site, near the Whenan Crusher had a single accumulation mode at 114 nm.

One site (#15) had a single mode with an average geometric mean (GM) of 114nm and a geometric standard deviation of 1.6. One site (#9) was bimodal with a 28% ultrafine mode (unattached fraction, f_p)

with an average GM of 0.6 nm (GSD = 1.1) and a 72% accumulation mode of 159 nm (GSD = 2.0). The remaining four sites had bimodal distributions with nucleation modes with average GM in the range 28 nm to 42 nm and accumulation modes with average GM in the range 180 nm to 270 nm. The fraction of the nucleation mode varied from 10% to 46% across these four sites. Reference Mine values are shown for comparison.

Table 4.3 Site average for modes in activity size distribution, by sites

ID	Location	GM_u	GSD_u	$Percent_u$	GM_a	GSD_a	$Percent_a$	Modes
		nm		%	nm		%	
	Reference Mine	0.9	1.3	1.0	250	2.0	99	U, A
1	420 Drill Workshop	28	1.2	46	267	1.3	53	N, A
5	49MB52 Exploration	27	1.2	10	186	1.2	90	N, A
9	420 Auto Workshop	0.6	1.1	28	159	2.0	72	U, A
8	39Blue 102	42	1.4	33	182	1.4	67	N, A
15	Whenan Crusher	-	-	-	114	1.6	100	A
28	36Yellow419	38	1.4	32	179	1.7	68	N, A
Note: U = Ultrafine Mode, N = Nucleation Mode, A = Accumulation Mode								

4.2.1 Location ID 1: 420 Drill Maintenance Workshop

This sample site was located in a drill maintenance workshop in a high traffic area, approximately 10 metres from the work area. This was a well-ventilated area with good airflow, cool conditions, with up to 8 personnel present at any one time.

The measured sample results are summarised in Table 4.4 and the size distributions are shown in Figure 4.2. The average PAEC at this site was ~134 nJ.m^{-3} (6.5 mWL). Prominent nucleation (GM_N = 27.6 nm) and accumulation (GM_A = 267 nm) modes were observed at this location. The presence of a minor ultrafine contribution is suggested in one measurement. The average CN concentration was 14,400 cm^{-3}. The conditions are consistent with very low CN and PAEC, indicating fresh air with limited ingrowth of radon progeny.

Figure 4.2 Activity size distributions for RDP at 420 Drill Maintenance Workshop site.

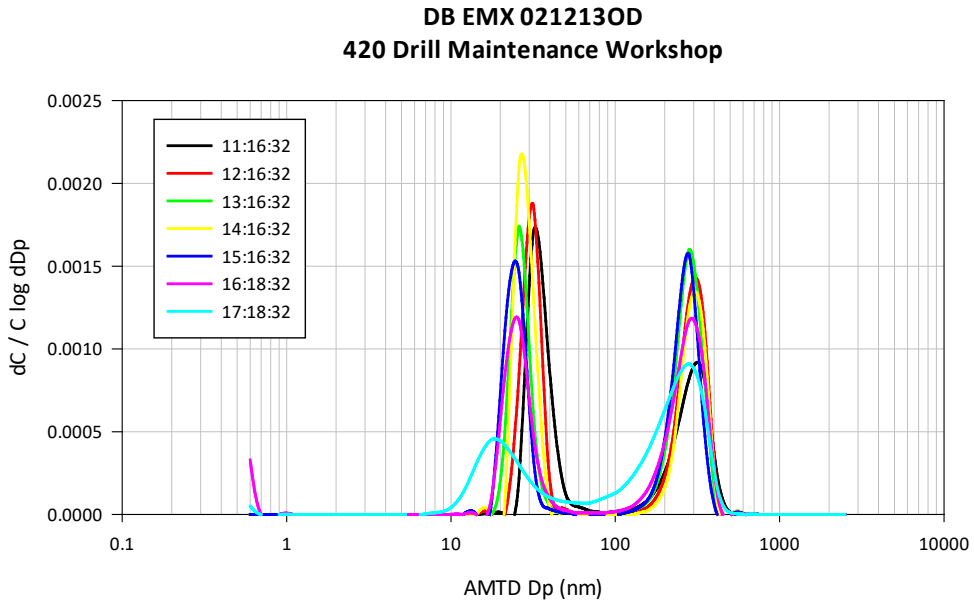


Table 4.4 Location Averages 420 Drill Maintenance Workshop

Time	Date	PAEC		f_{HE}	GM_n	GSD_n	$Pcnt_u$	GM_a	GSD_a	$Pcnt_a$
		nJ.m^{-3}	mWL	%	nm		%	nm		%
11:16:32	12/02/2013	122	5.9	5.0	35	1.2	55	279	1.32	45
12:16:32	12/02/2013	140	6.7	4.5	31	1.1	48	288	1.22	52
13:16:32	12/02/2013	132	6.4	7.0	27	1.2	44	271	1.23	56
14:16:32	12/02/2013	144	6.9	5.7	28	1.1	55	290	1.2	45
15:16:32	12/02/2013	136	6.5	7.4	25	1.2	46	260	1.22	54
16:18:32	12/02/2013	139	6.7	7.4	26	1.2	42	263	1.32	53
17:18:32	12/02/2013	128	6.1	8.1	21	1.5	33	218	1.54	66
	Mean	**134**	**6.5**	**6.4**	**28**	**1.2**	**46**	**267**	**1.3**	**53**
	1 SD	8	0.4	1.4	4	0.1	7	24	0.1	7

4.2.2 Location ID 5: 49MB52 Exploration Drill

This sampling site was near a single vent bag outlet with a vent raise nearby. The conditions were hot and stuffy with low airflow across the sampling site. A two person exploration drill crew was present with apparently low velocity air flow across the site from an overhead vent bag. There was no diesel equipment in the vicinity other than occasional light vehicle movements.

The measured sample results are summarised in Table 4.5 and the size distributions are shown in Figure 4.3. The average PAEC at this site was ~1350 nJ.m^{-3} (65 mWL). The CDB results for this site show a nucleation mode (GM_N = 28 nm) and a more prominent accumulation mode (GM_A = 187 nm) at this location. The average CN concentration during the sampling period was ~74,000 cm^{-3} with the data suggesting an intermittent CN generating process at this site.

Figure 4.3 Activity size distributions for RDP at 49MB52 Exploration Drill site.

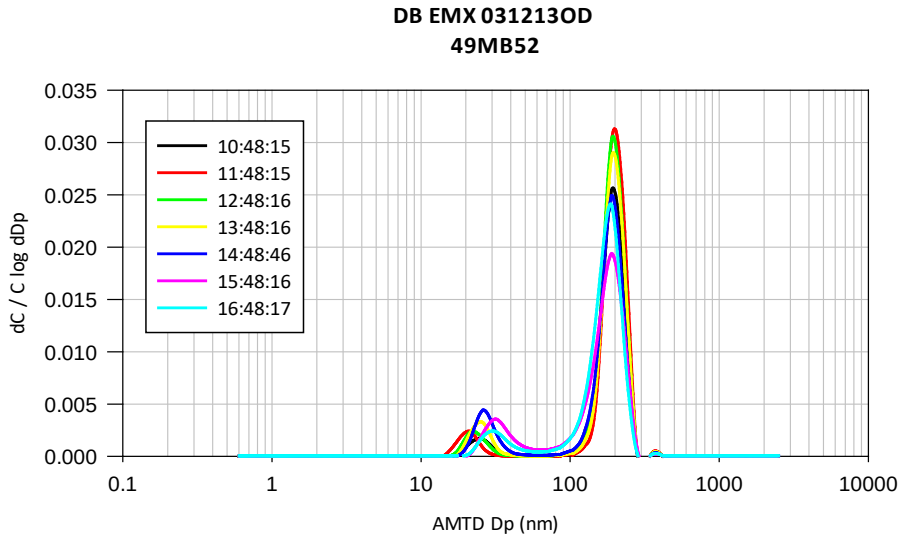


Table 4.5 Location Averages 49MB52 Exploration Drill

Time	Date	PAEC		$\%f_{HE}$	GM_n	GSD_n	$Pcnt_n$	GM_a	GSD_a	$Pcnt_a$
		nJ.m^{-3}	mWL		nm		%	nm		%
10:48:15	3/12/2013	1228	59.05	2.6	26	1.2	7	189	1.2	93
11:48:15	3/12/2013	1384	66.52	3.2	21	1.2	7	197	1.2	93
12:48:16	3/12/2013	1425	68.5	2.9	24	1.2	7	191	1.2	93
13:48:16	3/12/2013	1375	66.09	2.9	25	1.2	10	192	1.2	90
14:48:16	3/12/2013	1314	63.16	3.1	27	1.2	14	185	1.2	86
15:48:16	3/12/2013	1311	63.01	3.0	35	1.3	16	174	1.3	84
16:48:17	3/12/2013	1404	67.5	2.7	33	1.3	10	171	1.3	90
	Mean	**1349**	**65**	**2.9**	**27**	**1.2**	**10**	**186**	**1.2**	**90**
	1 SD	68	3	0.2	5	0.1	4	10	0.1	4

4.2.3 Location ID 9: 420 Auto Workshop

This sampling location was used for heavy vehicle maintenance – trucks, loaders, etc. The number of personnel at the site is variable, with up to five people within close proximity of sampling site at any one time. The 420 platform area is a fresh air base, with good strong ventilation coming from the drive and workshop area. The sampling site was very close to the vehicles being maintained

The measured sample results are summarised in Table 4.6 and the size distributions are shown in Figure 4.4. The PAEC at this site was very low, ~53 nJ.m^{-3} (2.5 mWL). Prominent ultrafine mode (GM_U = 0.6 nm) and an accumulation mode (GM_A = 159 nm) were observed, with a slight suggestion of particles in the coarse region. The average CN concentration during the sampling period was ~34,000 cm^{-3}.

Figure 4.4 Activity size distributions for RDP at 420 Auto Workshop site.

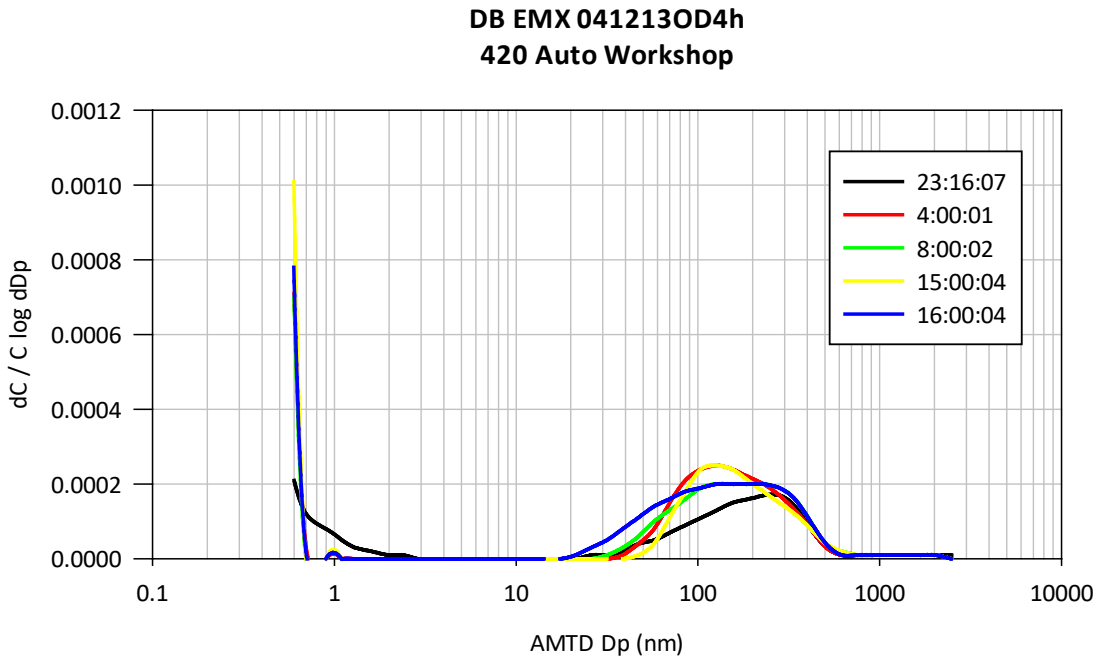


Table 4.6 Location Averages 420 Auto Workshop

Time	Date	PAEC		f_{HE}	GM_u	GSD_u	$Pcnt_u$	GM_a	GSD_a	$Pcnt_a$
		nJ.m^{-3}	mWL	%	nm		%	nm		%
23:16:07	4/12/2013	39	1.9	10.1	0.8	1.5	26	166	2.0	72
4:00:01	5/12/2013	55	2.7	7.7	0.6	1.0	26	157	1.9	74
8:00:02	5/12/2013	54	2.6	7.3	0.6	1.0	26	163	2.1	75
15:00:04	5/12/2013	55	2.7	8.9	0.6	1.0	35	169	1.9	65
16:00:04	5/12/2013	60	2.9	8.3	0.6	1.0	26	140	2.3	74
23:16:07	4/12/2013	39	1.9	10.1	0.8	1.5	26	166	2.0	72
	Mean	**53**	**2.5**	**8.5**	**0.6**	**1.1**	**28**	**159**	**2.0**	**72**
	1 SD	7.9	0.4	1.1	0.1	0.2	4	12	0.1	4

4.2.4 Location ID 8: 39Blue102

This sampling location is a raise drilling–backreaming site with one drill operator. The sampling site was located before the end of ventilation bag, but airflow was still strong and cool. The drill operator was inside a filtered air cabin for large portion of the shift. The drill was running in automatic with the operator hosing the ground during sampling. The average CN concentration at this site was 69,000 cm^{-3}.

The measured sample results are summarised in Table 4.7 the size distributions are shown in Figure 4.5. The average PAEC at this location was ~2290 $nJ.m^{-3}$ (110 mWL). At this location the CDB results show a partly resolved nucleation mode at GM_N = 42 nm and a more prominent accumulation mode at GM_A = 182 nm.

Figure 4.5 Activity size distributions for RDP at 39Blue102 site.

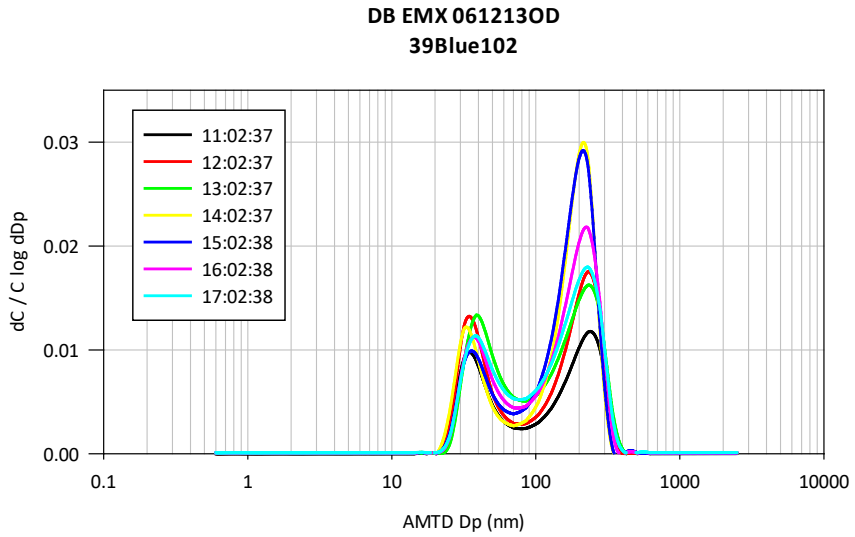


Table 4.7 Location Averages at 39Blue102 site

Time	Date	PAEC%		f_{HE}	GM_u	GSD_u	$Pcnt_u$	GM_a	GSD_a	$Pcnt_a$
		$nJ.m^{-3}$	mWL	%	nm		%	nm		%
11:02:37	6/12/2013	1573	76	5.3	42	1.4	41	194	1.4	59
12:02:37	6/12/2013	2069	99	5.0	41	1.4	39	193	1.4	61
13:02:37	6/12/2013	2333	112	4.5	47	1.4	40	185	1.5	60
14:02:37	6/12/2013	2597	125	4.5	38	1.3	27	180	1.4	73
15:02:38	6/12/2013	2656	128	4.0	42	1.3	24	175	1.4	76
16:02:38	6/12/2013	2433	117	4.3	42	1.3	29	176	1.5	71
17:02:38	6/12/2013	2341	113	4.7	43	1.3	32	173	1.5	68
	Mean	**2286**	**110**	**4.6**	**42**	**1.4**	**33**	**182**	**1.4**	**67**
	1 SD	369	18	0.4	3	0.0	7	9	0.0	7

4.2.5 Location ID 15: Whenan Crusher

The Whenan Crusher is the location where mined ore is transported from the stope and dumped into ore passes which feed the crushing system. The displacement feeder captures the ore, controls and directs the flow towards the crusher area. The displacement feeder directs ore into the jaw crusher. This crusher breaks down the ore and feeds onto one vibrating feeder, and then on to the conveyor system. There were no vehicles operating and not many personnel in the area when the crusher was in operation. The ventilation pushes air from the crusher chamber past the grab sampling site. The high dust levels at the grab sampling site were due to extremely high dust levels in the crusher chamber only 20 metres away from the grab sample location.

The measured sample results are summarised in Table 4.8 and the size distributions are shown in Figure 4.6. The average PAEC was relatively low at ~540 nJ.m^{-3} (26 mWL), reflecting young air in the ventilation system, although the average CN concentration at this site was ~ 71,000 cm^{-3} due to the proximity of the crusher. A single accumulation mode peak at GM_A = 113 nm was observed.

Figure 4.6 Activity size distributions for RDP at Whenan Crusher site.

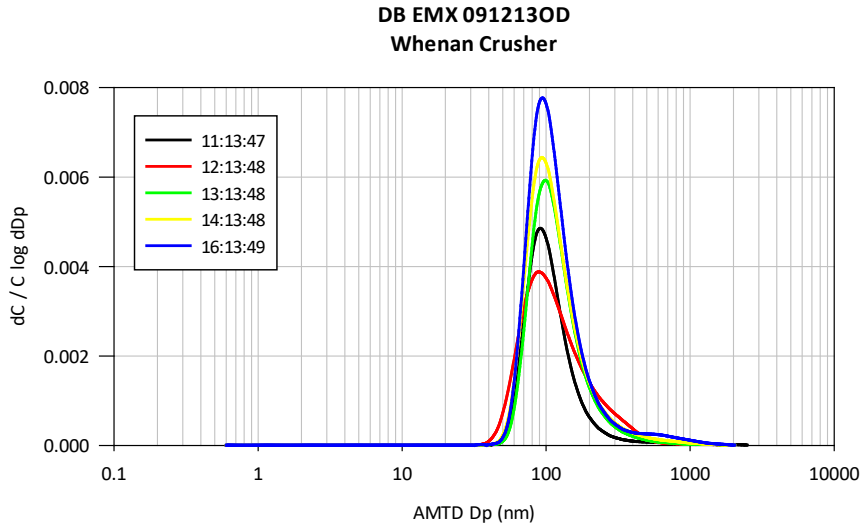


Table 4.8 Location averages at Whenan Crusher site

Time	Date	PAEC	Unit	f_{HE}	GM_a	GSD_a	$Pcnt_a$
		nJ.m^{-3}	mWL	%	nm		%
11:13:47	9/12/2013	402	19	3.9	108	1.6	100
12:13:48	9/12/2013	472	23	3.2	116	1.7	100
13:13:48	9/12/2013	524	25	3.0	117	1.5	100
14:13:48	9/12/2013	607	29	2.6	115	1.6	100
16:13:49	9/12/2013	689	33	2.7	116	1.6	100
	Mean	**539**	**26**	**3.1**	**114**	**1.6**	**100**
	1 SD	113	5	0.5	4	0.1	0

4.2.6 Location ID 21: 65 Rail Workshop

Samples were taken at the rail workshop where maintenance of locomotives occurs, tools and equipment is stored and where crib rooms are located. Ventilation and airflow was low, and the only airflow came from forced fan on the wall across from the grab sampling site (about 20 m away). The conditions were quite warm and humid due to low airflow. Low amounts of dust and particulate were in the air as there was no work activity in the workshop during the grab sample.

The measured sample results are summarised in Table 4.9 and the size distributions are shown in Figure 4.7. Measured activity size distributions at this site were very variable with modes changing significantly each hour. The average CN concentration at this site was ~16,600 cm^{-3} and the PAEC of ~170 $nJ.m^{-3}$ (8.1 mWL) was low during the sample period. It was assessed that the size distributions at this site are not meaningful due to low counting statistics and the results below were not included in the later analysis.

Figure 4.7 Activity size distributions for RDP at 65 Rail Workshop site.

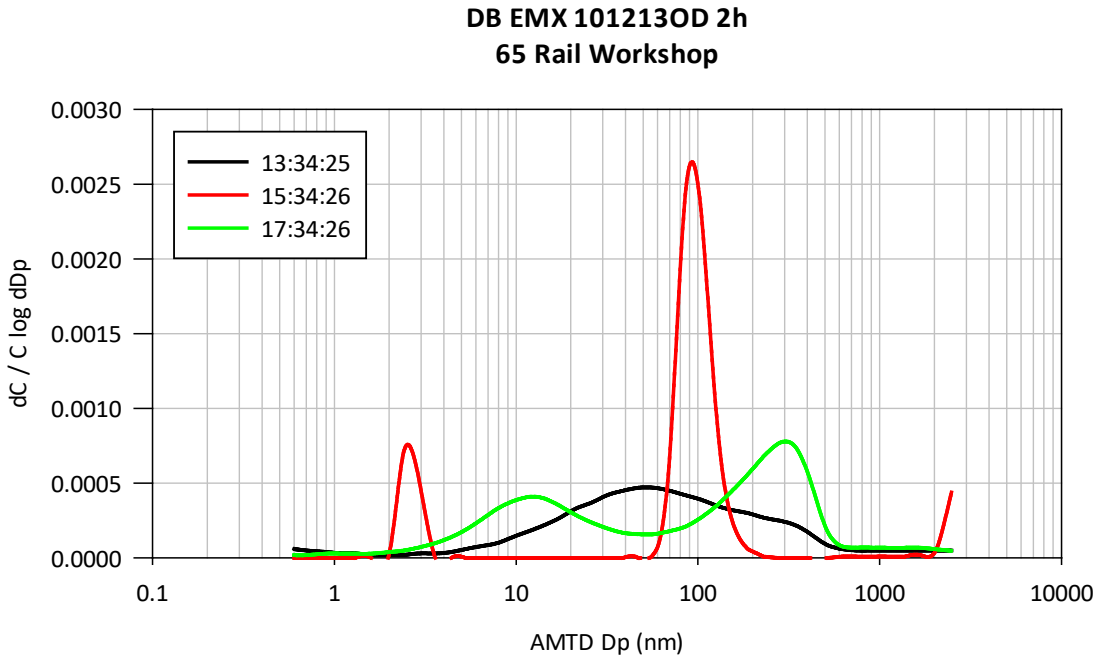


Table 4.9 Location Averages 65 Rail Workshop

Time	Date	PAEC		f_{HE}	GM_u	GSD_u	$Pcnt_u$	GM_a	GSD_a	$Pcnt_a$	GM_c	GSD_c	$Pcnt_c$
		$nJ.m^{-3}$	mWL	%	nm		%	nm		%	nm		%
13:34:25	10/12/2013	154	3.7	11.8	0.9	1.5	3	67	3.7	97			
15:34:26	10/12/2013	161	3.9	14.9	2.6	1.1	15	115	1.5	79	2368	1.2	6
17:34:26	10/12/2013	195	4.7	14.6	11	2.4	40	155	2.6	56	1349	1.5	4
	Mean	**170**	**4.1**	**13.8**	**4.9**	**1.7**	**20**	**112**	**2.6**	**77**	**1859**	**1.3**	**5**
	1 SD	22	1	2	5.5	0.7	19	44	1.1	20	721	0.2	1

4.2.7 Location ID 25: 32RB5 (Toilets)

The sampling location 32RB5 was near a fresh air intake from the surface at the 32 level. There was very good strong airflow with cool conditions. There were water trucks passing and filling up only 10 m away and heavy vehicle activity on main drive. It is possible that the airflow at the sampling location would have prevented any of the 'dirty' air passing the sampling site. There were no personnel present at time of sampling.

The measured sample results are summarised in Table 4.10 and the size distributions are shown in Figure 4.8. The RDP PAEC was very low (12 $nJ.m^{-3}$) as was the CN concentration (~1300 cm^{-3}) indicating clean, fresh air. An attempt was made to determine the size distribution from the aggregation of 6 one hour diffusion battery samples. However, due to the low activity, there was insufficient activity measured by the CDB system at this location to derive meaningful activity size distributions and AMD curves, and the results below were not included in the later analysis.

Figure 4.8 Activity size distributions for RDP at 32RB5 site.

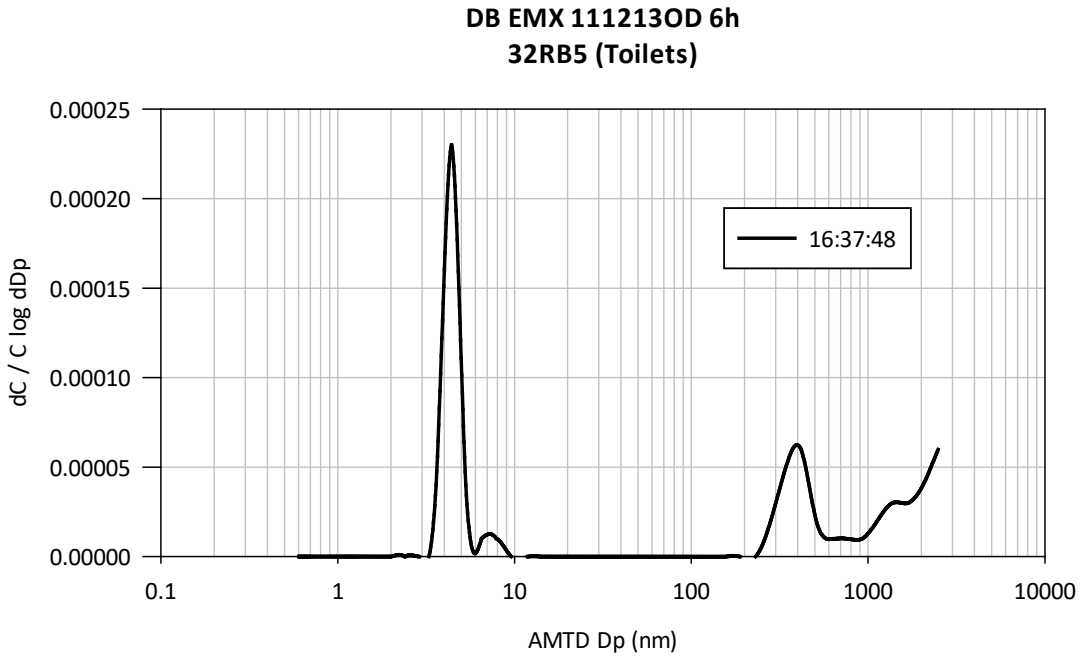


Table 4.10 Location Averages 32RB5 (Toilets)

Time	Date	PAEC		f_{HE}	GM_u	GSD_u	$Pcnt_u$	GM_a	GSD_a	$Pcnt_a$	GM_c	GSD_c	$Pcnt_c$
		$nJ.m^{-3}$	mWL	%	nm		%	nm		%	nm		%
16:37:48	11/12/2013	12	0.29	38.1	4.5	1.2	48	380	1.3	23	1642	1.5	29

4.2.8 Location ID 28: 36Yellow419

This sampling location was near a raise drilling rig set up. Back-reaming occurred on the sample day. Drilling was in automatic mode during the grab sampling period with one operator present. There was good airflow near the rig and the fixed monitoring site coming from auxiliary ventilation bag. There was visible particulate in the air.

The measured sample results are summarised in Table 4.11 and the size distributions are shown in Figure 4.9. There was high CN (~145,000 cm^{-3}) during sample period, the average PAEC was 540 $nJ.m^{-3}$ (26 mWL). While the distribution would indicate bimodal, the peaks were poorly resolved in four of the samples. The resultant distribution shows a nucleation mode at GM_N~38 nm and an accumulation mode at GM_A~180 nm.

Figure 4.9 Activity size distributions for RDP at 36Yellow419 site.

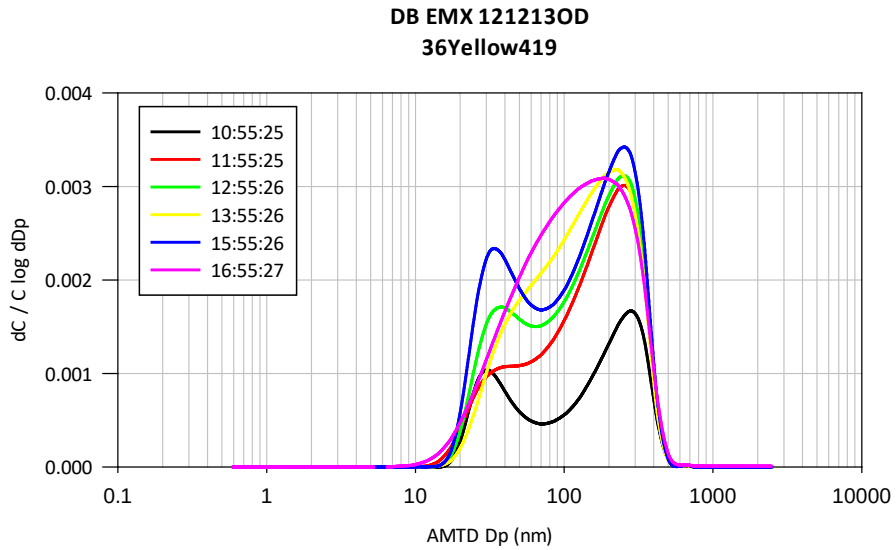


Table 4.11 Location Averages 36Yellow 419

Time	Date	PAEC		f_{HE}	GM_u	GSD_u	$Pcnt_u$	GM_a	GSD_a	$Pcnt_a$
		$nJ.m^{-3}$	mWL	%	nm		%	nm		%
10:55:25	12/12/2013	273	13.1	6.3	37	1.4	33	180	1.7	67
11:55:26	12/12/2013				Unresolved					
12:55:26	12/12/2013	624	30.0	5.1	39	1.4	30	178	1.7	70
13:55:26	12/12/2013				Unresolved					
14:55:26	12/12/2013				Unresolved					
15:55:26	12/12/2013	711	34.2	5.7	40	1.4	35	179	1.7	65
16:55:26	12/12/2013				Unresolved					
	Mean	**536**	**26**	**5.7**	**38**	**1.4**	**33**	**179**	**1.7**	**67**
	1 SD									

5. Dose Conversion Factors Results

The RDP activity weighted dose conversion factors were calculated from the CDB results using both the RADEP-derived and the HPA2012-derived dose conversion factors, for those measurement results where the distributions were assessed as meaningful. The results for each sampling location are summarised in Tables 5.1 to 5.6.

Table 5.1 **RDP activity weighted dose conversion factors from the CDB results using the RADEP-derived and the HPA2012-derived dose conversion factors**

Location ID 1 420 Drill Maintenance Workshop

Time	RADEP96		HPA2012	
	mSv/(J.h.m^{-3})	mSv/WLM	mSv/(J.h.m^{-3})	mSv/WLM
10:16:32 AM	6705	23.5	6200	21.8
11:16:32 AM	6876	24.1	6326	22.2
12:16:32 PM	6676	23.4	6192	21.7
1:16:32 PM	6884	24.2	6436	22.6
2:16:32 PM	7658	26.9	7116	25.0
3:16:32 PM	7374	25.9	6903	24.2
4:18:32 PM	7467	26.2	6901	24.2
5:18:32 PM	7007	24.6	6553	23.0
Mean	**7080**	**24.8**	**6580**	**23.1**
1 SD	370	1.3	350	1.2

Table 5.2 RDP activity weighted dose conversion factors from the CDB results using the RADEP-derived and the HPA2012-derived dose conversion factors

Location ID 5 49MB52

Time	RADEP96		HPA2012	
	mSv/(J.h.m^{-3})	mSv/WLM	mSv/(J.h.m^{-3})	mSv/WLM
9:48:15 AM	4602	16.1	4320	15.2
10:48:15 AM	3676	12.9	3501	12.3
11:48:15 AM	3789	13.3	3610	12.7
12:48:16 PM	3793	13.3	3613	12.7
1:48:16 PM	4009	14.1	3808	13.4
2:48:16 PM	4432	15.6	4189	14.7
3:48:16 PM	4441	15.6	4164	14.6
4:48:17 PM	4066	14.3	3838	13.5
Mean	**4100**	**14.4**	**3880**	**13.6**
1SD	350	1.2	308	1.1

Table 5.3 RDP activity weighted dose conversion factors from the CDB results using the RADEP-derived and the HPA2012-derived dose conversion factors

Location ID 9 420 Auto Workshop

Time	RADEP96		HPA2012	
	mSv/(J.h.m^{-3})	mSv/WLM	mSv/(J.h.m^{-3})	mSv/WLM
11:16:07 AM	8329	29.2	7615	26.7
13:16:07 PM	7058	24.8	6185	21.7
14:16:07 PM	6987	24.5	6119	21.5
15:16:07 PM	7870	27.6	6819	23.9
16:16:07 PM	7509	26.3	6581	23.1
Mean	**7550**	**26.5**	**6664**	**23.4**
1 SD	563	2.0	605	2.1

Table 5.4 RDP activity weighted dose conversion factors from the CDB results using the RADEP-derived and the HPA2012-derived dose conversion factors

Location ID 8 39Blue102

Time	RADEP96		HPA2012	
	mSv/(J.h.m^{-3})	mSv/WLM	mSv/(J.h.m^{-3})	mSv/WLM
10:02:37 AM	6112	21.4	5627	19.7
11:02:37 AM	5767	20.2	5314	18.6
12:02:37 PM	5654	19.8	5215	18.3
13:02:37 PM	5475	19.2	5031	17.7
14:02:37 PM	5071	17.8	4707	16.5
15:02:37 PM	4795	16.8	4449	15.6
16:02:37 PM	5113	17.9	4722	16.6
17:02:37 PM	5293	18.6	4877	17.1
Mean	**5410**	**19.0**	**4993**	**17.5**
1 SD	383	1.3	341	1.2

Table 5.5 RDP activity weighted dose conversion factors from the CDB results using the RADEP-derived and the HPA2012-derived dose conversion factors

Location ID 15 Whenan Crusher

Time	RADEP96		HPA2012	
	mSv/(J.h.m^{-3})	mSv/WLM	mSv/(J.h.m^{-3})	mSv/WLM
10:13:47 AM	4649	16.3	4284	15.0
11:13:47 AM	4891	17.2	4478	15.7
12:13:48 PM	4728	16.6	4328	15.2
13:13:48 PM	4575	16.1	4209	14.8
14:13:48 PM	4678	16.4	4292	15.1
15:13:48 PM	4612	16.2	4245	14.9
16:13:48 PM	4664	16.4	4284	15.0
17:13:48 PM	4559	16.0	4202	14.7
Mean	**4670**	**16.4**	**4290**	**15.1**
1 SD	118	0.4	99	0.3

Table 5.6 **RDP activity weighted dose conversion factors from the CDB results using the RADEP-derived and the HPA2012-derived dose conversion factors**

Location ID 28 36Yellow419

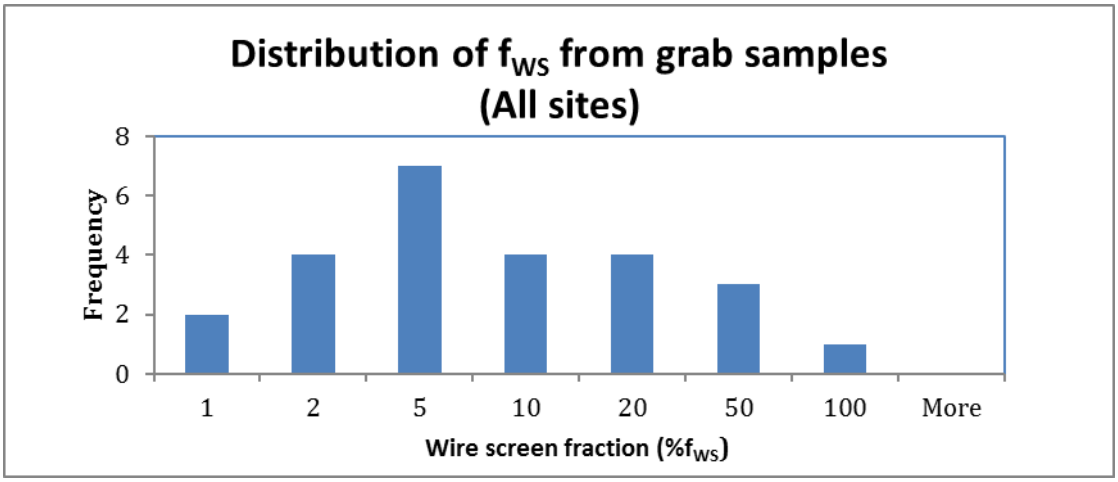
Time	RADEP96		HPA2012	
	mSv/(J.h.m^{-3})	mSv/WLM	mSv/(J.h.m^{-3})	mSv/WLM
10:55:25 AM	5550	19.5	5139	18.0
11:55:25 AM	4991	17.5	4626	16.2
12:55:25 PM	5326	18.7	4916	17.2
13:55:25 PM	4988	17.5	4598	16.1
15:55:25 PM	5676	19.9	5235	18.4
16:55:25 PM	5375	18.9	4951	17.4
Mean	**5320**	**18.7**	**4910**	**17.2**
1 SD	315	1.1	290	1.0

6. Discussion of Results

6.1 Typical conditions in Olympic Dam mine from sampling measurements

Grab sample monitoring results for 30 sites within the Olympic Dam mine indicated a wide range of radon concentration, PAEC, CN and f_{ws} values across the mine. The PAEC values were in the range 5 to 4580 $nJ.m^{-3}$, radon levels 8 to 2640 $Bq.m^{-3}$ and equilibrium ratio in the range 0.03 to 0.86. CN concentrations ranged from < 1000 cm^{-3} to > 100 000 cm^{-3}. Figure 6.1 shows the distribution of f_{ws} values across 26 valid grab samples. The mean f_{ws} value across all sites was 10.7% and the geometric mean was 5.3%.

Figure 6.1 Distribution of wire screen fraction f_{ws} at all grab sampling sites



In Table 6.1 and in Figure 6.2, the sites are grouped according to the equilibrium ratios (F) and CN. The trend line in Figure 6.2 is for the sites with intermediate equilibrium ratios only. Analysis shows that sites with low equilibrium ratios (F < 0.1) had f_{ws} values in the range 14% to 60%. Sites with high equilibrium ratios (F > 0.7) had f_{ws} values in the range 0.4% to 5%.

Figure 6.2 Measured wire screen fractions at all grab sampling sites

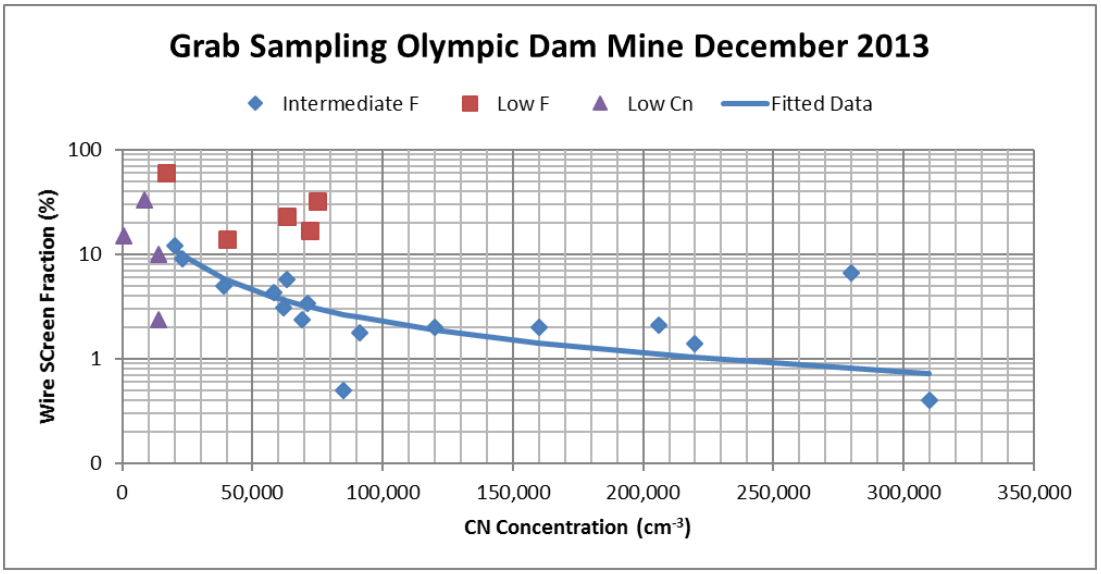
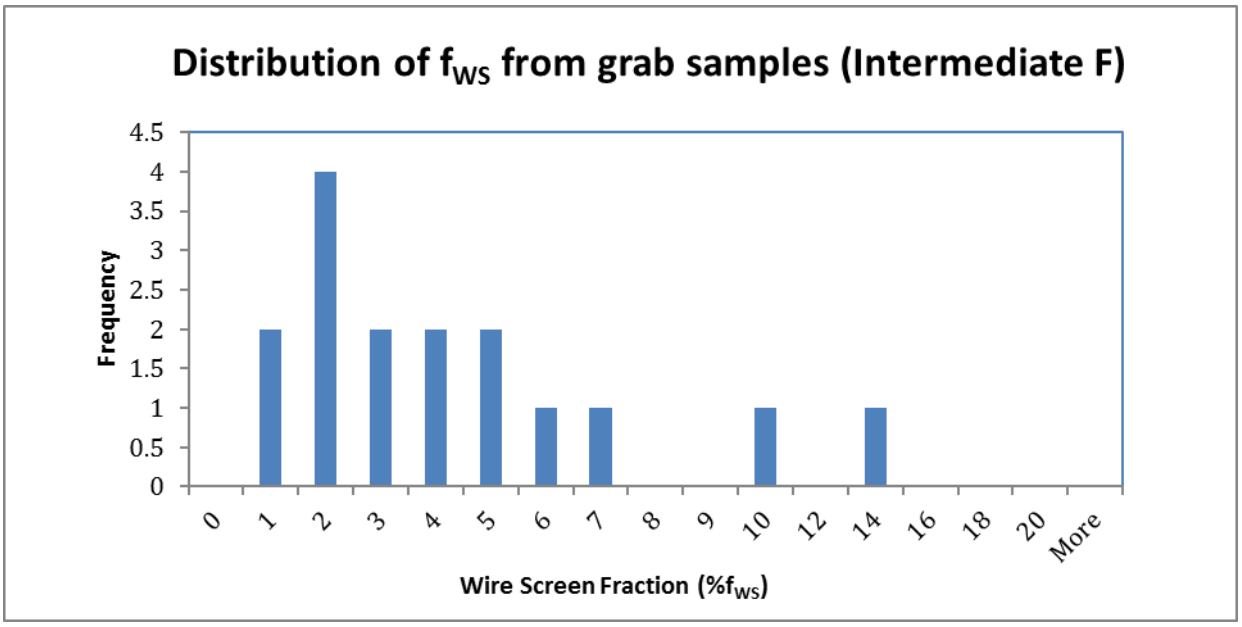


Table 6.1 Summary of results of grab sample measurements at sites in Olympic Dam mine

ID	Location	PAEC	1SD	RADON	1SD	f_{ws}	1SD	F	1SD	CN	1SD
		$nJ.m^{-3}$		$Bq.m^{-3}$		%				cm^{-3}	
(Very low F)											
26	54LK 57	5	2	30	16			0.03	0.03	1 070	360
9	420 Auto Workshop	33	7	53	12	60	21	0.11	0.05	17 000	3 000
29	39 Workshop	84	9	230	70	14	5	0.07	0.03	40 000	6 000
13	39 DCI Ore Pass	54	6	160	50	23	9	0.06	0.03	63 000	17 000
14	39 Blue 7 Access_1 Dec	47	6	100	20	17	7	0.09	0.03	72 000	32 000
14	39 Blue 7 Access_2 Dec	30	5	100	25	32	14	0.05	0.03	75 000	21 000
	Group average	**50**		**129**		**29**		**0.08**			
(Low CN, low F)											
25	32RB5	14	4	8	4	15	18	0.30	0.23	500	45
27	54 Workshop	37	6	30	20	33	13	0.22	0.20	8 400	2 600
30	68 Transfer	280	15	280	90	2.4	1.2	0.18	0.08	14 000	2 000
31	65LK 62	210	14	1 190	60	10	3	0.19	0.07	14 000	2 000
	Group average	**135**		**377**		**15.1**		**0.22**		**9 225**	
(Intermediate F)											
21	65 Rail Workshop	120	10	60	30	12	4	0.34	0.18	20 000	3 000
10	32 Purple 253	360	17	290	100	9.1	1.8	0.22	0.08	23 000	7 000
17	52 Amber 305_1	780	30	220	50	5.0	0.9	0.63	0.16	39 000	27 000
22	58LG64 Decline	670	30	200	120	4.3	0.9	0.59	0.30	58 000	5 000
17	52 Amber 305_2	860	30	370	120	3.1	0.7	0.42	0.10	62 000	31 000
15	Whenan Crusher	560	25	290	70	5.7	1.0	0.35	0.10	63 000	16 000
20	27 Amber 385	2 030	50	830	150	2.4	0.3	0.44	0.10	69 000	46 000
8	39 Blue 102	2 800	50	1 540	200	3.4	0.3	0.32	0.05	71 000	6 000
18	45 Jade 325	860	30	180	100	0.5	0.3	0.86	0.50	85 000	28 000
16	420 Tyre Bay	180	12	140	50	1.8	1.8	0.21	0.09	91 000	35 000
12	52 Purple 245	4 580	70	2 640	142	2.0	0.2	0.31	0.03	120 000	4 000
23	52 Cyan 114	830	30	340	150	2.0	0.5	0.44	0.22	160 000	12 000
19	37 Jade 117	670	25	400	130	2.1	0.5	0.30	0.10	206 000	49 000
28	36 Yellow 419	1 670	40	670	150	1.4	0.3	0.44	0.11	220 000	34 000
24	52F2 Ore Pass	120	10	70	30	6.7	3.5	0.30	0.17	280 000	39 000
11	45 Olive 103	1 600	40	470	100	0.4	0.2	0.60	0.10	310 000	18 000
	Group average	**1 168**		**544**		**3.9**		**0.42**		**117 313**	

Figure 6.3 shows the distribution of f_{ws} values, excluding those sites with very low F or low CN. The mean value of f_{ws} for these sites was 3.9% and the geometric mean was 2.7%.

Figure 6.3 Distribution of wire screen fraction f_{ws} at grab sampling sites



The average values of PAEC, radon, f_p, f_{ws}, F and CN at the Continuous Diffusion Battery (CDB) sites are summarised in Table 6.2. The CDB results for f_{ws} were also variable but broadly correlated with the values obtained from the grab sample measurements. The range of CDB derived f_{ws} values was 1.3% – 28.1%, with an average of f_{ws} = 8.7%. However, the fraction in the ultrafine modes in the measured distribution indicate that f_p were in most cases ~ 0%.

Table 6.2 Summary of measured parameters at CDB sampling sites

ID No	Location	PAEC		Radon*	f_{ws}	f_p	F	CN
		$nJ.m^{-3}$	mWL	$Bq.m^{-3}$	%	%		cm^{-3}
1	420 Drill Maintenance	134	6.5	74	3.7	0.8	0.33	14 417
5	49MB52	1 349	65	526	1.3	0	0.46	74 420
9	420 Auto Workshop	53	2.55	46	28.1	28	0.21	34 326
8	39Blue 102	2 125	102	1 640	1.8	0	0.23	69 000
15	Whenan Crusher	573	27.5	385	1.3	0	0.26	70 876
21	65 Rail Workshop	85	4.1	62	9.9	-	0.51	16 569
25	32RB5	12	0.58	18	21.7	-	0	1 299
28#	36 Yellow 419	541	26	352	1.7	0	0.27	145 075

6.2 Correlations between unattached fraction and CN concentration

The magnitude of the unattached fraction primarily depends on the concentration of particles of ambient aerosol. For homes and other indoor locations it has been shown that f_p can be estimated with the semi-empirical equations

$$f_p \sim 414/ Z$$

where Z is the CN concentration (cm^{-3}) (Porstendörfer, 2001).

The single wire screen based grab sampling measurements at Olympic Dam mine measured the wire screen fraction f_{ws} not f_p. The determination of f_p values from single screen measurements is not straight forward, particularly when there is a nucleation mode in the RDP aerosol size distribution, as was the case at the Olympic Dam mine. The f_{ws} values as a function of CN concentration are summarised in Figure 6.3. For the full dataset there is little evidence of a correlation between f_{ws} and CN. However if the data for sites with very low equilibrium ratios (< 0.1) and/or low CN concentrations (< 20,000 cm^{-3}) are excluded, then the correlation is improved. The data points for the medium F sites was fitted to a function of the form

$$f_{ws} \sim 2300/ Z$$

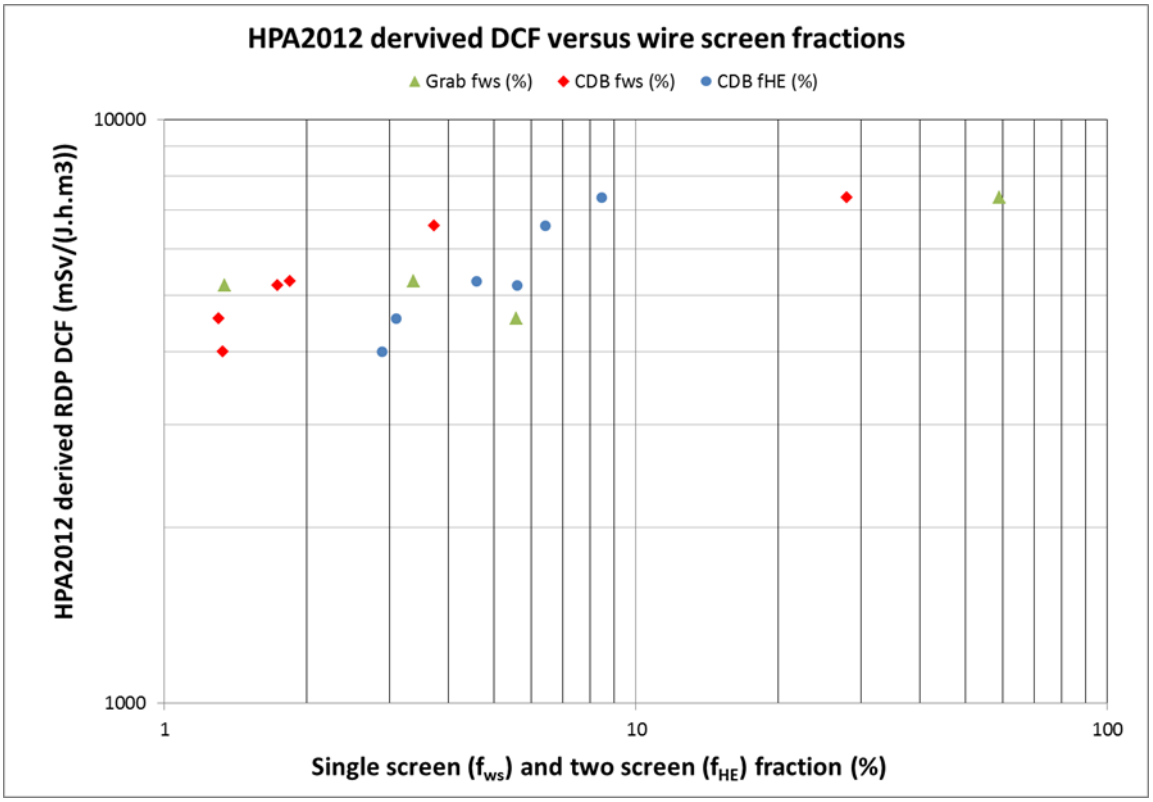
where Z is the CN concentration (cm^{-3}).

The predominance of a nucleation mode in the RDP activity size distribution at many of the sampling locations means that the single screen unattached fraction results have to be interpreted with some care. Comparison of the unattached fraction values in Table 6.2 with the corresponding wire screen fractions would suggest that there is a poor correlation between the wire screen fraction and suggests that the single wire screen sampler should not be interpreted as the unattached fraction.

6.3 Correlations between unattached fraction and dose conversion factors

Some dosimetric models during the 1980's parameterised the DCF in terms of the AMTD and f_p (James, 1980, Jacobi and Eisfeld, 1980). Figure 6.4 shows the calculated DCF ratios (based on RADEP) versus the measured wire screen fraction for the CDB sites. There is poor or no correlation between the measured single screen fractions and the calculated RDP DCF values.

Figure 6.4 HPA2012 derived RDP DCF values versus the measured wire screen fractions for the CDB sites

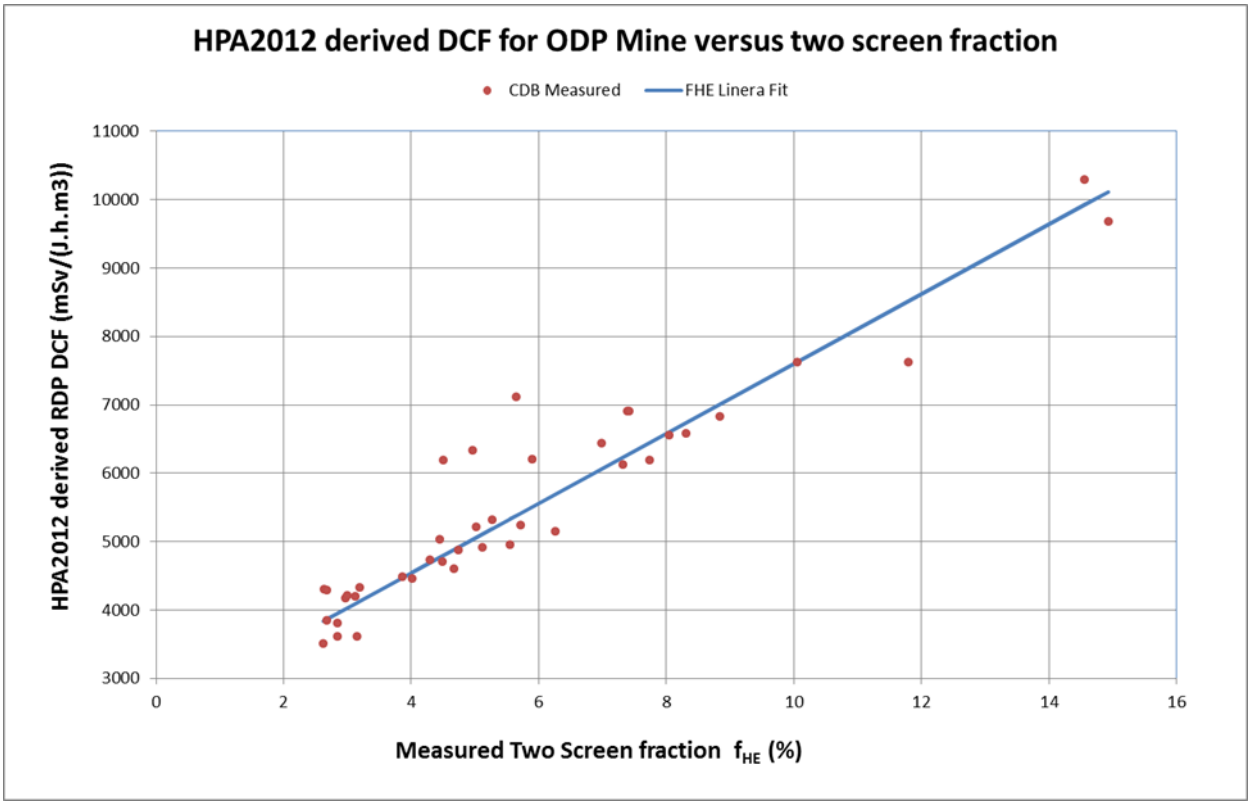


However, the second stage of the CDB operates as a 2-screen sampler (Solomon, 1997) with a collection efficiency optimised to match the particle size dependence of the DCF. As expected, Figure 6.5 shows there is a clear linear correlation between the f_{HE} values and the size weighted DCF values based on the measured RDP activity size distributions. A simple regression analysis (r2 = 0.891) was applied to the HPA2012 derived DCF values to derived a linear function f_{HE};

$$\mathbf{DCF\ (mSv/(J.h.m^{-3})) = 2500 + 510 * f_{HE}\ (\%)}$$

While the 2-screen sampler does not provide information on the actual activity size distribution, the 2-screen sampler does provide a good measure of the aerosol size dependency of the DCF values for most of the conditions in the Olympic Dam mine.

Figure 6.5 HPA2012 derived RDP DCF values versus the measured 2-screen fractions for the CDB sites



6.4 Comparison of dose conversion factors relative to Reference Mine values

Table 6.3 summarises the average RADEP96 and HPA2012 derived DCF values for each sampling location. In addition a third estimate was derived from the second stage measurement results, since this operates as a 2-screen sampler (Solomon, 1997) with a collection efficiency optimised to match the particle size dependence of the DCF. The derived DCF values from the RADEP-derived dosimetric models were in the range 4100 mSv/(J.h.m^{-3}) to 7080 mSv/(J.h.m^{-3}) (14.4 mSv/WLM to 24.8 mSv/WLM). The derived DCF values from the HPA2012 dosimetric model were in the range 3995 mSv/(J.h.m^{-3}) to 7350 mSv/(J.h.m^{-3}) (14.0 mSv/WLM to 23.4 mSv/WLM). For comparison, the ICRP *Conversion Convention* value is 1425 mSv/(J.h.m^{-3}) or 5 mSv/WLM.

The 'Reference Mine' conditions, based on size distribution measurements in uranium mines from the 1970's, provide a benchmark for comparison with dose conversion factors based on epidemiological studies that use data for exposures before 1970. The DCF ratios for each sampling location, relative to the DCF for the 'Reference Mine' size distribution, were calculated. The derived size weighted DCF for the 'Reference Mine' conditions was 3160 mSv/(J.h.m^{-3}) or 11.1 mSv/WLM from the RADEP program, and 3060 mSv/(J.h.m^{-3}) or 10.7 mSv/WLM from the HPA2012. These DCF ratios are summarised in Table 6.3.

Table 6.3 Summary of DCF estimates at CDB sites and ratio to Reference Mine values

ID	Location	RADEP DCF from CDB		HPA2012 DCF from CDB		HPA2012 DCF from f_{HE}	
		mSv/ (J.h.m^{-3})	Ratio to Ref. Mine	mSv/ (J.h.m^{-3})	Ratio to Ref. Mine	mSv/ (J.h.m^{-3})	Ratio to Ref. Mine
Reference Mine conditions from 1970's measurements							
		3160	1.0	3060	1.0	3060	1.0
Non-mining work sites with high ventilation							
1	420 Drill Wrkshp	7080	2.2	6580	2.2	5780	1.9
9	420 Auto Wrkshp	7550	2.4	7350	2.2	6810	2.2
Operational sites with mining related activities							
5	49MB52	4100	1.3	3995	1.3	3980	1.3
8	39Blue 102	5410	1.7	5270	1.7	4960	1.6
15	Whenan Crusher	4670	1.5	4550	1.5	4020	1.3
28	36Yellow419	5320	1.7	5190	1.7	4720	1.5

The results for the two dosimetric models and for the 2-screen sampler assessments are in excellent agreement. Both programs give size weighted DCF values about a factor of two greater than the ICRP conversion convention. These ratios are consistent between the computational approaches and range from 1.3 to 2.4, depending on the location. The sampling sites can be grouped into two categories; the two workshop sites characterised by low PAEC and low equilibrium factors (high ventilation rates) and the remaining four sites in locations within the operational portions of the mine, with higher levels of PAEC. Table 6.4 summarises the measured parameters, aerosol conditions and DCF ratio, grouped according to these two categories. For the workshop locations the average DCF ratio is 2.3. For the operational work areas of the mine the average DCF ratio was 1.5 for the RADEP-derived DCF values and 1.6 for the HPA2012 derived DCF values.

Table 6.4 Summary of measured parameters at CDB sites

ID	Location	PAEC	CN	F	f_{ws}	PAEC	CN
Non-mining work sites with high ventilation							
1	420 Drill Wkshp	Low	Medium	Low	3.7	U, A	2.2
9	420 Auto Wkshp	Low	Medium	Low	28	N,A	2.4
Operational sites with mining related activities							
5	49MB52	High	Medium	Medium	0.8	U,N,A	1.3
8	39Blue 102	High	Medium	Medium	3.4	N,A	1.7
15	Whenan Crusher	Medium	Medium	Medium	5.6	A	1.5
28	36Yellow419	Medium	High	Medium	1.4	N,A	1.7

6.5 Comparison with previous measurements at Olympic Dam

During the early 1990's, RDP activity size distributions had been previously measured at the Olympic Dam mine. Over the period July 20 to July 30, 1992, measurements were carried out in the mine at Olympic Dam by the Australian Radiation Laboratory (now ARPANSA). The PAEC activity size distributions were measured at one site using a five stage wire screen parallel diffusion battery, operated in a continuous sampling mode and at the other six sites using a second diffusion battery/graded screen array system that was operated in a grab sampling mode (Solomon, 1993). The derived parameters for the size distributions at each site together with the particle size dependent DCF values and the DCF ratios, calculated from RADEP, are summarised in Table 6.5.

At the time of the original 1992 measurements analysis, the results were interpreted in terms of the 'diesel' and 'non-diesel' areas of the mine. Four of the sites (32LJ61 Sub Station, 41LJ61 Sub Station, A Block Pump Station, Vent bag Store) were away from the actual working mine areas. Figure 6.5 shows the measured size distributions at one of the 'non-working area' sites. The average of the DCF ratios at these sites was 2.3, comparable to the values measured at the Workshop sites in the 2013 Olympic Dam mine measurements. The distributions show ultrafine and accumulation modes.

Figure 6.5 Size distributions at Vent Bag Store from 1992 measurements

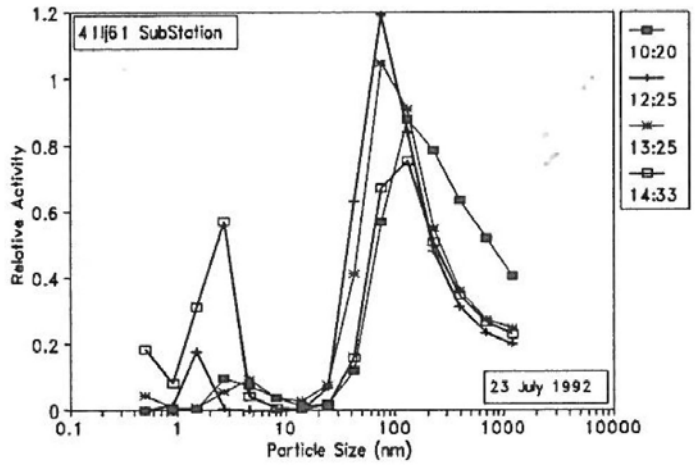
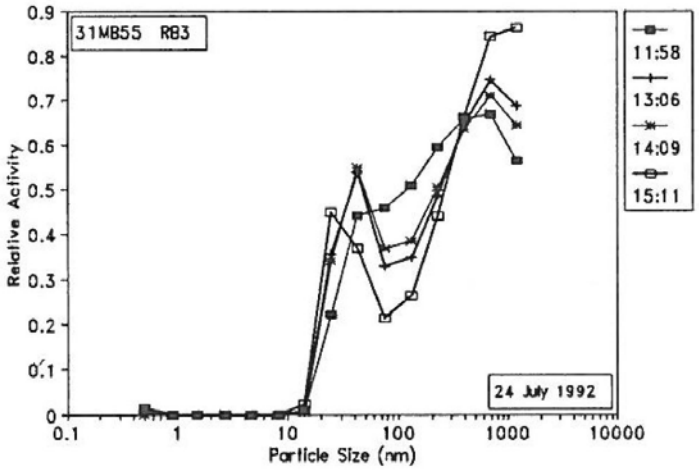


Figure 6.6 Size distribution at 31MB55 from 1992 measurements



The three remaining sites (31MD55, 26F Brown (Raise Bore) and 35F Brown 7 Slot (Jumbo 7)) were close to operating areas of the mine and had the higher PAEC values. The activity size distributions at one of these sites in Figure 6.6 shows a nucleation and an accumulation mode. The average DCF ratios at these sites was 1.4, comparable to the values measured at the operational sites in the 2013 Olympic Dam mine measurements.

Table 6.5 Summary of results from 1992 diffusion battery measurements

Olympic Dam 1992 Results

Site	$\%f_{ws}$	PAEC	GM_U	GM_N	GM_A	RADEP DCF	DCF ratio
		mWL	nm		nm	mSv/WLM	
32LJ61 Sub Station	0	14		27	475	30.9	2.8
	0.4	16	0.8		250	14	1.3
	7.2	16	6.5		212	22.3	2.0
41LJ61 Sub Station	5	17	4.2		239	20.5	1.8
	4.6	17	1.5		128	24.9	2.2
	6.3	14			147	24.6	2.2
	28	22			184	48	4.3
A Block Pump Station	5.3	33	2.4		136	24.5	2.2
	3.7	46	1.3		121	22.8	2.1
	3.3	34	0.5		87	26.6	2.4
	4.7	36	0.5		126	24.5	2.2
Vent bag Store	0	35			219	13.8	1.2
	2.9	27	1.4		216	16.2	1.5
Average							2.2
31MD55	0.2	128	0.5		227	16	1.4
		145		42	391	17.2	1.5
		146		43	370	17.2	1.5
		165		37	464	17.2	1.5
26F Brown (Raise Bore)	1.1	117	0.5		161	19.1	1.7
	0.7	107	0.5		207	14.6	1.3
		109		48	359	15.4	1.4
		110			228	13.9	1.3
35F Brown 7 Slot (Jumbo 7)	1.9	46	0.5		272	12.8	1.2
	2.6	45			230	14.6	1.3
	7	45			402	16.5	1.5
	7.4	47			303	18.1	1.6
Average							1.4

7. Summary and conclusion

The results of the measurements at the Olympic Dam underground in the December 2013 can be summarised as:

> the grab sample monitoring results for 30 sites within the Olympic Dam mine indicated a wide range of radon concentration, potential alpha energy concentration (PAEC), condensation nuclei concentration (CN) and single wire screen fraction (f_{ws}) values across the mine. The PAEC values were in the range 5 to 4580 nJ.m^{-3}, radon levels 8 to 2640 Bq.m^{-3} and the equilibrium ratio were in the range 0.03 to 0.86. CN concentrations ranged from <1000 cm^{-3} to >100,000 cm^{-3}.

The mean of the single wire screen fraction values across all of the grab sampling sites was 10.7% and the geometric mean was 5.3%. Further analysis of the results shows that sites with low equilibrium ratios ($F < 0.1$) had single wire screen fraction values in the range 14% to 60%. Sites with medium equilibrium ratios ($0.2 < F < 0.7$) had single wire screen fractions in the range 2% to 30%, dependent on the particle concentration. The mean value of the wire screen fraction for these sites was 3.9% with a geometric mean of 2.7% Sites with high equilibrium ratios ($F > 0.7$) had wire screen fraction values in the range 0.4% to 5%. For those sites with PAEC > 1 µJ.m^{-3}, the average wire screen fraction was ~2%.

For the full set of grab sample measurements there is little evidence of a correlation between unattached fraction (f_p) and CN concentration. However, for the single wire screen fractions, excluding the data for sites with very low equilibrium ratios (< 0.1) and/or low CN concentrations (< 20,000 cm^{-3}), there is good correlation between f_{ws} and CN, with the data fitting a function of the form $f_{ws} \sim 2300 / Z$, where Z is the CN concentration (cm^{-3}).

The ARPANSA Continuous Diffusion Battery (CDB) was operated at 8 powered sites in the underground mine. Grab sample measurements of RDP concentrations and PAEC were also carried out at five of these sites. The CDB results for the single wire screen fractions were also variable, but broadly correlated with the values obtained from the grab sample measurements. The range of CDB wire screen fraction values was 1.3–28%, with an average of 8.7%.

The two workshop sites on the 420 Level had activity size distributions that were bimodal, one with an ultrafine mode and an accumulation mode, the other with a nucleation mode and an accumulation mode. The locations were characterised by low PAEC and low equilibrium factors (i.e. high ventilation rates).

The remaining four CDB sites were in locations within the operational portions of the mine, with higher levels of PAEC. Three of these sites had bimodal distributions with nucleation modes with average geometric means in the range 28 nm to 42 nm and accumulation modes with average geometric means in the range 180 nm to 270 nm. The fraction of the nucleation mode varied from 10% to 46% across these three sites. The fourth site, near the Whenan Crusher had a single accumulation mode at 114 nm.

For a restricted set of ventilation and aerosol conditions there was a good correlation between the CN concentration and the single wire screen fraction. The predominance of a nucleation mode at many of the sampling locations means that the single wire screen fraction results have to be interpreted with some care. For the Olympic Dam mine, the fraction collected on a wire screen sampler with a Dp_{50} of 4 nm was not a good measure of the ultrafine mode (unattached fraction, f_p) because of the presence of a nucleation mode.

The CDB activity size distribution measurements at six sites were assessed as having sufficient statistics to provide meaningful size distribution results. The RDP size-weighted dose conversion factors were calculated from the CDB results using both the RADEP and the HPA2012 dosimetric models.

The derived DCF values from the RADEP dosimetric model were in the range 4100 mSv/(J.h.m^{-3}) to 7550 mSv/(J.h.m^{-3}) (14.4 mSv/WLM to 24.8 mSv/WLM). The derived DCF values from the HPA2012 dosimetric model were in the range 3880 mSv/(J.h.m^{-3}) to 7350 mSv/(J.h.m^{-3}) (13.6 mSv/WLM to 25.8 mSv/WLM). For comparison, the ICRP Conversion Convention value is 1425 mSv/(J.h.m^{-3})) or 5 mSv/WLM.

The ratio of these measurement-derived DCF values to the Reference Mine DCF value are consistent between the two dosimetric approaches and range from 1.3 to 2.4, depending on the work activity and the ventilation conditions.

For work locations with high ventilation and/or low CN concentrations the average DCF ratio was about 2.3 relative to the Reference Mine DCF and about 5, relative to the ICRP65 Conversion Convention. For the operational areas of the mine the average DCF ratio is about 1.5 relative to the Reference Mine DCF and about 3.3 relative to the ICRP65 Conversion Convention.

A comparison was made of the present measurement results with the results of the 1992 study. At the time of the original 1992 measurements analysis, the results were interpreted in terms of the 'diesel' and 'non-diesel' areas of the mine. A re-evaluation of the measurement results determined that four of the sites were away from the actual working mine areas. The distributions show ultrafine and accumulation modes. The average DCF ratios at these sites was 2.3, comparable to the values measured at the Workshop sites in the present 2013 Olympic Dam mine measurements. The three remaining 1992 sites were close to operating areas of the mine and had higher PAEC values. The activity size distributions at one of these sites show a nucleation and an accumulation mode. The average DCF ratios at these sites was 1.4, comparable to the values measured at the operational sites in the 2013 Olympic Dam mine measurements.

It was found that for the Olympic Dam mine, the fraction collected on a single wire screen sampler with a Dp_{50} of 4 nm was not a good measure of the ultrafine mode (unattached fraction, f_p) because of the presence of a nucleation mode. No correlation was found between the single wire screen fractions and the size-weighted RDP DCF values.

The 2-screen sampler provided estimates of the RDP DCF values that were in good agreement with the size weighted DCF values based on the measured RDP activity size distributions. While the 2-screen sampler does not provide information on the actual activity size distribution, the two sampler does provide a good measure of the aerosol size dependency of the DCF values for all of the conditions in the Olympic Dam mine.

8. References

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Appendix 1: Theory of operation of wire screen diffusion battery.

ARPANSA Wire Screen Diffusion Battery

Wire screen diffusion batteries have been in use since the early 1970s and have proven to be the most convenient of the available methods to measure radon progeny activity size distributions. The five stage wire screen diffusion battery used for the Olympic Dam mine measurements was developed at the Australian Radiation Laboratory (ARL). The system has a sixth stage which is a single stage inertial impactor designed with a 50% efficiency collection of 500 nm (AMAD). The diffusion battery parameters are summarised in Table A.1. Figure A.1 shows a cross-section though the sampling assembly for the wire screen stages.

Table A.1 The ARPANSA CDB parameters

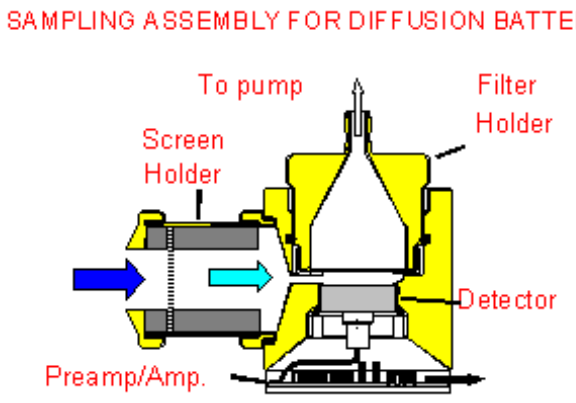
Stage	No/Screens	Mesh	Screen Diam	Flow	Effic	Dp_{50}
		(Note 1)	cm	lpm		nm
1	0	Filter	3.8	0.8	0.127	0
2	2	100	0.7	0.8	0.108	(Note 2)
3	1	100	3.8	0.8	0.13	4.0
4	10	100	3.8	0.8	0.13	
5	80	100	3.8	0.8	0.13	
6	0	(Note 3)	-	0.7	0.22	500

Note 1. 100 Mesh wire screen, Wire Diameter 112 µm , Screen Thickness 215 µm, Solid Fraction 31.3%

Note 2. 2-screen sampler (Solomon, 1997).

Note 3. Stage 6 is a single stage inertial impactor designed with a 50% efficiency collection of 500 nm (AMAD).

Figure A.1 Cross-section of ARPANSA CDB sampling head.



Wire Screen Penetration Theory

The use of wire screens for the aerosol size separation of radon daughters has been investigated by a number of groups. The application of the fan-filtration penetration theory to wire screens by Cheng and Yeh (1980) and Cheng et al. (1980) and the use of a semi-empirical diffusion coefficient equation in the molecular cluster size range (Cheng, 1988), allows the estimation of the penetration efficiency curves over both the ultrafine and the accumulation mode size ranges. The theory shows good agreement with experimental determinations of wire screen penetration down to 1 nm and up to 950 nm. The wire screen theory has not been validated for particles greater than 1 µm. Recent studies have shown that a small proportion of the radon progeny size distribution (<10%) is associated with coarse modes with particle diameters greater than 1 µm.

For a particular set of wire screens and sampling configurations, these equations can be applied to derive the efficiency as a function of particle size for collection of activity on a filter located behind each stage of the diffusion battery. For particle sizes greater than 0.1 µm the diffusion term in the single fibre collection efficiency E_D, is supplemented by terms for interception efficency E_R, impaction efficiency E_i and diffusional interception efficiency E_{DR} (Reineking and Porstendorfer 1986). The penetration through n identical wire screens is given by,

$$P = \exp\left[-\frac{4\alpha n w E_T}{\pi(1-\alpha)d_f}\right]$$

with $\mathbf{E_T = E_D + E_R + E_i + E_{DR}}$ is the single fiber collection efficiency, with

$$E_R = f(R) / (2K_u)$$

$$E_{DR} = 1.24(K_u P_e)^{-1/2} R^{2/3}$$

$$E_i = IS_t / (2K_u)$$

where

$$f(R) = (1+R)^{-1} - (1+R) + 2(1+R)\ln(1+R)$$

$$S_t = (\rho_p d_p^2 C)/(9\mu d_f)$$

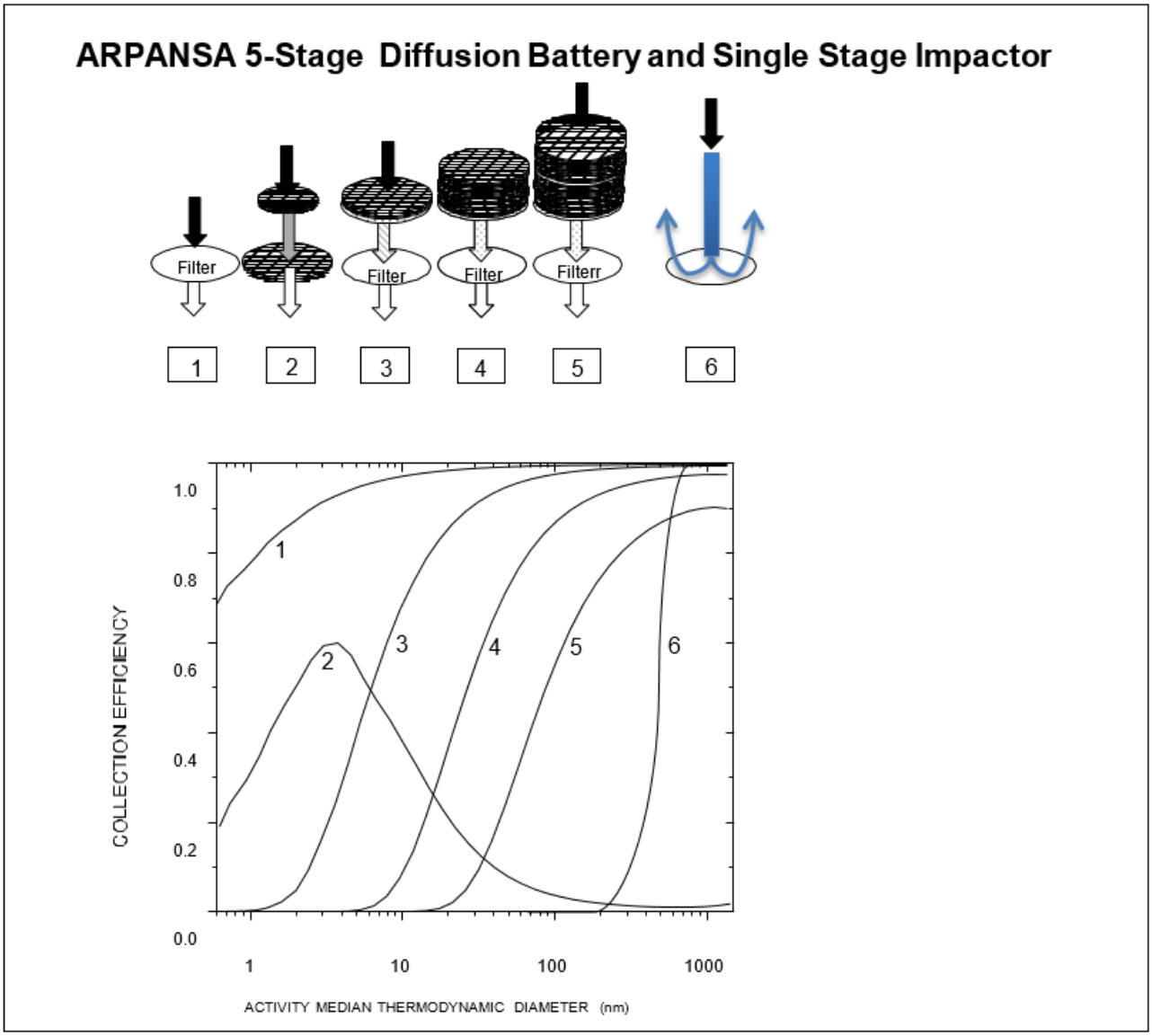
$$K_u = -0.5\ln(2\alpha/\pi) + 2\alpha/\pi - 0.75 - (\alpha/\pi)^2$$

$R = d_p/d_f$ is the interception parameter,

$$I = (29.6 - 28\alpha^{0.62})R^2 - 27.5R^{2.8}$$

and ρ_p is the particle density.

Figure A.2 ARPANSA 5 stage wire screen diffusion battery and single stage impactor



Deconvolution of Diffusion Battery Data

Diffusion batteries do not produce sharp particle size cut-points; and the observed activity concentrations for each stage of the parallel diffusion battery or graded screen array contain information that combines the activity size distribution with the particular penetration or collection efficiency function. For a continuous particle size distribution A(y), the measured activity for each stage is given by Maher and Laird (1985),

$$Z(i) = \int P(i,y)\, A(y)\, dy + \epsilon$$

where P(i,y) is the size versus penetration characteristic for stage i, and E is the measurement error.

There are two common approaches to the analysis of diffusion battery data. In the first method, the activity size distribution is approximated by a series of log-normal distributions and fitted using the SIMPLEX algorithm (Reineking and Porstendorfer, 1986). This method requires assumptions about the shape of the particle size distribution which may not be appropriate for the ultrafine mode. For the second method, A(y) is approximated by a series of discrete values of the size distribution. The previous equation can then be expressed as a series of simultaneous equations, or in matrix form as

$$Z_i = P_{ij}\, A_j$$

where Z_i are the observed stage penetrations, A_j are the size interval activity fractions and P_{ij} is the penetration matrix for the j^{th} particle size through the i^{th} stage. The solution to this equation is complicated by measurement errors and inaccuracies in the penetration functions. Such sets of equations are considered to be 'ill-conditioned' and not normally suitable to direct inversion techniques. Iterative methods like the Twomey non-linear perturbation technique (Twomey, 1975) or the Expectation-Maximisation (EMax) algorithm (Maher and Laird, 1985) have both been used on diffusion battery data with good results.

Twomey Algorithm

The iterative solution using the Twomey algorithm involves the repetitive estimation of the activity of each size interval according to the rule

$$N_j^{p+1} = N_j^p \left[1 + P_{ij} \left[\frac{Z_i}{(\Sigma_j P_{ij} N_j^p)} - 1 \right] \right]$$

where N_{jp+1} and N_{jp} are the estimates of the j^{th} size interval activity from the $p+1^{th}$ and p^{th} estimate, respectively.

Expectation Maximisation Algorithm (EMax)

Similarly, the EMax algorithm uses the iterative rule

$$N_j^{p+1} = N_j^p \left[\frac{\sum_i Z_i P_{ij}}{\sum_j P_{ij} N_j^p}\right]\left[\frac{1}{\sum_i P_{ij}}\right]$$

In general, both algorithms lead to similar solutions. The Twomey method comes to its solution in fewer iterations than the Emax algorithm, since the number of solution updates per iteration is greater by a factor equal to the number of battery stages. This is offset by the greater stability of the EMax algorithm due to averaging over the entire data set in each iteration.

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Appendix 2: Detailed hourly outputs for all CDB locations

Location ID 1 420 Drill Maintenance Workshop 2/12/13

Rn Progeny Particle Size Spectrometer

Logged at 22:43:46 on 01-20-2014
Repeat 021213OD with 60 minutes

BATTERY SPECIFICATIONS

Stage	No/Scrns	Mesh	Scrn Dia	Flow	Effic	BGcpm
1	0	Flter	3.8	0.80	0.099	0.00
2	1	100	0.7	0.80	0.091	0.00
3	1	100	3.8	0.80	0.103	0.00
4	10	100	3.8	0.80	0.105	0.00
5	80	100	3.8	0.80	0.106	0.00
6	0	0.0	0.70	0.187	0.00	

Battery Inlet Tube (cm) = 0.00 Battery Outlet Tube (cm) = 4.00

SCREEN SPECIFICATIONS

Label	Mesh No.	Wire Dia. (microns)	Thickness (microns)	Solid Frac %	Comments
A	100	112.00	215.00	31.00	ARL 100 Mesh Screen
B	200	35.00	80.00	29.00	ARL 200 Mesh Screen
C	400	24.00	53.00	30.00	ARL 400 Mesh Screen
D	635	20.00	50.00	35.00	EML 635 Mesh Screen
F	Flter	0.00	0.00	0.00	Filter
T	Tube	0.00	0.00	0.00	ARL Cyl Tube Battery

IMPACTOR SPECIFICATIONS

Impactor Curve Fits with Simoid Fit

Stage	Dp50 (nm)	Dp50LB (nm)	Dp50UB (nm)	Slope	Intrcpt	Flow (lpm)	Effic	BGcpm
1	500.00	450.00	550.00	1.230	2.020	0.7	0.187	0.00

DECONVOLUTION ANALYSIS

Twomey Algorithm : Y No of Iterations : 2000 Twomey Speed : 0.70
EMax Algorithm : Y Max Iterations : 5000 Converg Criteria : 100[ppm]
No of Size Ranges : 43
Smallest Diameter : 0.60 (nm)
Largest Diameter : 2493.90 (nm)

PARAMETER SPECIFICATIONS

Effective Energy (Mev) = 7.200
Convrsn Factor (per WL) = 130000
Acquisition Time (secs) = 3600
Particle Density (g/cm3) = 1.00

Location ID 1 420 Drill Maintenance Workshop 2/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 1 Analysis Time : 22:44:06 on 01-20-2014
Sampling Time : 10:16:32 on 12-02-2013

Measd nJ/m3	58	3	68	40	19	2
Twmy Fit :	63	5	60	43	19	2
EMax Fit :	62	4	60	44	19	2

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.009		0.0 0.011	
26.0	.79E-04	0.5 1.767		0.4 1.365	
31.7	.54E-04	0.9 3.613		0.8 3.233	
38.7	.37E-04	0.1 0.535		0.2 0.947	
47.2	.26E-04	0.0 0.029		0.0 0.139	
57.5	.18E-04	0.0 0.002		0.0 0.026	
70.1	.12E-04	0.0 0.000		0.0 0.010	
85.5	.87E-05	0.0 0.000		0.0 0.008	
104.3	.62E-05	0.0 0.000		0.0 0.012	
127.2	.44E-05	0.0 0.001		0.0 0.030	
155.1	.32E-05	0.0 0.007		0.0 0.090	
189.1	.24E-05	0.0 0.049		0.1 0.275	
230.7	.18E-05	0.1 0.319		0.2 0.756	
281.3	.13E-05	0.4 1.491		0.4 1.644	
343.0	.10E-05	0.8 3.066		0.6 2.163	
418.3	.78E-06	0.2 0.714		0.2 0.846	
510.0	.61E-06	0.0 0.002		0.0 0.044	
622.0	.48E-06	0.0 0.000		0.0 0.003	
758.4	.38E-06	0.0 0.000		0.0 0.001	
924.9	.30E-06	0.0 0.000		0.0 0.001	
1128	.24E-06	0.0 0.000		0.0 0.001	
1375	.19E-06	0.0 0.000		0.0 0.000	
1677	.15E-06	0.0 0.000		0.0 0.000	
2045	.12E-06	0.0 0.000		0.0 0.000	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 1 420 Drill Maintenance Workshop 2/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 2 Analysis Time : 22:44:26 on 01-20-2014
Sampling Time : 11:16:32 on 12-02-2013

Measd nJ/m3	122	6	129	77	33	3
Twmy Fit :	121	8	116	84	32	3
EMax Fit :	123	8	118	86	32	3

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.001	
26.0	.79E-04	0.1 0.269		0.2 0.436	
31.7	.54E-04	1.8 3.627		1.7 3.312	
38.7	.37E-04	1.1 2.164		1.0 2.008	
47.2	.26E-04	0.2 0.305		0.2 0.443	
57.5	.18E-04	0.0 0.035		0.0 0.097	
70.1	.12E-04	0.0 0.007		0.0 0.036	
85.5	.87E-05	0.0 0.004		0.0 0.026	
104.3	.62E-05	0.0 0.005		0.0 0.034	
127.2	.44E-05	0.0 0.011		0.0 0.067	
155.1	.32E-05	0.0 0.038		0.1 0.160	
189.1	.24E-05	0.1 0.159		0.2 0.395	
230.7	.18E-05	0.3 0.625		0.5 0.892	
281.3	.13E-05	0.9 1.803		0.8 1.593	
343.0	.10E-05	1.1 2.268		0.8 1.654	
418.3	.78E-06	0.1 0.287		0.2 0.439	
510.0	.61E-06	0.0 0.000		0.0 0.012	
622.0	.48E-06	0.0 0.000		0.0 0.000	
758.4	.38E-06	0.0 0.000		0.0 0.000	
924.9	.30E-06	0.0 0.000		0.0 0.000	
1128	.24E-06	0.0 0.000		0.0 0.000	
1375	.19E-06	0.0 0.000		0.0 0.000	
1677	.15E-06	0.0 0.000		0.0 0.000	
2045	.12E-06	0.0 0.000		0.0 0.000	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 1 420 Drill Maintenance Workshop 2/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 3 Analysis Time : 22:44:45 on 01-20-2014
Sampling Time : 12:16:32 on 12-02-2013

Measd nJ/m3	140	6	138	85	42	3
Twmy Fit :	130	9	125	93	41	3
EMax Fit :	136	9	130	95	41	3

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS dC dC/ClogdDp RESULTS	EMAX ANALYSIS dC dC/ClogdDp RESULTS
0.6	.77E-01	0.0 0.000	0.0 0.000
0.7	.59E-01	0.0 0.000	0.0 0.000
0.9	.44E-01	0.0 0.000	0.0 0.000
1.1	.33E-01	0.0 0.000	0.0 0.000
1.3	.25E-01	0.0 0.000	0.0 0.000
1.6	.18E-01	0.0 0.000	0.0 0.000
2.0	.12E-01	0.0 0.000	0.0 0.000
2.4	.86E-02	0.0 0.000	0.0 0.000
2.9	.58E-02	0.0 0.000	0.0 0.000
3.6	.39E-02	0.0 0.000	0.0 0.000
4.4	.27E-02	0.0 0.000	0.0 0.000
5.3	.18E-02	0.0 0.000	0.0 0.000
6.5	.12E-02	0.0 0.000	0.0 0.000
7.9	.82E-03	0.0 0.000	0.0 0.000
9.6	.55E-03	0.0 0.000	0.0 0.000
11.8	.37E-03	0.0 0.000	0.0 0.000
14.3	.25E-03	0.0 0.000	0.0 0.000
17.5	.17E-03	0.0 0.000	0.0 0.000
21.3	.12E-03	0.0 0.002	0.0 0.007
26.0	.79E-04	0.6 1.091	0.9 1.509
31.7	.54E-04	2.0 3.683	1.9 3.315
38.7	.37E-04	0.3 0.598	0.4 0.662
47.2	.26E-04	0.0 0.029	0.0 0.062
57.5	.18E-04	0.0 0.002	0.0 0.008
70.1	.12E-04	0.0 0.000	0.0 0.003
85.5	.87E-05	0.0 0.000	0.0 0.002
104.3	.62E-05	0.0 0.000	0.0 0.005
127.2	.44E-05	0.0 0.001	0.0 0.016
155.1	.32E-05	0.0 0.010	0.0 0.067
189.1	.24E-05	0.0 0.084	0.2 0.281
230.7	.18E-05	0.3 0.625	0.6 0.988
281.3	.13E-05	1.5 2.693	1.3 2.321
343.0	.10E-05	1.5 2.740	1.2 2.165
418.3	.78E-06	0.0 0.049	0.1 0.194
510.0	.61E-06	0.0 0.000	0.0 0.000
622.0	.48E-06	0.0 0.000	0.0 0.000
758.4	.38E-06	0.0 0.000	0.0 0.000
924.9	.30E-06	0.0 0.000	0.0 0.000
1128	.24E-06	0.0 0.000	0.0 0.000
1375	.19E-06	0.0 0.000	0.0 0.000
1677	.15E-06	0.0 0.000	0.0 0.000
2045	.12E-06	0.0 0.000	0.0 0.000
2494	.10E-06	0.0 0.000	0.0 0.000

Location ID 1 420 Drill Maintenance Workshop 2/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 4 Analysis Time : 22:45:05 on 01-20-2014
Sampling Time : 13:16:32 on 12-02-2013

Measd nJ/m3	132	9	145	90	44	3
Twmy Fit :	140	11	134	95	44	3
EMax Fit :	139	10	133	96	44	3

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.005		0.0 0.005	
21.3	.12E-03	0.5 0.928		0.5 0.858	
26.0	.79E-04	2.0 3.415		1.7 3.004	
31.7	.54E-04	0.5 0.890		0.6 1.077	
38.7	.37E-04	0.0 0.061		0.1 0.143	
47.2	.26E-04	0.0 0.003		0.0 0.018	
57.5	.18E-04	0.0 0.000		0.0 0.004	
70.1	.12E-04	0.0 0.000		0.0 0.002	
85.5	.87E-05	0.0 0.000		0.0 0.003	
104.3	.62E-05	0.0 0.000		0.0 0.008	
127.2	.44E-05	0.0 0.002		0.0 0.029	
155.1	.32E-05	0.0 0.018		0.1 0.120	
189.1	.24E-05	0.1 0.159		0.3 0.471	
230.7	.18E-05	0.6 1.083		0.8 1.461	
281.3	.13E-05	2.0 3.496		1.6 2.762	
343.0	.10E-05	0.9 1.543		0.9 1.599	
418.3	.78E-06	0.0 0.002		0.0 0.041	
510.0	.61E-06	0.0 0.000		0.0 0.000	
622.0	.48E-06	0.0 0.000		0.0 0.000	
758.4	.38E-06	0.0 0.000		0.0 0.000	
924.9	.30E-06	0.0 0.000		0.0 0.000	
1128	.24E-06	0.0 0.000		0.0 0.000	
1375	.19E-06	0.0 0.000		0.0 0.000	
1677	.15E-06	0.0 0.000		0.0 0.000	
2045	.12E-06	0.0 0.000		0.0 0.000	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 1 420 Drill Maintenance Workshop 2/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 5 Analysis Time : 22:45:25 on 01-20-2014
Sampling Time : 14:16:32 on 12-02-2013

Measd nJ/m3	144	8	136	81	37	3
Twmy Fit :	132	10	126	88	37	3
EMax Fit :	138	11	131	90	36	3

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.044		0.1 0.121	
26.0	.79E-04	1.7 3.085		2.1 3.644	
31.7	.54E-04	1.5 2.804		1.3 2.329	
38.7	.37E-04	0.1 0.216		0.1 0.226	
47.2	.26E-04	0.0 0.007		0.0 0.015	
57.5	.18E-04	0.0 0.000		0.0 0.002	
70.1	.12E-04	0.0 0.000		0.0 0.001	
85.5	.87E-05	0.0 0.000		0.0 0.001	
104.3	.62E-05	0.0 0.000		0.0 0.002	
127.2	.44E-05	0.0 0.001		0.0 0.007	
155.1	.32E-05	0.0 0.006		0.0 0.037	
189.1	.24E-05	0.0 0.060		0.1 0.195	
230.7	.18E-05	0.3 0.530		0.5 0.821	
281.3	.13E-05	1.4 2.503		1.2 2.152	
343.0	.10E-05	1.3 2.327		1.1 1.939	
418.3	.78E-06	0.0 0.022		0.1 0.116	
510.0	.61E-06	0.0 0.000		0.0 0.000	
622.0	.48E-06	0.0 0.000		0.0 0.000	
758.4	.38E-06	0.0 0.000		0.0 0.000	
924.9	.30E-06	0.0 0.000		0.0 0.000	
1128	.24E-06	0.0 0.000		0.0 0.000	
1375	.19E-06	0.0 0.000		0.0 0.000	
1677	.15E-06	0.0 0.000		0.0 0.000	
2045	.12E-06	0.0 0.000		0.0 0.000	
2494	.10E-06	0.0 0.000		0.0 0.000	

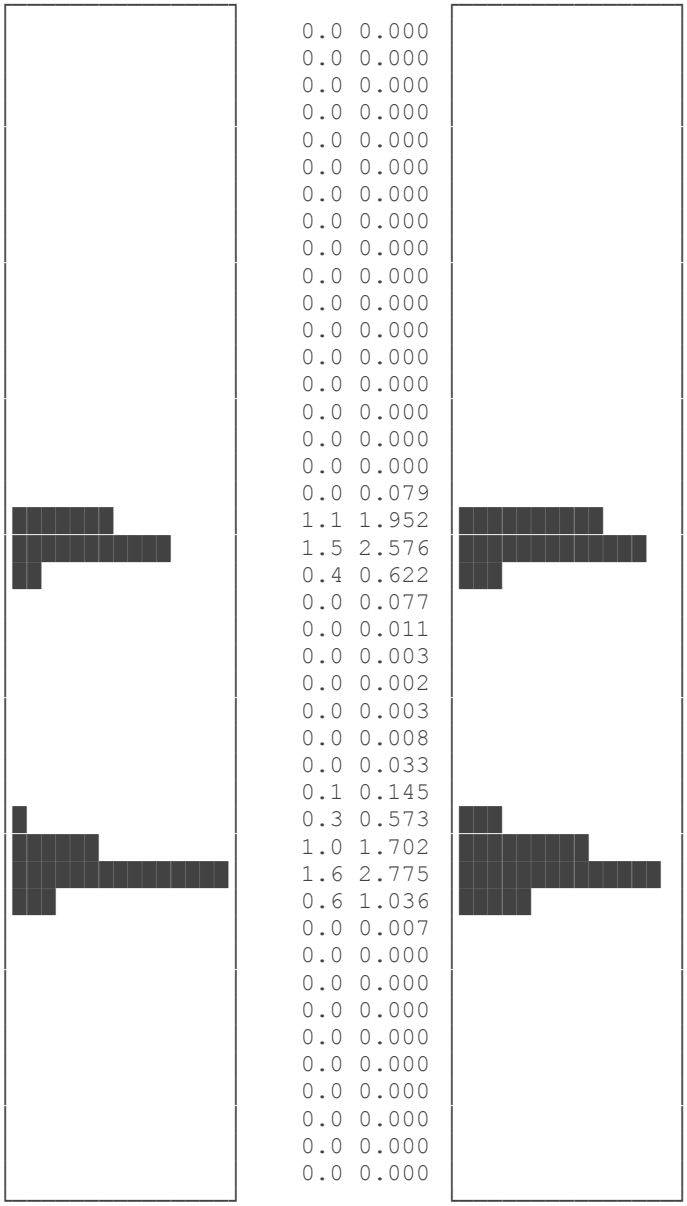
Location ID 1 420 Drill Maintenance Workshop 2/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 6 Analysis Time : 22:45:45 on 01-20-2014
Sampling Time : 15:16:32 on 12-02-2013

Measd nJ/m3	136	10	135	86	41	2
Twmy Fit :	135	11	128	89	41	2
EMax Fit :	136	11	129	90	41	2

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS dC	TWOMEY ANALYSIS dC/ClogdDp	EMAX ANALYSIS dC	EMAX ANALYSIS dC/ClogdDp
0.6	.77E-01	0.0	0.000	0.0	0.000
0.7	.59E-01	0.0	0.000	0.0	0.000
0.9	.44E-01	0.0	0.000	0.0	0.000
1.1	.33E-01	0.0	0.000	0.0	0.000
1.3	.25E-01	0.0	0.000	0.0	0.000
1.6	.18E-01	0.0	0.000	0.0	0.000
2.0	.12E-01	0.0	0.000	0.0	0.000
2.4	.86E-02	0.0	0.000	0.0	0.000
2.9	.58E-02	0.0	0.000	0.0	0.000
3.6	.39E-02	0.0	0.000	0.0	0.000
4.4	.27E-02	0.0	0.000	0.0	0.000
5.3	.18E-02	0.0	0.000	0.0	0.000
6.5	.12E-02	0.0	0.000	0.0	0.000
7.9	.82E-03	0.0	0.000	0.0	0.000
9.6	.55E-03	0.0	0.000	0.0	0.000
11.8	.37E-03	0.0	0.000	0.0	0.000
14.3	.25E-03	0.0	0.000	0.0	0.000
17.5	.17E-03	0.0	0.066	0.0	0.079
21.3	.12E-03	1.0	1.862	1.1	1.952
26.0	.79E-04	1.6	2.778	1.5	2.576
31.7	.54E-04	0.3	0.606	0.4	0.622
38.7	.37E-04	0.0	0.053	0.0	0.077
47.2	.26E-04	0.0	0.004	0.0	0.011
57.5	.18E-04	0.0	0.001	0.0	0.003
70.1	.12E-04	0.0	0.000	0.0	0.002
85.5	.87E-05	0.0	0.000	0.0	0.003
104.3	.62E-05	0.0	0.001	0.0	0.008
127.2	.44E-05	0.0	0.006	0.0	0.033
155.1	.32E-05	0.0	0.041	0.1	0.145
189.1	.24E-05	0.2	0.290	0.3	0.573
230.7	.18E-05	0.9	1.513	1.0	1.702
281.3	.13E-05	2.0	3.493	1.6	2.775
343.0	.10E-05	0.5	0.891	0.6	1.036
418.3	.78E-06	0.0	0.000	0.0	0.007
510.0	.61E-06	0.0	0.000	0.0	0.000
622.0	.48E-06	0.0	0.000	0.0	0.000
758.4	.38E-06	0.0	0.000	0.0	0.000
924.9	.30E-06	0.0	0.000	0.0	0.000
1128	.24E-06	0.0	0.000	0.0	0.000
1375	.19E-06	0.0	0.000	0.0	0.000
1677	.15E-06	0.0	0.000	0.0	0.000
2045	.12E-06	0.0	0.000	0.0	0.000
2494	.10E-06	0.0	0.000	0.0	0.000



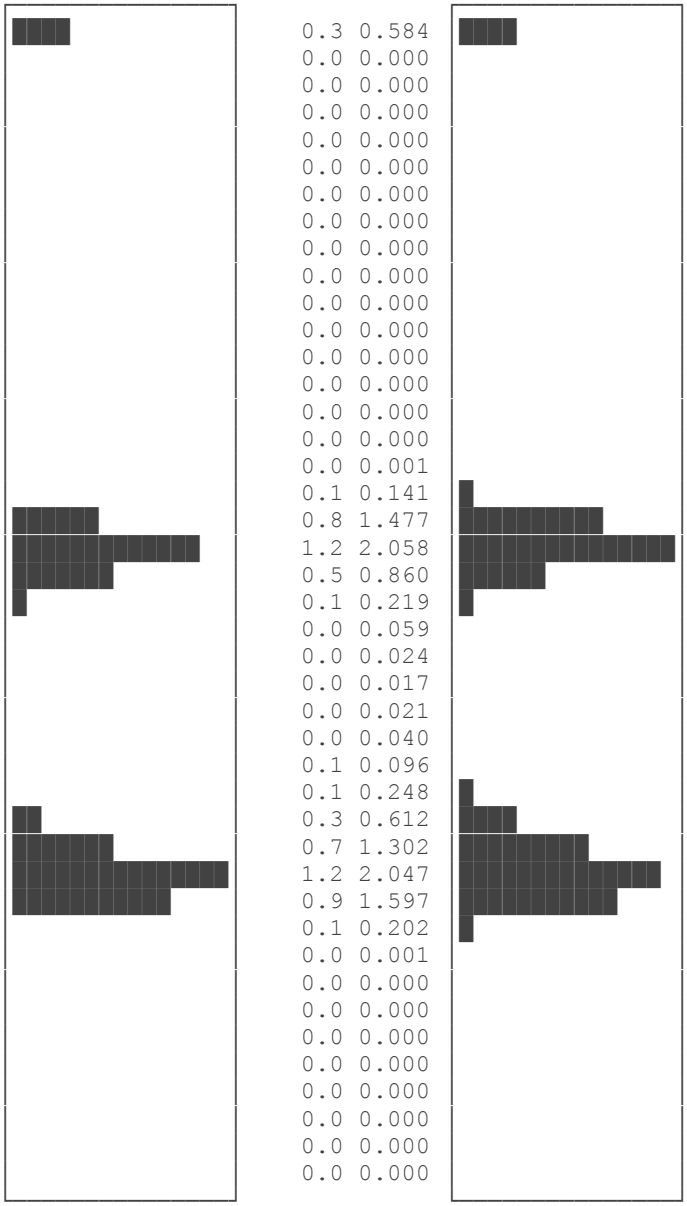
Location ID 1 420 Drill Maintenance Workshop 2/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 7 Analysis Time : 22:46:05 on 01-20-2014
Sampling Time : 16:18:32 on 12-02-2013

Measd nJ/m3	139	10	124	86	41	3
Twmy Fit :	133	11	121	88	40	3
EMax Fit :	135	11	124	89	40	3

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS dC	TWOMEY ANALYSIS dC/dlogDp	EMAX ANALYSIS dC	EMAX ANALYSIS dC/dlogDp
0.6	.77E-01	0.4	0.725	0.3	0.584
0.7	.59E-01	0.0	0.000	0.0	0.000
0.9	.44E-01	0.0	0.000	0.0	0.000
1.1	.33E-01	0.0	0.000	0.0	0.000
1.3	.25E-01	0.0	0.000	0.0	0.000
1.6	.18E-01	0.0	0.000	0.0	0.000
2.0	.12E-01	0.0	0.000	0.0	0.000
2.4	.86E-02	0.0	0.000	0.0	0.000
2.9	.58E-02	0.0	0.000	0.0	0.000
3.6	.39E-02	0.0	0.000	0.0	0.000
4.4	.27E-02	0.0	0.000	0.0	0.000
5.3	.18E-02	0.0	0.000	0.0	0.000
6.5	.12E-02	0.0	0.000	0.0	0.000
7.9	.82E-03	0.0	0.000	0.0	0.000
9.6	.55E-03	0.0	0.000	0.0	0.000
11.8	.37E-03	0.0	0.000	0.0	0.000
14.3	.25E-03	0.0	0.000	0.0	0.001
17.5	.17E-03	0.0	0.068	0.1	0.141
21.3	.12E-03	0.6	1.050	0.8	1.477
26.0	.79E-04	1.2	2.137	1.2	2.058
31.7	.54E-04	0.6	1.112	0.5	0.860
38.7	.37E-04	0.2	0.287	0.1	0.219
47.2	.26E-04	0.0	0.065	0.0	0.059
57.5	.18E-04	0.0	0.020	0.0	0.024
70.1	.12E-04	0.0	0.011	0.0	0.017
85.5	.87E-05	0.0	0.011	0.0	0.021
104.3	.62E-05	0.0	0.020	0.0	0.040
127.2	.44E-05	0.0	0.048	0.1	0.096
155.1	.32E-05	0.1	0.144	0.1	0.248
189.1	.24E-05	0.2	0.441	0.3	0.612
230.7	.18E-05	0.7	1.197	0.7	1.302
281.3	.13E-05	1.3	2.312	1.2	2.047
343.0	.10E-05	1.0	1.840	0.9	1.597
418.3	.78E-06	0.1	0.116	0.1	0.202
510.0	.61E-06	0.0	0.000	0.0	0.001
622.0	.48E-06	0.0	0.000	0.0	0.000
758.4	.38E-06	0.0	0.000	0.0	0.000
924.9	.30E-06	0.0	0.000	0.0	0.000
1128	.24E-06	0.0	0.000	0.0	0.000
1375	.19E-06	0.0	0.000	0.0	0.000
1677	.15E-06	0.0	0.000	0.0	0.000
2045	.12E-06	0.0	0.000	0.0	0.000
2494	.10E-06	0.0	0.000	0.0	0.000



Location ID 1 420 Drill Maintenance Workshop 2/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 8 Analysis Time : 22:46:25 on 01-20-2014
Sampling Time : 17:18:32 on 12-02-2013

Measd nJ/m3	128	10	120	88	41	3
Twmy Fit :	127	10	120	89	41	3
EMax Fit :	128	10	120	89	41	3

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.083		0.1 0.099	
0.7	.59E-01	0.0 0.026		0.0 0.006	
0.9	.44E-01	0.0 0.008		0.0 0.001	
1.1	.33E-01	0.0 0.002		0.0 0.000	
1.3	.25E-01	0.0 0.001		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.003		0.0 0.002	
7.9	.82E-03	0.0 0.014		0.0 0.010	
9.6	.55E-03	0.0 0.063		0.0 0.059	
11.8	.37E-03	0.1 0.220		0.1 0.240	
14.3	.25E-03	0.3 0.522		0.3 0.590	
17.5	.17E-03	0.4 0.797		0.5 0.852	
21.3	.12E-03	0.4 0.820		0.4 0.794	
26.0	.79E-04	0.3 0.630		0.3 0.555	
31.7	.54E-04	0.2 0.409		0.2 0.341	
38.7	.37E-04	0.1 0.255		0.1 0.211	
47.2	.26E-04	0.1 0.171		0.1 0.148	
57.5	.18E-04	0.1 0.136		0.1 0.127	
70.1	.12E-04	0.1 0.133		0.1 0.137	
85.5	.87E-05	0.1 0.162		0.1 0.180	
104.3	.62E-05	0.1 0.231		0.1 0.271	
127.2	.44E-05	0.2 0.366		0.2 0.434	
155.1	.32E-05	0.3 0.603		0.4 0.695	
189.1	.24E-05	0.5 0.976		0.6 1.062	
230.7	.18E-05	0.8 1.461		0.8 1.478	
281.3	.13E-05	1.0 1.822		0.9 1.715	
343.0	.10E-05	0.8 1.416		0.7 1.288	
418.3	.78E-06	0.1 0.274		0.2 0.302	
510.0	.61E-06	0.0 0.003		0.0 0.010	
622.0	.48E-06	0.0 0.000		0.0 0.000	
758.4	.38E-06	0.0 0.000		0.0 0.000	
924.9	.30E-06	0.0 0.000		0.0 0.000	
1128	.24E-06	0.0 0.000		0.0 0.000	
1375	.19E-06	0.0 0.000		0.0 0.000	
1677	.15E-06	0.0 0.000		0.0 0.000	
2045	.12E-06	0.0 0.000		0.0 0.000	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 5	49 MB52 Exploration Drive	3/12/13

Rn Progeny Particle Size Spectrometer

Logged at 08:48:15 on 12-03-2013

BATTERY SPECIFICATIONS

Stage	No/Scrns	Mesh	Scrn Dia	Flow	Effic	BGcpm
1	0	Flter	3.8	0.80	0.127	0.00
2	1	100	0.7	0.80	0.108	0.00
3	1	100	3.8	0.80	0.130	0.00
4	10	100	3.8	0.80	0.130	0.00
5	80	100	3.8	0.80	0.130	0.00
6	0	0.0	0.70	0.220	0.00	

Battery Inlet Tube (cm) = 0.00 Battery Outlet Tube (cm) = 4.00

SCREEN SPECIFICATIONS

Label	Mesh No.	Wire Dia. (microns)	Thickness (microns)	Solid Frac %	Comments
A	100	112.00	215.00	31.30	ARL 100 Mesh Screen
B	200	35.00	80.00	29.10	ARL 200 Mesh Screen
C	400	24.00	53.00	30.20	ARL 400 Mesh Screen
D	635	20.00	50.00	34.50	EML 635 Mesh Screen
F	Flter	0.00	0.00	0.00	Filter
T	Tube	0.00	0.00	0.00	ARL Cyl Tube Battery

IMPACTOR SPECIFICATIONS

Impactor Curve Fits with Simoid Fit

Stage	Dp50 (nm)	Dp50LB (nm)	Dp50UB (nm)	Slope	Intrcpt	Flow (lpm)	Effic	BGcpm
1	500.00	450.00	550.00	1.230	2.020	0.7	0.220	0.00

DECONVOLUTION ANALYSIS

Twomey Algorithm : Y No of Iterations : 1000 Twomey Speed : 0.70
EMax Algorithm : Y Max Iterations : 2000 Converg Criteria : 100[ppm]
No of Size Ranges : 43
Smallest Diameter : 0.60 (nm)
Largest Diameter : 2493.90 (nm)

PARAMETER SPECIFICATIONS

Effective Energy (Mev) = 7.200
Convrsn Factor (per WL) = 130000
Acquisition Time (secs) = 3600
Particle Density (g/cm3) = 1.00

Location ID 5	49 MB52 Exploration Drive	3/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 1 Analysis Time : 09:48:16 on 12-03-2013
Sampling Time : 09:48:15 on 12-03-2013

Measd nJ/m3	656	23	698	472	252	5
Twmy Fit :	631	30	616	515	246	7
EMax Fit :	653	31	638	533	245	6

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS RESULTS dC	dC/ClogdDp	EMAX ANALYSIS RESULTS dC	dC/ClogdDp
0.6	.77E-01	0.0	0.000	0.0	0.000
0.7	.59E-01	0.0	0.000	0.0	0.000
0.9	.44E-01	0.0	0.000	0.0	0.000
1.1	.33E-01	0.0	0.000	0.0	0.000
1.3	.25E-01	0.0	0.000	0.0	0.000
1.6	.18E-01	0.0	0.000	0.0	0.000
2.0	.12E-01	0.0	0.000	0.0	0.000
2.4	.86E-02	0.0	0.000	0.0	0.000
2.9	.58E-02	0.0	0.000	0.0	0.000
3.6	.39E-02	0.0	0.000	0.0	0.000
4.4	.27E-02	0.0	0.000	0.0	0.000
5.3	.18E-02	0.0	0.000	0.0	0.000
6.5	.12E-02	0.0	0.000	0.0	0.000
7.9	.82E-03	0.0	0.000	0.0	0.000
9.6	.55E-03	0.0	0.000	0.0	0.000
11.8	.37E-03	0.0	0.000	0.0	0.000
14.3	.25E-03	0.0	0.000	0.0	0.000
17.5	.17E-03	0.0	0.000	0.0	0.003
21.3	.12E-03	0.2	0.081	0.5	0.187
26.0	.79E-04	2.5	0.958	2.3	0.854
31.7	.54E-04	2.6	1.003	2.0	0.734
38.7	.37E-04	0.7	0.266	0.8	0.282
47.2	.26E-04	0.1	0.046	0.3	0.096
57.5	.18E-04	0.0	0.011	0.1	0.047
70.1	.12E-04	0.0	0.006	0.1	0.040
85.5	.87E-05	0.0	0.008	0.2	0.062
104.3	.62E-05	0.1	0.022	0.4	0.146
127.2	.44E-05	0.3	0.103	1.2	0.425
155.1	.32E-05	1.5	0.560	3.3	1.229
189.1	.24E-05	6.5	2.472	7.6	2.809
230.7	.18E-05	12.9	4.928	9.7	3.585
281.3	.13E-05	3.0	1.141	3.0	1.099
343.0	.10E-05	0.0	0.000	0.0	0.006
418.3	.78E-06	0.0	0.000	0.0	0.000
510.0	.61E-06	0.0	0.000	0.0	0.000
622.0	.48E-06	0.0	0.000	0.0	0.000
758.4	.38E-06	0.0	0.000	0.0	0.000
924.9	.30E-06	0.0	0.000	0.0	0.000
1128	.24E-06	0.0	0.000	0.0	0.000
1375	.19E-06	0.0	0.000	0.0	0.000
1677	.15E-06	0.0	0.000	0.0	0.000
2045	.12E-06	0.0	0.000	0.0	0.000
2494	.10E-06	0.0	0.000	0.0	0.000

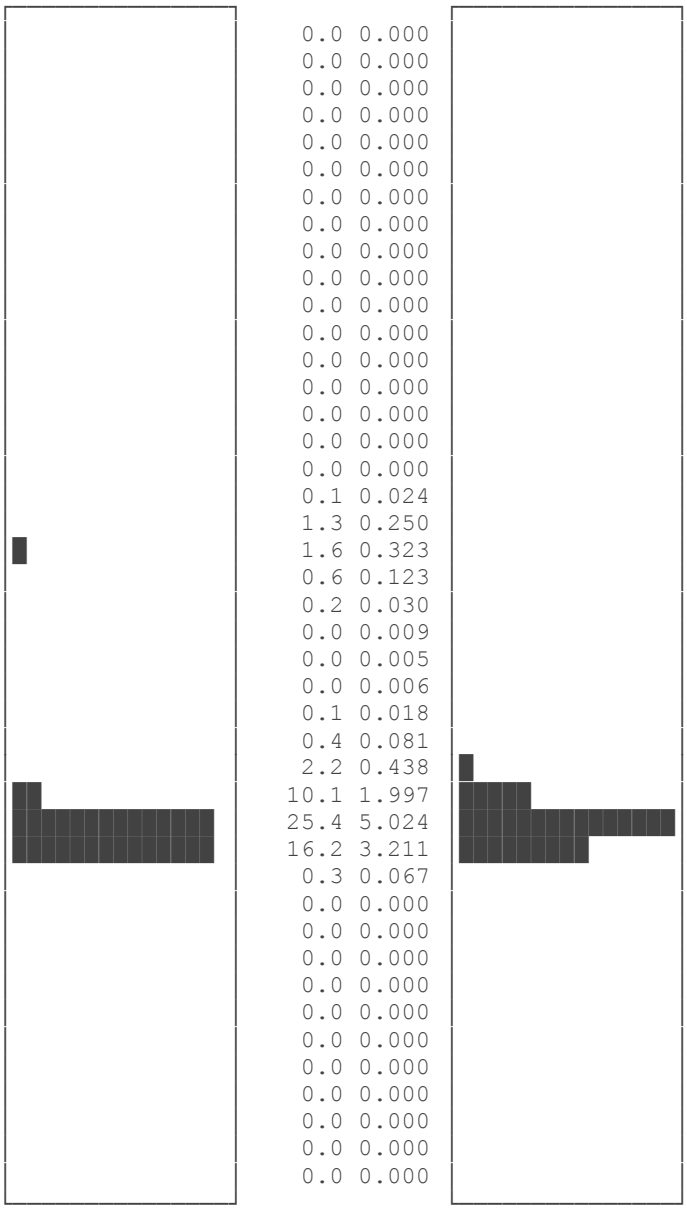
Location ID 5	49 MB52 Exploration Drive	3/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 2 Analysis Time : 10:48:16 on 12-03-2013
Sampling Time : 10:48:15 on 12-03-2013

Measd nJ/m3	1228	32	1285	945	527	4
Twmy Fit :	1177	39	1158	1022	509	11
EMax Fit :	1217	41	1197	1054	504	9

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS dC	TWOMEY ANALYSIS dC/dlogDp	EMAX ANALYSIS dC	EMAX ANALYSIS dC/dlogDp
0.6	.77E-01	0.0	0.000	0.0	0.000
0.7	.59E-01	0.0	0.000	0.0	0.000
0.9	.44E-01	0.0	0.000	0.0	0.000
1.1	.33E-01	0.0	0.000	0.0	0.000
1.3	.25E-01	0.0	0.000	0.0	0.000
1.6	.18E-01	0.0	0.000	0.0	0.000
2.0	.12E-01	0.0	0.000	0.0	0.000
2.4	.86E-02	0.0	0.000	0.0	0.000
2.9	.58E-02	0.0	0.000	0.0	0.000
3.6	.39E-02	0.0	0.000	0.0	0.000
4.4	.27E-02	0.0	0.000	0.0	0.000
5.3	.18E-02	0.0	0.000	0.0	0.000
6.5	.12E-02	0.0	0.000	0.0	0.000
7.9	.82E-03	0.0	0.000	0.0	0.000
9.6	.55E-03	0.0	0.000	0.0	0.000
11.8	.37E-03	0.0	0.000	0.0	0.000
14.3	.25E-03	0.0	0.000	0.0	0.000
17.5	.17E-03	0.0	0.009	0.1	0.024
21.3	.12E-03	1.2	0.247	1.3	0.250
26.0	.79E-04	2.2	0.456	1.6	0.323
31.7	.54E-04	0.7	0.141	0.6	0.123
38.7	.37E-04	0.1	0.018	0.2	0.030
47.2	.26E-04	0.0	0.002	0.0	0.009
57.5	.18E-04	0.0	0.001	0.0	0.005
70.1	.12E-04	0.0	0.001	0.0	0.006
85.5	.87E-05	0.0	0.001	0.1	0.018
104.3	.62E-05	0.0	0.008	0.4	0.081
127.2	.44E-05	0.4	0.083	2.2	0.438
155.1	.32E-05	4.2	0.866	10.1	1.997
189.1	.24E-05	23.8	4.872	25.4	5.024
230.7	.18E-05	23.7	4.852	16.2	3.211
281.3	.13E-05	0.2	0.048	0.3	0.067
343.0	.10E-05	0.0	0.000	0.0	0.000
418.3	.78E-06	0.0	0.000	0.0	0.000
510.0	.61E-06	0.0	0.000	0.0	0.000
622.0	.48E-06	0.0	0.000	0.0	0.000
758.4	.38E-06	0.0	0.000	0.0	0.000
924.9	.30E-06	0.0	0.000	0.0	0.000
1128	.24E-06	0.0	0.000	0.0	0.000
1375	.19E-06	0.0	0.000	0.0	0.000
1677	.15E-06	0.0	0.000	0.0	0.000
2045	.12E-06	0.0	0.000	0.0	0.000
2494	.10E-06	0.0	0.000	0.0	0.000



Location ID 5	49 MB52 Exploration Drive	3/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 3 Analysis Time : 11:48:17 on 12-03-2013
Sampling Time : 11:48:15 on 12-03-2013

Measd nJ/m3	1384	44	1464	1087	624	4
Twmy Fit :	1364	51	1339	1172	598	13
EMax Fit :	1392	51	1367	1197	589	11

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.005		0.1 0.016	
17.5	.17E-03	1.1 0.202		1.5 0.251	
21.3	.12E-03	3.2 0.558		2.4 0.410	
26.0	.79E-04	1.1 0.188		0.8 0.141	
31.7	.54E-04	0.1 0.017		0.1 0.022	
38.7	.37E-04	0.0 0.001		0.0 0.003	
47.2	.26E-04	0.0 0.000		0.0 0.001	
57.5	.18E-04	0.0 0.000		0.0 0.000	
70.1	.12E-04	0.0 0.000		0.0 0.001	
85.5	.87E-05	0.0 0.000		0.0 0.003	
104.3	.62E-05	0.0 0.001		0.1 0.021	
127.2	.44E-05	0.1 0.020		1.1 0.192	
155.1	.32E-05	2.4 0.423		8.2 1.422	
189.1	.24E-05	24.1 4.252		30.0 5.197	
230.7	.18E-05	33.4 5.895		22.4 3.870	
281.3	.13E-05	0.2 0.044		0.3 0.057	
343.0	.10E-05	0.0 0.000		0.0 0.000	
418.3	.78E-06	0.0 0.000		0.0 0.000	
510.0	.61E-06	0.0 0.000		0.0 0.000	
622.0	.48E-06	0.0 0.000		0.0 0.000	
758.4	.38E-06	0.0 0.000		0.0 0.000	
924.9	.30E-06	0.0 0.000		0.0 0.000	
1128	.24E-06	0.0 0.000		0.0 0.000	
1375	.19E-06	0.0 0.000		0.0 0.000	
1677	.15E-06	0.0 0.000		0.0 0.000	
2045	.12E-06	0.0 0.000		0.0 0.000	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 5	49 MB52 Exploration Drive	3/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 4 Analysis Time : 12:48:17 on 12-03-2013
Sampling Time : 12:48:16 on 12-03-2013

Measd nJ/m3	1425	41	1463	1087	610	4
Twmy Fit :	1359	48	1336	1172	587	12
EMax Fit :	1403	50	1379	1207	580	11

Dp (nm)	DiffCoeff cm2/sec	dC	dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC	dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0	0.000		0.0	0.000	
0.7	.59E-01	0.0	0.000		0.0	0.000	
0.9	.44E-01	0.0	0.000		0.0	0.000	
1.1	.33E-01	0.0	0.000		0.0	0.000	
1.3	.25E-01	0.0	0.000		0.0	0.000	
1.6	.18E-01	0.0	0.000		0.0	0.000	
2.0	.12E-01	0.0	0.000		0.0	0.000	
2.4	.86E-02	0.0	0.000		0.0	0.000	
2.9	.58E-02	0.0	0.000		0.0	0.000	
3.6	.39E-02	0.0	0.000		0.0	0.000	
4.4	.27E-02	0.0	0.000		0.0	0.000	
5.3	.18E-02	0.0	0.000		0.0	0.000	
6.5	.12E-02	0.0	0.000		0.0	0.000	
7.9	.82E-03	0.0	0.000		0.0	0.000	
9.6	.55E-03	0.0	0.000		0.0	0.000	
11.8	.37E-03	0.0	0.000		0.0	0.000	
14.3	.25E-03	0.0	0.000		0.0	0.001	
17.5	.17E-03	0.3	0.049		0.5	0.083	
21.3	.12E-03	2.5	0.439		2.3	0.392	
26.0	.79E-04	2.1	0.374		1.7	0.290	
31.7	.54E-04	0.4	0.068		0.4	0.076	
38.7	.37E-04	0.0	0.006		0.1	0.014	
47.2	.26E-04	0.0	0.001		0.0	0.004	
57.5	.18E-04	0.0	0.000		0.0	0.002	
70.1	.12E-04	0.0	0.000		0.0	0.003	
85.5	.87E-05	0.0	0.001		0.1	0.010	
104.3	.62E-05	0.0	0.004		0.3	0.053	
127.2	.44E-05	0.3	0.055		2.0	0.345	
155.1	.32E-05	4.1	0.724		10.8	1.856	
189.1	.24E-05	27.5	4.863		30.2	5.187	
230.7	.18E-05	28.1	4.986		18.9	3.242	
281.3	.13E-05	0.2	0.035		0.3	0.049	
343.0	.10E-05	0.0	0.000		0.0	0.000	
418.3	.78E-06	0.0	0.000		0.0	0.000	
510.0	.61E-06	0.0	0.000		0.0	0.000	
622.0	.48E-06	0.0	0.000		0.0	0.000	
758.4	.38E-06	0.0	0.000		0.0	0.000	
924.9	.30E-06	0.0	0.000		0.0	0.000	
1128	.24E-06	0.0	0.000		0.0	0.000	
1375	.19E-06	0.0	0.000		0.0	0.000	
1677	.15E-06	0.0	0.000		0.0	0.000	
2045	.12E-06	0.0	0.000		0.0	0.000	
2494	.10E-06	0.0	0.000		0.0	0.000	

Location ID 5	49 MB52 Exploration Drive	3/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 5 Analysis Time : 13:48:17 on 12-03-2013
Sampling Time : 13:48:16 on 12-03-2013

Measd nJ/m3	1375	39	1460	1002	580	4
Twmy Fit :	1307	51	1282	1111	555	12
EMax Fit :	1360	53	1334	1154	548	10

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS dC	TWOMEY ANALYSIS dC/dlogDp	EMAX ANALYSIS dC	EMAX ANALYSIS dC/dlogDp
0.6	.77E-01	0.0	0.000	0.0	0.000
0.7	.59E-01	0.0	0.000	0.0	0.000
0.9	.44E-01	0.0	0.000	0.0	0.000
1.1	.33E-01	0.0	0.000	0.0	0.000
1.3	.25E-01	0.0	0.000	0.0	0.000
1.6	.18E-01	0.0	0.000	0.0	0.000
2.0	.12E-01	0.0	0.000	0.0	0.000
2.4	.86E-02	0.0	0.000	0.0	0.000
2.9	.58E-02	0.0	0.000	0.0	0.000
3.6	.39E-02	0.0	0.000	0.0	0.000
4.4	.27E-02	0.0	0.000	0.0	0.000
5.3	.18E-02	0.0	0.000	0.0	0.000
6.5	.12E-02	0.0	0.000	0.0	0.000
7.9	.82E-03	0.0	0.000	0.0	0.000
9.6	.55E-03	0.0	0.000	0.0	0.000
11.8	.37E-03	0.0	0.000	0.0	0.000
14.3	.25E-03	0.0	0.000	0.0	0.000
17.5	.17E-03	0.0	0.005	0.1	0.019
21.3	.12E-03	1.9	0.343	2.2	0.387
26.0	.79E-04	4.2	0.766	3.2	0.566
31.7	.54E-04	0.9	0.164	1.0	0.171
38.7	.37E-04	0.1	0.011	0.2	0.028
47.2	.26E-04	0.0	0.001	0.0	0.006
57.5	.18E-04	0.0	0.000	0.0	0.002
70.1	.12E-04	0.0	0.000	0.0	0.003
85.5	.87E-05	0.0	0.000	0.0	0.008
104.3	.62E-05	0.0	0.002	0.3	0.044
127.2	.44E-05	0.1	0.026	1.7	0.299
155.1	.32E-05	2.5	0.462	9.6	1.703
189.1	.24E-05	22.9	4.210	28.6	5.053
230.7	.18E-05	30.3	5.573	18.5	3.268
281.3	.13E-05	0.2	0.043	0.3	0.047
343.0	.10E-05	0.0	0.000	0.0	0.000
418.3	.78E-06	0.0	0.000	0.0	0.000
510.0	.61E-06	0.0	0.000	0.0	0.000
622.0	.48E-06	0.0	0.000	0.0	0.000
758.4	.38E-06	0.0	0.000	0.0	0.000
924.9	.30E-06	0.0	0.000	0.0	0.000
1128	.24E-06	0.0	0.000	0.0	0.000
1375	.19E-06	0.0	0.000	0.0	0.000
1677	.15E-06	0.0	0.000	0.0	0.000
2045	.12E-06	0.0	0.000	0.0	0.000
2494	.10E-06	0.0	0.000	0.0	0.000

Location ID 5	49 MB52 Exploration Drive	3/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 6 Analysis Time : 14:48:17 on 12-03-2013
Sampling Time : 14:48:16 on 12-03-2013

Measd nJ/m3	1314	41	1366	925	503	4
Twmy Fit :	1231	54	1204	1021	484	10
EMax Fit :	1286	57	1258	1063	479	9

Dp (nm)	DiffCoeff cm2/sec	dC	dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC	dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0	0.000		0.0	0.000	
0.7	.59E-01	0.0	0.000		0.0	0.000	
0.9	.44E-01	0.0	0.000		0.0	0.000	
1.1	.33E-01	0.0	0.000		0.0	0.000	
1.3	.25E-01	0.0	0.000		0.0	0.000	
1.6	.18E-01	0.0	0.000		0.0	0.000	
2.0	.12E-01	0.0	0.000		0.0	0.000	
2.4	.86E-02	0.0	0.000		0.0	0.000	
2.9	.58E-02	0.0	0.000		0.0	0.000	
3.6	.39E-02	0.0	0.000		0.0	0.000	
4.4	.27E-02	0.0	0.000		0.0	0.000	
5.3	.18E-02	0.0	0.000		0.0	0.000	
6.5	.12E-02	0.0	0.000		0.0	0.000	
7.9	.82E-03	0.0	0.000		0.0	0.000	
9.6	.55E-03	0.0	0.000		0.0	0.000	
11.8	.37E-03	0.0	0.000		0.0	0.000	
14.3	.25E-03	0.0	0.000		0.0	0.000	
17.5	.17E-03	0.0	0.001		0.0	0.006	
21.3	.12E-03	0.8	0.160		1.6	0.293	
26.0	.79E-04	5.2	1.013		4.4	0.821	
31.7	.54E-04	2.7	0.529		2.2	0.419	
38.7	.37E-04	0.4	0.073		0.5	0.102	
47.2	.26E-04	0.0	0.008		0.1	0.026	
57.5	.18E-04	0.0	0.002		0.1	0.012	
70.1	.12E-04	0.0	0.001		0.1	0.012	
85.5	.87E-05	0.0	0.002		0.1	0.028	
104.3	.62E-05	0.1	0.010		0.6	0.109	
127.2	.44E-05	0.5	0.092		2.8	0.515	
155.1	.32E-05	4.6	0.898		11.2	2.091	
189.1	.24E-05	24.1	4.720		24.9	4.653	
230.7	.18E-05	20.8	4.071		13.3	2.484	
281.3	.13E-05	0.1	0.027		0.2	0.036	
343.0	.10E-05	0.0	0.000		0.0	0.000	
418.3	.78E-06	0.0	0.000		0.0	0.000	
510.0	.61E-06	0.0	0.000		0.0	0.000	
622.0	.48E-06	0.0	0.000		0.0	0.000	
758.4	.38E-06	0.0	0.000		0.0	0.000	
924.9	.30E-06	0.0	0.000		0.0	0.000	
1128	.24E-06	0.0	0.000		0.0	0.000	
1375	.19E-06	0.0	0.000		0.0	0.000	
1677	.15E-06	0.0	0.000		0.0	0.000	
2045	.12E-06	0.0	0.000		0.0	0.000	
2494	.10E-06	0.0	0.000		0.0	0.000	

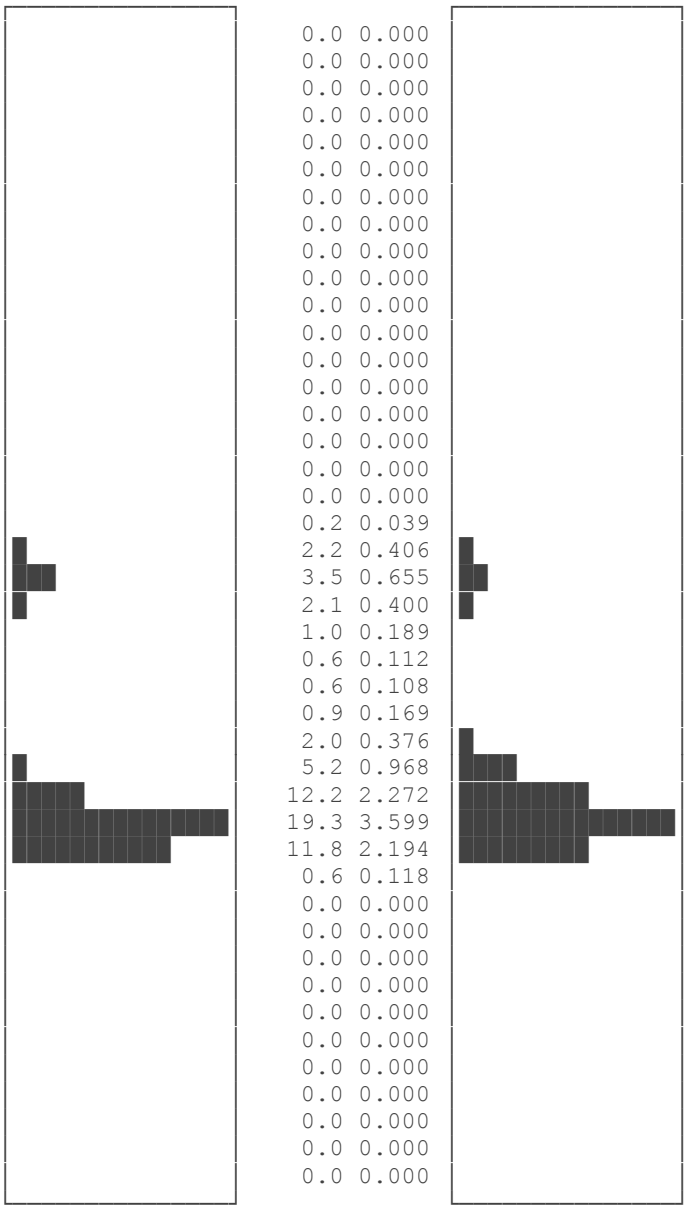
Location ID 5	49 MB52 Exploration Drive	3/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 7 Analysis Time : 15:48:18 on 12-03-2013
Sampling Time : 15:48:16 on 12-03-2013

Measd nJ/m3	1311	39	1378	945	465	5
Twmy Fit :	1241	53	1215	1028	454	9
EMax Fit :	1292	55	1265	1071	452	8

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS dC	TWOMEY ANALYSIS dC/ClogdDp	EMAX ANALYSIS dC	EMAX ANALYSIS dC/ClogdDp
0.6	.77E-01	0.0	0.000	0.0	0.000
0.7	.59E-01	0.0	0.000	0.0	0.000
0.9	.44E-01	0.0	0.000	0.0	0.000
1.1	.33E-01	0.0	0.000	0.0	0.000
1.3	.25E-01	0.0	0.000	0.0	0.000
1.6	.18E-01	0.0	0.000	0.0	0.000
2.0	.12E-01	0.0	0.000	0.0	0.000
2.4	.86E-02	0.0	0.000	0.0	0.000
2.9	.58E-02	0.0	0.000	0.0	0.000
3.6	.39E-02	0.0	0.000	0.0	0.000
4.4	.27E-02	0.0	0.000	0.0	0.000
5.3	.18E-02	0.0	0.000	0.0	0.000
6.5	.12E-02	0.0	0.000	0.0	0.000
7.9	.82E-03	0.0	0.000	0.0	0.000
9.6	.55E-03	0.0	0.000	0.0	0.000
11.8	.37E-03	0.0	0.000	0.0	0.000
14.3	.25E-03	0.0	0.000	0.0	0.000
17.5	.17E-03	0.0	0.000	0.0	0.000
21.3	.12E-03	0.0	0.008	0.2	0.039
26.0	.79E-04	1.7	0.334	2.2	0.406
31.7	.54E-04	4.8	0.934	3.5	0.655
38.7	.37E-04	2.7	0.533	2.1	0.400
47.2	.26E-04	0.8	0.163	1.0	0.189
57.5	.18E-04	0.3	0.057	0.6	0.112
70.1	.12E-04	0.2	0.036	0.6	0.108
85.5	.87E-05	0.2	0.048	0.9	0.169
104.3	.62E-05	0.6	0.118	2.0	0.376
127.2	.44E-05	2.2	0.431	5.2	0.968
155.1	.32E-05	8.5	1.640	12.2	2.272
189.1	.24E-05	21.4	4.157	19.3	3.599
230.7	.18E-05	15.8	3.068	11.8	2.194
281.3	.13E-05	0.4	0.078	0.6	0.118
343.0	.10E-05	0.0	0.000	0.0	0.000
418.3	.78E-06	0.0	0.000	0.0	0.000
510.0	.61E-06	0.0	0.000	0.0	0.000
622.0	.48E-06	0.0	0.000	0.0	0.000
758.4	.38E-06	0.0	0.000	0.0	0.000
924.9	.30E-06	0.0	0.000	0.0	0.000
1128	.24E-06	0.0	0.000	0.0	0.000
1375	.19E-06	0.0	0.000	0.0	0.000
1677	.15E-06	0.0	0.000	0.0	0.000
2045	.12E-06	0.0	0.000	0.0	0.000
2494	.10E-06	0.0	0.000	0.0	0.000



Location ID 5	49 MB52 Exploration Drive	3/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 8 Analysis Time : 16:48:18 on 12-03-2013
Sampling Time : 16:48:17 on 12-03-2013

Measd nJ/m3	1404	38	1456	1040	524	4
Twmy Fit :	1322	49	1298	1124	510	9
EMax Fit :	1377	51	1353	1170	507	8

Dp (nm)	DiffCoeff cm2/sec	dC	dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC	dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0	0.000		0.0	0.000	
0.7	.59E-01	0.0	0.000		0.0	0.000	
0.9	.44E-01	0.0	0.000		0.0	0.000	
1.1	.33E-01	0.0	0.000		0.0	0.000	
1.3	.25E-01	0.0	0.000		0.0	0.000	
1.6	.18E-01	0.0	0.000		0.0	0.000	
2.0	.12E-01	0.0	0.000		0.0	0.000	
2.4	.86E-02	0.0	0.000		0.0	0.000	
2.9	.58E-02	0.0	0.000		0.0	0.000	
3.6	.39E-02	0.0	0.000		0.0	0.000	
4.4	.27E-02	0.0	0.000		0.0	0.000	
5.3	.18E-02	0.0	0.000		0.0	0.000	
6.5	.12E-02	0.0	0.000		0.0	0.000	
7.9	.82E-03	0.0	0.000		0.0	0.000	
9.6	.55E-03	0.0	0.000		0.0	0.000	
11.8	.37E-03	0.0	0.000		0.0	0.000	
14.3	.25E-03	0.0	0.000		0.0	0.000	
17.5	.17E-03	0.0	0.000		0.0	0.001	
21.3	.12E-03	0.1	0.018		0.3	0.049	
26.0	.79E-04	1.8	0.331		1.9	0.324	
31.7	.54E-04	3.3	0.597		2.3	0.404	
38.7	.37E-04	1.5	0.276		1.3	0.221	
47.2	.26E-04	0.4	0.081		0.6	0.103	
57.5	.18E-04	0.2	0.030		0.4	0.066	
70.1	.12E-04	0.1	0.022		0.4	0.072	
85.5	.87E-05	0.2	0.036		0.8	0.135	
104.3	.62E-05	0.6	0.110		2.1	0.360	
127.2	.44E-05	2.7	0.483		6.2	1.083	
155.1	.32E-05	11.3	2.067		15.9	2.776	
189.1	.24E-05	27.7	5.037		24.0	4.188	
230.7	.18E-05	13.7	2.501		10.3	1.793	
281.3	.13E-05	0.1	0.017		0.2	0.031	
343.0	.10E-05	0.0	0.000		0.0	0.000	
418.3	.78E-06	0.0	0.000		0.0	0.000	
510.0	.61E-06	0.0	0.000		0.0	0.000	
622.0	.48E-06	0.0	0.000		0.0	0.000	
758.4	.38E-06	0.0	0.000		0.0	0.000	
924.9	.30E-06	0.0	0.000		0.0	0.000	
1128	.24E-06	0.0	0.000		0.0	0.000	
1375	.19E-06	0.0	0.000		0.0	0.000	
1677	.15E-06	0.0	0.000		0.0	0.000	
2045	.12E-06	0.0	0.000		0.0	0.000	
2494	.10E-06	0.0	0.000		0.0	0.000	

Location ID 9	420 Auto Workshop	4/12/13

Rn Progeny Particle Size Spectrometer

Logged at 21:26:02 on 01-21-2014

BATTERY SPECIFICATIONS

Stage	No/Scrns	Mesh	Scrn Dia	Flow	Effic	BGcpm
1	0	Flter	3.8	0.80	0.127	0.00
2	1	100	0.7	0.80	0.108	0.00
3	1	100	3.8	0.80	0.130	0.00
4	10	100	3.8	0.80	0.130	0.00
5	80	100	3.8	0.80	0.130	0.00
6	0	0.0	0.70	0.220	0.00	

Battery Inlet Tube (cm) = 0.00 Battery Outlet Tube (cm) = 4.00

SCREEN SPECIFICATIONS

Label	Mesh No.	Wire Dia. (microns)	Thickness (microns)	Solid Frac %	Comments
A	100	112.00	215.00	31.00	ARL 100 Mesh Screen
B	200	35.00	80.00	29.00	ARL 200 Mesh Screen
C	400	24.00	53.00	30.00	ARL 400 Mesh Screen
D	635	20.00	50.00	35.00	EML 635 Mesh Screen
F	Flter	0.00	0.00	0.00	Filter
T	Tube	0.00	0.00	0.00	ARL Cyl Tube Battery

IMPACTOR SPECIFICATIONS

Impactor Curve Fits with Simoid Fit

Stage	Dp50 (nm)	Dp50LB (nm)	Dp50UB (nm)	Slope	Intrcpt	Flow (lpm)	Effic	BGcpm
1	500.00	450.00	550.00	1.230	2.020	0.7	0.220	0.00

DECONVOLUTION ANALYSIS

Twomey Algorithm : Y No of Iterations : 1000 Twomey Speed : 0.70
EMax Algorithm : Y Max Iterations : 2000 Converg Criteria : 100[ppm]
No of Size Ranges : 43
Smallest Diameter : 0.60 (nm)
Largest Diameter : 2493.90 (nm)

PARAMETER SPECIFICATIONS

Effective Energy (Mev) = 7.200
Convrsn Factor (per WL) = 130000
Acquisition Time (secs) = 14400
Particle Density (g/cm3) = 1.00

Location ID 9	420 Auto Workshop	4/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 1 Analysis Time : 21:26:11 on 01-21-2014
Sampling Time : 23:16:07 on 12-04-2013

Measd nJ/m3	39	4	31	27	13	2
Twmy Fit :	39	4	31	27	13	2
EMax Fit :	39	4	31	27	13	2

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.2 1.072		0.2 1.225	
0.7	.59E-01	0.1 0.748		0.1 0.709	
0.9	.44E-01	0.1 0.497		0.1 0.430	
1.1	.33E-01	0.1 0.315		0.0 0.268	
1.3	.25E-01	0.0 0.187		0.0 0.167	
1.6	.18E-01	0.0 0.102		0.0 0.100	
2.0	.12E-01	0.0 0.050		0.0 0.057	
2.4	.86E-02	0.0 0.022		0.0 0.030	
2.9	.58E-02	0.0 0.009		0.0 0.016	
3.6	.39E-02	0.0 0.005		0.0 0.009	
4.4	.27E-02	0.0 0.003		0.0 0.006	
5.3	.18E-02	0.0 0.003		0.0 0.005	
6.5	.12E-02	0.0 0.002		0.0 0.003	
7.9	.82E-03	0.0 0.002		0.0 0.003	
9.6	.55E-03	0.0 0.002		0.0 0.003	
11.8	.37E-03	0.0 0.002		0.0 0.003	
14.3	.25E-03	0.0 0.004		0.0 0.005	
17.5	.17E-03	0.0 0.007		0.0 0.010	
21.3	.12E-03	0.0 0.014		0.0 0.019	
26.0	.79E-04	0.0 0.030		0.0 0.037	
31.7	.54E-04	0.0 0.060		0.0 0.070	
38.7	.37E-04	0.0 0.112		0.0 0.124	
47.2	.26E-04	0.0 0.194		0.0 0.200	
57.5	.18E-04	0.1 0.305		0.1 0.299	
70.1	.12E-04	0.1 0.435		0.1 0.414	
85.5	.87E-05	0.1 0.569		0.1 0.537	
104.3	.62E-05	0.1 0.689		0.1 0.656	
127.2	.44E-05	0.1 0.785		0.1 0.764	
155.1	.32E-05	0.1 0.855		0.1 0.855	
189.1	.24E-05	0.2 0.898		0.2 0.924	
230.7	.18E-05	0.2 0.914		0.2 0.962	
281.3	.13E-05	0.2 0.894		0.2 0.946	
343.0	.10E-05	0.1 0.800		0.1 0.811	
418.3	.78E-06	0.1 0.549		0.1 0.480	
510.0	.61E-06	0.0 0.201		0.0 0.149	
622.0	.48E-06	0.0 0.059		0.0 0.052	
758.4	.38E-06	0.0 0.037		0.0 0.039	
924.9	.30E-06	0.0 0.034		0.0 0.038	
1128	.24E-06	0.0 0.033		0.0 0.038	
1375	.19E-06	0.0 0.031		0.0 0.038	
1677	.15E-06	0.0 0.029		0.0 0.037	
2045	.12E-06	0.0 0.026		0.0 0.035	
2494	.10E-06	0.0 0.021		0.0 0.031	

Location ID 9	420 Auto Workshop	4/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 2 Analysis Time : 21:26:20 on 01-21-2014
Sampling Time : 04:00:01 on 12-05-2013

Measd nJ/m3	55	4	43	38	16	2
Twmy Fit :	55	4	44	38	16	2
EMax Fit :	55	4	44	38	16	2

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.6 2.457		0.7 2.883	
0.7	.59E-01	0.1 0.407		0.0 0.106	
0.9	.44E-01	0.0 0.057		0.0 0.005	
1.1	.33E-01	0.0 0.007		0.0 0.000	
1.3	.25E-01	0.0 0.001		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.000	
26.0	.79E-04	0.0 0.000		0.0 0.002	
31.7	.54E-04	0.0 0.002		0.0 0.010	
38.7	.37E-04	0.0 0.016		0.0 0.045	
47.2	.26E-04	0.0 0.076		0.0 0.145	
57.5	.18E-04	0.1 0.248		0.1 0.342	
70.1	.12E-04	0.1 0.562		0.2 0.607	
85.5	.87E-05	0.2 0.916		0.2 0.847	
104.3	.62E-05	0.3 1.147		0.2 0.988	
127.2	.44E-05	0.3 1.184		0.3 1.020	
155.1	.32E-05	0.3 1.078		0.2 0.977	
189.1	.24E-05	0.2 0.912		0.2 0.897	
230.7	.18E-05	0.2 0.744		0.2 0.801	
281.3	.13E-05	0.1 0.595		0.2 0.691	
343.0	.10E-05	0.1 0.464		0.1 0.544	
418.3	.78E-06	0.1 0.327		0.1 0.326	
510.0	.61E-06	0.0 0.167		0.0 0.120	
622.0	.48E-06	0.0 0.068		0.0 0.049	
758.4	.38E-06	0.0 0.043		0.0 0.036	
924.9	.30E-06	0.0 0.035		0.0 0.034	
1128	.24E-06	0.0 0.030		0.0 0.032	
1375	.19E-06	0.0 0.024		0.0 0.030	
1677	.15E-06	0.0 0.019		0.0 0.027	
2045	.12E-06	0.0 0.012		0.0 0.023	
2494	.10E-06	0.0 0.006		0.0 0.017	

Location ID 9	420 Auto Workshop	4/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 3 Analysis Time : 21:26:28 on 01-21-2014
Sampling Time : 08:00:02 on 12-05-2013

Measd nJ/m3	54	4	42	36	16	3
Twmy Fit :	52	4	42	37	16	3
EMax Fit :	53	4	42	37	16	3

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.7 2.868		0.7 2.952	
0.7	.59E-01	0.0 0.108		0.0 0.007	
0.9	.44E-01	0.0 0.003		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.003	
26.0	.79E-04	0.0 0.003		0.0 0.015	
31.7	.54E-04	0.0 0.017		0.0 0.052	
38.7	.37E-04	0.0 0.064		0.0 0.131	
47.2	.26E-04	0.0 0.171		0.1 0.254	
57.5	.18E-04	0.1 0.347		0.1 0.407	
70.1	.12E-04	0.1 0.562		0.1 0.560	
85.5	.87E-05	0.2 0.755		0.2 0.687	
104.3	.62E-05	0.2 0.880		0.2 0.778	
127.2	.44E-05	0.2 0.927		0.2 0.832	
155.1	.32E-05	0.2 0.915		0.2 0.857	
189.1	.24E-05	0.2 0.865		0.2 0.859	
230.7	.18E-05	0.2 0.797		0.2 0.839	
281.3	.13E-05	0.2 0.718		0.2 0.788	
343.0	.10E-05	0.1 0.617		0.2 0.668	
418.3	.78E-06	0.1 0.458		0.1 0.426	
510.0	.61E-06	0.1 0.231		0.0 0.164	
622.0	.48E-06	0.0 0.095		0.0 0.069	
758.4	.38E-06	0.0 0.061		0.0 0.053	
924.9	.30E-06	0.0 0.050		0.0 0.049	
1128	.24E-06	0.0 0.040		0.0 0.046	
1375	.19E-06	0.0 0.028		0.0 0.041	
1677	.15E-06	0.0 0.017		0.0 0.033	
2045	.12E-06	0.0 0.007		0.0 0.023	
2494	.10E-06	0.0 0.001		0.0 0.012	

Location ID 9	420 Auto Workshop	4/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 4 Analysis Time : 21:26:37 on 01-21-2014
Sampling Time : 15:00:04 on 12-05-2013

Measd nJ/m3	55	5	38	35	15	3
Twmy Fit :	54	5	39	35	15	3
EMax Fit :	54	5	39	35	15	3

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	1.0 3.857		1.0 4.030	
0.7	.59E-01	0.0 0.104		0.0 0.004	
0.9	.44E-01	0.0 0.002		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.000	
26.0	.79E-04	0.0 0.000		0.0 0.000	
31.7	.54E-04	0.0 0.000		0.0 0.000	
38.7	.37E-04	0.0 0.001		0.0 0.006	
47.2	.26E-04	0.0 0.009		0.0 0.041	
57.5	.18E-04	0.0 0.069		0.0 0.166	
70.1	.12E-04	0.1 0.292		0.1 0.421	
85.5	.87E-05	0.2 0.706		0.2 0.727	
104.3	.62E-05	0.3 1.093		0.2 0.938	
127.2	.44E-05	0.3 1.223		0.3 0.996	
155.1	.32E-05	0.3 1.104		0.2 0.938	
189.1	.24E-05	0.2 0.879		0.2 0.829	
230.7	.18E-05	0.2 0.658		0.2 0.708	
281.3	.13E-05	0.1 0.483		0.1 0.589	
343.0	.10E-05	0.1 0.357		0.1 0.460	
418.3	.78E-06	0.1 0.266		0.1 0.299	
510.0	.61E-06	0.0 0.184		0.0 0.139	
622.0	.48E-06	0.0 0.106		0.0 0.070	
758.4	.38E-06	0.0 0.071		0.0 0.054	
924.9	.30E-06	0.0 0.053		0.0 0.048	
1128	.24E-06	0.0 0.039		0.0 0.043	
1375	.19E-06	0.0 0.027		0.0 0.038	
1677	.15E-06	0.0 0.016		0.0 0.030	
2045	.12E-06	0.0 0.007		0.0 0.021	
2494	.10E-06	0.0 0.002		0.0 0.011	

Location ID 9	420 Auto Workshop	4/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 5 Analysis Time : 21:26:46 on 01-21-2014
Sampling Time : 16:00:04 on 12-05-2013

Measd nJ/m3	60	5	47	40	16	3
Twmy Fit :	59	5	47	40	16	3
EMax Fit :	60	5	47	40	16	3

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.7 2.641		0.8 2.906	
0.7	.59E-01	0.1 0.321		0.0 0.077	
0.9	.44E-01	0.0 0.032		0.0 0.003	
1.1	.33E-01	0.0 0.003		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.001	
14.3	.25E-03	0.0 0.001		0.0 0.003	
17.5	.17E-03	0.0 0.005		0.0 0.012	
21.3	.12E-03	0.0 0.020		0.0 0.039	
26.0	.79E-04	0.0 0.059		0.0 0.094	
31.7	.54E-04	0.0 0.137		0.0 0.181	
38.7	.37E-04	0.1 0.253		0.1 0.290	
47.2	.26E-04	0.1 0.392		0.1 0.407	
57.5	.18E-04	0.1 0.530		0.1 0.515	
70.1	.12E-04	0.2 0.643		0.2 0.605	
85.5	.87E-05	0.2 0.721		0.2 0.672	
104.3	.62E-05	0.2 0.762		0.2 0.718	
127.2	.44E-05	0.2 0.773		0.2 0.746	
155.1	.32E-05	0.2 0.764		0.2 0.759	
189.1	.24E-05	0.2 0.742		0.2 0.760	
230.7	.18E-05	0.2 0.709		0.2 0.746	
281.3	.13E-05	0.2 0.663		0.2 0.704	
343.0	.10E-05	0.2 0.584		0.2 0.596	
418.3	.78E-06	0.1 0.424		0.1 0.370	
510.0	.61E-06	0.1 0.189		0.0 0.133	
622.0	.48E-06	0.0 0.068		0.0 0.053	
758.4	.38E-06	0.0 0.044		0.0 0.040	
924.9	.30E-06	0.0 0.038		0.0 0.038	
1128	.24E-06	0.0 0.032		0.0 0.037	
1375	.19E-06	0.0 0.026		0.0 0.034	
1677	.15E-06	0.0 0.018		0.0 0.030	
2045	.12E-06	0.0 0.010		0.0 0.024	
2494	.10E-06	0.0 0.004		0.0 0.016	

Location ID 8	39 Blue 102	6/12/13

Rn Progeny Particle Size Spectrometer

Logged at 09:02:36 on 12-06-2013

BATTERY SPECIFICATIONS

Stage	No/Scrns	Mesh	Scrn Dia	Flow	Effic	BGcpm
1	0	Flter	3.8	0.80	0.127	0.00
2	1	100	0.7	0.80	0.108	0.00
3	1	100	3.8	0.80	0.130	0.00
4	10	100	3.8	0.80	0.130	0.00
5	80	100	3.8	0.80	0.130	0.00
6	0	0.0	0.70	0.220	0.00	

Battery Inlet Tube (cm) = 0.00 Battery Outlet Tube (cm) = 4.00

SCREEN SPECIFICATIONS

Label	Mesh No.	Wire Dia. (microns)	Thickness (microns)	Solid Frac %	Comments
A	100	112.00	215.00	31.30	ARL 100 Mesh Screen
B	200	35.00	80.00	29.10	ARL 200 Mesh Screen
C	400	24.00	53.00	30.20	ARL 400 Mesh Screen
D	635	20.00	50.00	34.50	EML 635 Mesh Screen
F	Flter	0.00	0.00	0.00	Filter
T	Tube	0.00	0.00	0.00	ARL Cyl Tube Battery

IMPACTOR SPECIFICATIONS

Impactor Curve Fits with Simoid Fit

Stage	Dp50 (nm)	Dp50LB (nm)	Dp50UB (nm)	Slope	Intrcpt	Flow (lpm)	Effic	BGcpm
1	500.00	450.00	550.00	1.230	2.020	0.7	0.220	0.00

DECONVOLUTION ANALYSIS

Twomey Algorithm : Y No of Iterations : 1000 Twomey Speed : 0.70
EMax Algorithm : Y Max Iterations : 2000 Converg Criteria : 100[ppm]
No of Size Ranges : 43
Smallest Diameter : 0.60 (nm)
Largest Diameter : 2493.90 (nm)

PARAMETER SPECIFICATIONS

Effective Energy (Mev) = 7.200
Convrsn Factor (per WL) = 130000
Acquisition Time (secs) = 3600
Particle Density (g/cm3) = 1.00

Location ID 8	39 Blue 102	6/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 2 Analysis Time : 10:02:38 on 12-06-2013
Sampling Time : 10:02:36 on 12-06-2013

Measd nJ/m3	1000	63	1265	756	301	16
Twmy Fit :	1141	86	1098	812	297	16
EMax Fit :	1114	75	1076	823	297	16

Dp (nm)	DiffCoeff cm2/sec	dC	dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC	dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0	0.000		0.0	0.000	
0.7	.59E-01	0.0	0.000		0.0	0.000	
0.9	.44E-01	0.0	0.000		0.0	0.000	
1.1	.33E-01	0.0	0.000		0.0	0.000	
1.3	.25E-01	0.0	0.000		0.0	0.000	
1.6	.18E-01	0.0	0.000		0.0	0.000	
2.0	.12E-01	0.0	0.000		0.0	0.000	
2.4	.86E-02	0.0	0.000		0.0	0.000	
2.9	.58E-02	0.0	0.000		0.0	0.000	
3.6	.39E-02	0.0	0.000		0.0	0.000	
4.4	.27E-02	0.0	0.000		0.0	0.000	
5.3	.18E-02	0.0	0.000		0.0	0.000	
6.5	.12E-02	0.0	0.000		0.0	0.000	
7.9	.82E-03	0.0	0.000		0.0	0.000	
9.6	.55E-03	0.0	0.000		0.0	0.000	
11.8	.37E-03	0.0	0.000		0.0	0.000	
14.3	.25E-03	0.0	0.000		0.0	0.000	
17.5	.17E-03	0.0	0.000		0.0	0.001	
21.3	.12E-03	0.1	0.021		0.3	0.063	
26.0	.79E-04	3.4	0.713		3.2	0.685	
31.7	.54E-04	10.9	2.299		6.8	1.474	
38.7	.37E-04	8.3	1.744		6.0	1.293	
47.2	.26E-04	3.2	0.682		3.7	0.789	
57.5	.18E-04	1.2	0.249		2.2	0.479	
70.1	.12E-04	0.6	0.123		1.6	0.350	
85.5	.87E-05	0.4	0.094		1.5	0.327	
104.3	.62E-05	0.5	0.112		1.7	0.377	
127.2	.44E-05	0.9	0.183		2.3	0.498	
155.1	.32E-05	1.7	0.362		3.2	0.700	
189.1	.24E-05	3.6	0.750		4.5	0.978	
230.7	.18E-05	6.7	1.407		5.9	1.265	
281.3	.13E-05	8.9	1.884		6.2	1.346	
343.0	.10E-05	4.5	0.955		3.9	0.851	
418.3	.78E-06	0.1	0.027		0.6	0.128	
510.0	.61E-06	0.0	0.000		0.0	0.002	
622.0	.48E-06	0.0	0.000		0.0	0.000	
758.4	.38E-06	0.0	0.000		0.0	0.000	
924.9	.30E-06	0.0	0.000		0.0	0.000	
1128	.24E-06	0.0	0.000		0.0	0.000	
1375	.19E-06	0.0	0.000		0.0	0.000	
1677	.15E-06	0.0	0.000		0.0	0.000	
2045	.12E-06	0.0	0.000		0.0	0.000	
2494	.10E-06	0.0	0.000		0.0	0.000	

Location ID 8	39 Blue 102	6/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 3 Analysis Time : 11:02:38 on 12-06-2013
Sampling Time : 11:02:37 on 12-06-2013

Measd nJ/m3	1573	83	1947	1172	481	16
Twmy Fit :	1730	117	1672	1274	474	17
EMax Fit :	1714	105	1662	1301	473	16

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.005		0.2 0.023	
26.0	.79E-04	2.8 0.386		3.2 0.448	
31.7	.54E-04	14.2 1.969		9.1 1.281	
38.7	.37E-04	12.8 1.778		8.9 1.249	
47.2	.26E-04	5.1 0.710		5.5 0.777	
57.5	.18E-04	1.8 0.252		3.4 0.471	
70.1	.12E-04	0.9 0.123		2.5 0.350	
85.5	.87E-05	0.7 0.099		2.4 0.342	
104.3	.62E-05	0.9 0.128		3.0 0.422	
127.2	.44E-05	1.7 0.238		4.3 0.604	
155.1	.32E-05	3.8 0.531		6.5 0.910	
189.1	.24E-05	8.6 1.190		9.4 1.319	
230.7	.18E-05	15.2 2.114		11.7 1.639	
281.3	.13E-05	13.5 1.868		9.8 1.374	
343.0	.10E-05	1.5 0.212		2.8 0.389	
418.3	.78E-06	0.0 0.000		0.0 0.005	
510.0	.61E-06	0.0 0.000		0.0 0.000	
622.0	.48E-06	0.0 0.000		0.0 0.000	
758.4	.38E-06	0.0 0.000		0.0 0.000	
924.9	.30E-06	0.0 0.000		0.0 0.000	
1128	.24E-06	0.0 0.000		0.0 0.000	
1375	.19E-06	0.0 0.000		0.0 0.000	
1677	.15E-06	0.0 0.000		0.0 0.000	
2045	.12E-06	0.0 0.000		0.0 0.000	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 8	39 Blue 102	6/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 4 Analysis Time : 12:02:38 on 12-06-2013
Sampling Time : 12:02:37 on 12-06-2013

Measd nJ/m3	2069	104	2656	1554	660	20
Twmy Fit :	2313	155	2236	1710	648	21
EMax Fit :	2288	136	2220	1749	648	20

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.002		0.1 0.014	
26.0	.79E-04	3.2 0.335		3.7 0.390	
31.7	.54E-04	20.1 2.083		12.2 1.284	
38.7	.37E-04	17.2 1.788		11.9 1.251	
47.2	.26E-04	5.9 0.608		7.0 0.735	
57.5	.18E-04	1.8 0.184		4.0 0.422	
70.1	.12E-04	0.8 0.081		2.9 0.306	
85.5	.87E-05	0.6 0.065		2.9 0.304	
104.3	.62E-05	0.9 0.091		3.7 0.393	
127.2	.44E-05	1.9 0.194		5.7 0.601	
155.1	.32E-05	4.9 0.508		9.2 0.968	
189.1	.24E-05	12.6 1.309		14.0 1.475	
230.7	.18E-05	23.7 2.458		17.5 1.839	
281.3	.13E-05	17.5 1.813		13.1 1.375	
343.0	.10E-05	0.8 0.085		2.4 0.248	
418.3	.78E-06	0.0 0.000		0.0 0.001	
510.0	.61E-06	0.0 0.000		0.0 0.000	
622.0	.48E-06	0.0 0.000		0.0 0.000	
758.4	.38E-06	0.0 0.000		0.0 0.000	
924.9	.30E-06	0.0 0.000		0.0 0.000	
1128	.24E-06	0.0 0.000		0.0 0.000	
1375	.19E-06	0.0 0.000		0.0 0.000	
1677	.15E-06	0.0 0.000		0.0 0.000	
2045	.12E-06	0.0 0.000		0.0 0.000	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 8	39 Blue 102	6/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 5 Analysis Time : 13:02:38 on 12-06-2013
Sampling Time : 13:02:37 on 12-06-2013

Measd nJ/m3	2333	104	2932	1748	712	23
Twmy Fit :	2549	158	2470	1922	701	24
EMax Fit :	2541	141	2472	1974	701	23

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.002	
26.0	.79E-04	1.0 0.092		1.5 0.138	
31.7	.54E-04	13.4 1.267		8.7 0.825	
38.7	.37E-04	21.6 2.033		13.3 1.259	
47.2	.26E-04	11.4 1.079		10.6 1.003	
57.5	.18E-04	4.5 0.424		7.2 0.678	
70.1	.12E-04	2.2 0.205		5.4 0.512	
85.5	.87E-05	1.6 0.153		5.1 0.478	
104.3	.62E-05	1.9 0.181		5.8 0.546	
127.2	.44E-05	3.2 0.303		7.5 0.714	
155.1	.32E-05	6.5 0.613		10.4 0.983	
189.1	.24E-05	13.3 1.256		13.9 1.314	
230.7	.18E-05	22.0 2.071		16.2 1.532	
281.3	.13E-05	18.4 1.734		13.2 1.245	
343.0	.10E-05	2.1 0.195		3.9 0.369	
418.3	.78E-06	0.0 0.000		0.1 0.006	
510.0	.61E-06	0.0 0.000		0.0 0.000	
622.0	.48E-06	0.0 0.000		0.0 0.000	
758.4	.38E-06	0.0 0.000		0.0 0.000	
924.9	.30E-06	0.0 0.000		0.0 0.000	
1128	.24E-06	0.0 0.000		0.0 0.000	
1375	.19E-06	0.0 0.000		0.0 0.000	
1677	.15E-06	0.0 0.000		0.0 0.000	
2045	.12E-06	0.0 0.000		0.0 0.000	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 8	39 Blue 102	6/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 6 Analysis Time : 14:02:39 on 12-06-2013
Sampling Time : 14:02:37 on 12-06-2013

Measd nJ/m3	2597	117	3319	2043	927	19
Twmy Fit :	2893	169	2809	2232	909	23
EMax Fit :	2868	148	2795	2281	909	21

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.1 0.005		0.3 0.026	
26.0	.79E-04	5.0 0.419		5.1 0.427	
31.7	.54E-04	20.8 1.732		11.9 0.999	
38.7	.37E-04	14.4 1.196		9.7 0.812	
47.2	.26E-04	4.6 0.378		5.4 0.452	
57.5	.18E-04	1.4 0.119		3.2 0.271	
70.1	.12E-04	0.7 0.060		2.7 0.222	
85.5	.87E-05	0.7 0.058		3.1 0.263	
104.3	.62E-05	1.2 0.103		4.9 0.414	
127.2	.44E-05	3.3 0.271		9.1 0.761	
155.1	.32E-05	10.0 0.835		16.8 1.411	
189.1	.24E-05	26.9 2.239		26.8 2.245	
230.7	.18E-05	39.6 3.290		28.4 2.379	
281.3	.13E-05	10.8 0.898		10.8 0.904	
343.0	.10E-05	0.0 0.002		0.2 0.019	
418.3	.78E-06	0.0 0.000		0.0 0.000	
510.0	.61E-06	0.0 0.000		0.0 0.000	
622.0	.48E-06	0.0 0.000		0.0 0.000	
758.4	.38E-06	0.0 0.000		0.0 0.000	
924.9	.30E-06	0.0 0.000		0.0 0.000	
1128	.24E-06	0.0 0.000		0.0 0.000	
1375	.19E-06	0.0 0.000		0.0 0.000	
1677	.15E-06	0.0 0.000		0.0 0.000	
2045	.12E-06	0.0 0.000		0.0 0.000	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 8	39 Blue 102	6/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 7 Analysis Time : 15:02:39 on 12-06-2013
Sampling Time : 15:02:38 on 12-06-2013

Measd nJ/m3	2656	107	3386	2127	960	20
Twmy Fit :	2939	156	2862	2319	944	24
EMax Fit :	2924	136	2857	2372	944	22

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.001		0.1 0.008	
26.0	.79E-04	2.3 0.188		2.5 0.208	
31.7	.54E-04	15.5 1.270		8.6 0.710	
38.7	.37E-04	15.9 1.301		9.4 0.777	
47.2	.26E-04	6.7 0.550		6.5 0.534	
57.5	.18E-04	2.5 0.207		4.4 0.363	
70.1	.12E-04	1.4 0.111		3.8 0.311	
85.5	.87E-05	1.3 0.104		4.4 0.359	
104.3	.62E-05	2.0 0.165		6.4 0.527	
127.2	.44E-05	4.6 0.374		10.7 0.883	
155.1	.32E-05	12.0 0.981		18.1 1.490	
189.1	.24E-05	27.9 2.286		26.7 2.200	
230.7	.18E-05	38.1 3.120		27.5 2.267	
281.3	.13E-05	11.5 0.945		11.4 0.940	
343.0	.10E-05	0.0 0.003		0.4 0.029	
418.3	.78E-06	0.0 0.000		0.0 0.000	
510.0	.61E-06	0.0 0.000		0.0 0.000	
622.0	.48E-06	0.0 0.000		0.0 0.000	
758.4	.38E-06	0.0 0.000		0.0 0.000	
924.9	.30E-06	0.0 0.000		0.0 0.000	
1128	.24E-06	0.0 0.000		0.0 0.000	
1375	.19E-06	0.0 0.000		0.0 0.000	
1677	.15E-06	0.0 0.000		0.0 0.000	
2045	.12E-06	0.0 0.000		0.0 0.000	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 8	39 Blue 102	6/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 8 Analysis Time : 16:02:39 on 12-06-2013
Sampling Time : 16:02:38 on 12-06-2013

Measd nJ/m3	2433	105	3076	1896	822	22
Twmy Fit :	2680	154	2604	2070	810	24
EMax Fit :	2667	136	2600	2119	810	23

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS dC dC/ClogdDp	TWOMEY ANALYSIS RESULTS	EMAX ANALYSIS dC dC/ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.001		0.1 0.006	
26.0	.79E-04	1.8 0.159		2.2 0.196	
31.7	.54E-04	14.9 1.339		8.9 0.806	
38.7	.37E-04	18.0 1.615		11.0 0.995	
47.2	.26E-04	8.4 0.753		8.0 0.723	
57.5	.18E-04	3.2 0.290		5.4 0.488	
70.1	.12E-04	1.7 0.149		4.3 0.392	
85.5	.87E-05	1.4 0.125		4.5 0.407	
104.3	.62E-05	1.9 0.171		5.8 0.527	
127.2	.44E-05	3.7 0.331		8.7 0.781	
155.1	.32E-05	8.5 0.762		13.3 1.196	
189.1	.24E-05	18.7 1.681		18.9 1.706	
230.7	.18E-05	29.4 2.641		21.6 1.949	
281.3	.13E-05	17.2 1.541		14.0 1.264	
343.0	.10E-05	0.5 0.048		1.9 0.167	
418.3	.78E-06	0.0 0.000		0.0 0.000	
510.0	.61E-06	0.0 0.000		0.0 0.000	
622.0	.48E-06	0.0 0.000		0.0 0.000	
758.4	.38E-06	0.0 0.000		0.0 0.000	
924.9	.30E-06	0.0 0.000		0.0 0.000	
1128	.24E-06	0.0 0.000		0.0 0.000	
1375	.19E-06	0.0 0.000		0.0 0.000	
1677	.15E-06	0.0 0.000		0.0 0.000	
2045	.12E-06	0.0 0.000		0.0 0.000	
2494	.10E-06	0.0 0.000		0.0 0.000	

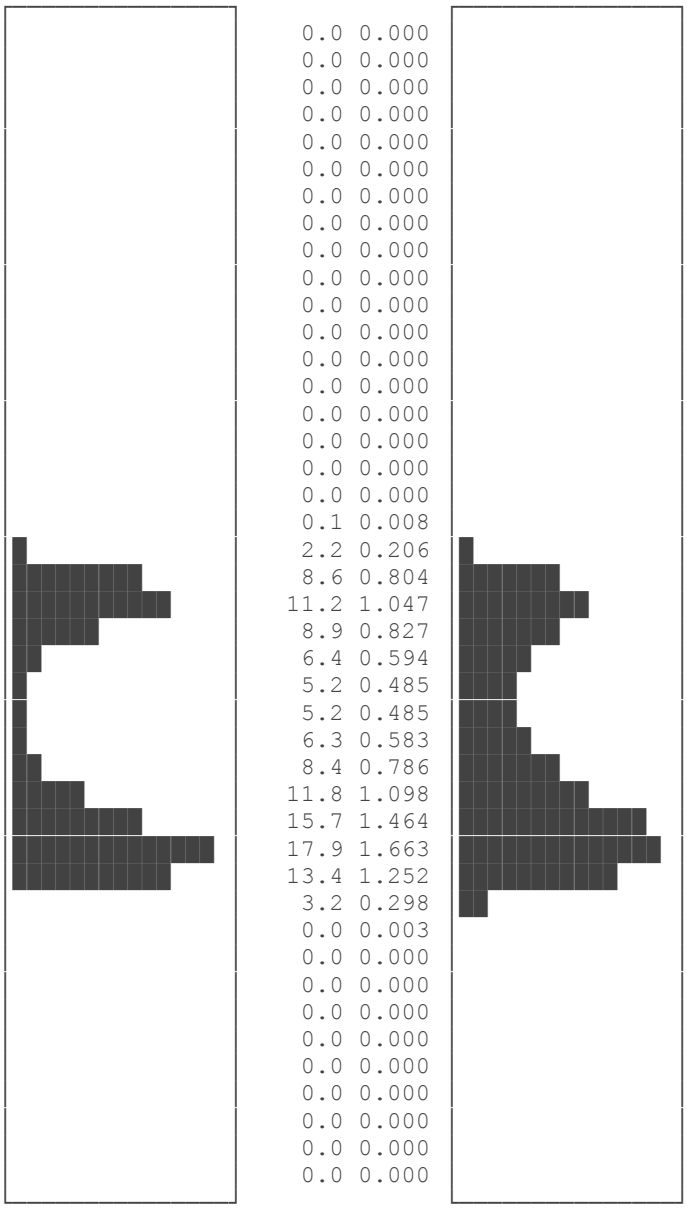
Location ID 8	39 Blue 102	6/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 9 Analysis Time : 17:02:39 on 12-06-2013
Sampling Time : 17:02:38 on 12-06-2013

Measd nJ/m3	2341	111	2963	1843	756	22
Twmy Fit :	2615	157	2537	1992	746	24
EMax Fit :	2583	137	2516	1992	746	23

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS dC	TWOMEY ANALYSIS dC/ClogdDp	EMAX ANALYSIS dC	EMAX ANALYSIS dC/ClogdDp
0.6	.77E-01	0.0	0.000	0.0	0.000
0.7	.59E-01	0.0	0.000	0.0	0.000
0.9	.44E-01	0.0	0.000	0.0	0.000
1.1	.33E-01	0.0	0.000	0.0	0.000
1.3	.25E-01	0.0	0.000	0.0	0.000
1.6	.18E-01	0.0	0.000	0.0	0.000
2.0	.12E-01	0.0	0.000	0.0	0.000
2.4	.86E-02	0.0	0.000	0.0	0.000
2.9	.58E-02	0.0	0.000	0.0	0.000
3.6	.39E-02	0.0	0.000	0.0	0.000
4.4	.27E-02	0.0	0.000	0.0	0.000
5.3	.18E-02	0.0	0.000	0.0	0.000
6.5	.12E-02	0.0	0.000	0.0	0.000
7.9	.82E-03	0.0	0.000	0.0	0.000
9.6	.55E-03	0.0	0.000	0.0	0.000
11.8	.37E-03	0.0	0.000	0.0	0.000
14.3	.25E-03	0.0	0.000	0.0	0.000
17.5	.17E-03	0.0	0.000	0.0	0.000
21.3	.12E-03	0.0	0.002	0.1	0.008
26.0	.79E-04	2.0	0.184	2.2	0.206
31.7	.54E-04	14.5	1.335	8.6	0.804
38.7	.37E-04	18.3	1.685	11.2	1.047
47.2	.26E-04	9.7	0.893	8.9	0.827
57.5	.18E-04	4.2	0.390	6.4	0.594
70.1	.12E-04	2.3	0.214	5.2	0.485
85.5	.87E-05	1.9	0.176	5.2	0.485
104.3	.62E-05	2.4	0.220	6.3	0.583
127.2	.44E-05	4.0	0.372	8.4	0.786
155.1	.32E-05	8.0	0.736	11.8	1.098
189.1	.24E-05	15.6	1.436	15.7	1.464
230.7	.18E-05	23.9	2.198	17.9	1.663
281.3	.13E-05	17.7	1.626	13.4	1.252
343.0	.10E-05	1.5	0.140	3.2	0.298
418.3	.78E-06	0.0	0.000	0.0	0.003
510.0	.61E-06	0.0	0.000	0.0	0.000
622.0	.48E-06	0.0	0.000	0.0	0.000
758.4	.38E-06	0.0	0.000	0.0	0.000
924.9	.30E-06	0.0	0.000	0.0	0.000
1128	.24E-06	0.0	0.000	0.0	0.000
1375	.19E-06	0.0	0.000	0.0	0.000
1677	.15E-06	0.0	0.000	0.0	0.000
2045	.12E-06	0.0	0.000	0.0	0.000
2494	.10E-06	0.0	0.000	0.0	0.000



Location ID 15	Whenan Crusher	9/12/13

Rn Progeny Particle Size Spectrometer

Logged at 09:13:47 on 12-09-2013

BATTERY SPECIFICATIONS

Stage	No/Scrns	Mesh	Scrn Dia	Flow	Effic	BGcpm
1	0	Flter	3.8	0.80	0.127	0.00
2	1	100	0.7	0.80	0.108	0.00
3	1	100	3.8	0.80	0.130	0.00
4	10	100	3.8	0.80	0.130	0.00
5	80	100	3.8	0.80	0.130	0.00
6	0	0.0	0.70	0.220	0.00	

Battery Inlet Tube (cm) = 0.00 Battery Outlet Tube (cm) = 4.00

SCREEN SPECIFICATIONS

Label	Mesh No.	Wire Dia. (microns)	Thickness (microns)	Solid Frac %	Comments
A	100	112.00	215.00	31.30	ARL 100 Mesh Screen
B	200	35.00	80.00	29.10	ARL 200 Mesh Screen
C	400	24.00	53.00	30.20	ARL 400 Mesh Screen
D	635	20.00	50.00	34.50	EML 635 Mesh Screen
F	Flter	0.00	0.00	0.00	Filter
T	Tube	0.00	0.00	0.00	ARL Cyl Tube Battery

IMPACTOR SPECIFICATIONS

Impactor Curve Fits with Simoid Fit

Stage	Dp50 (nm)	Dp50LB (nm)	Dp50UB (nm)	Slope	Intrcpt	Flow (lpm)	Effic	BGcpm
1	500.00	450.00	550.00	1.230	2.020	0.7	0.220	0.00

DECONVOLUTION ANALYSIS

Twomey Algorithm : Y No of Iterations : 1000 Twomey Speed : 0.70
EMax Algorithm : Y Max Iterations : 2000 Converg Criteria : 100[ppm]
No of Size Ranges : 43
Smallest Diameter : 0.60 (nm)
Largest Diameter : 2493.90 (nm)

PARAMETER SPECIFICATIONS

Effective Energy (Mev) = 7.200
Convrsn Factor (per WL) = 130000
Acquisition Time (secs) = 3600
Particle Density (g/cm3) = 1.00

Location ID 15	Whenan Crusher	9/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 1 Analysis Time : 10:13:48 on 12-09-2013
Sampling Time : 10:13:47 on 12-09-2013

Measd nJ/m3	212	8	216	189	55	6
Twmy Fit :	223	9	219	185	56	6
EMax Fit :	219	9	215	182	57	6

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS dC dC/ClogdDp	TWOMEY ANALYSIS RESULTS	EMAX ANALYSIS dC dC/ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.000	
26.0	.79E-04	0.0 0.000		0.0 0.000	
31.7	.54E-04	0.0 0.000		0.0 0.000	
38.7	.37E-04	0.0 0.000		0.0 0.000	
47.2	.26E-04	0.0 0.002		0.0 0.006	
57.5	.18E-04	0.1 0.080		0.1 0.152	
70.1	.12E-04	0.8 0.849		1.0 1.095	
85.5	.87E-05	2.6 2.789		2.5 2.719	
104.3	.62E-05	3.3 3.580		2.8 3.079	
127.2	.44E-05	2.2 2.361		1.9 2.110	
155.1	.32E-05	1.0 1.032		1.0 1.105	
189.1	.24E-05	0.3 0.369		0.5 0.521	
230.7	.18E-05	0.1 0.125		0.2 0.246	
281.3	.13E-05	0.0 0.046		0.1 0.125	
343.0	.10E-05	0.0 0.022		0.1 0.072	
418.3	.78E-06	0.0 0.019		0.0 0.054	
510.0	.61E-06	0.0 0.047		0.1 0.059	
622.0	.48E-06	0.1 0.100		0.1 0.063	
758.4	.38E-06	0.1 0.077		0.0 0.053	
924.9	.30E-06	0.0 0.046		0.0 0.041	
1128	.24E-06	0.0 0.028		0.0 0.033	
1375	.19E-06	0.0 0.017		0.0 0.027	
1677	.15E-06	0.0 0.010		0.0 0.021	
2045	.12E-06	0.0 0.005		0.0 0.016	
2494	.10E-06	0.0 0.002		0.0 0.010	

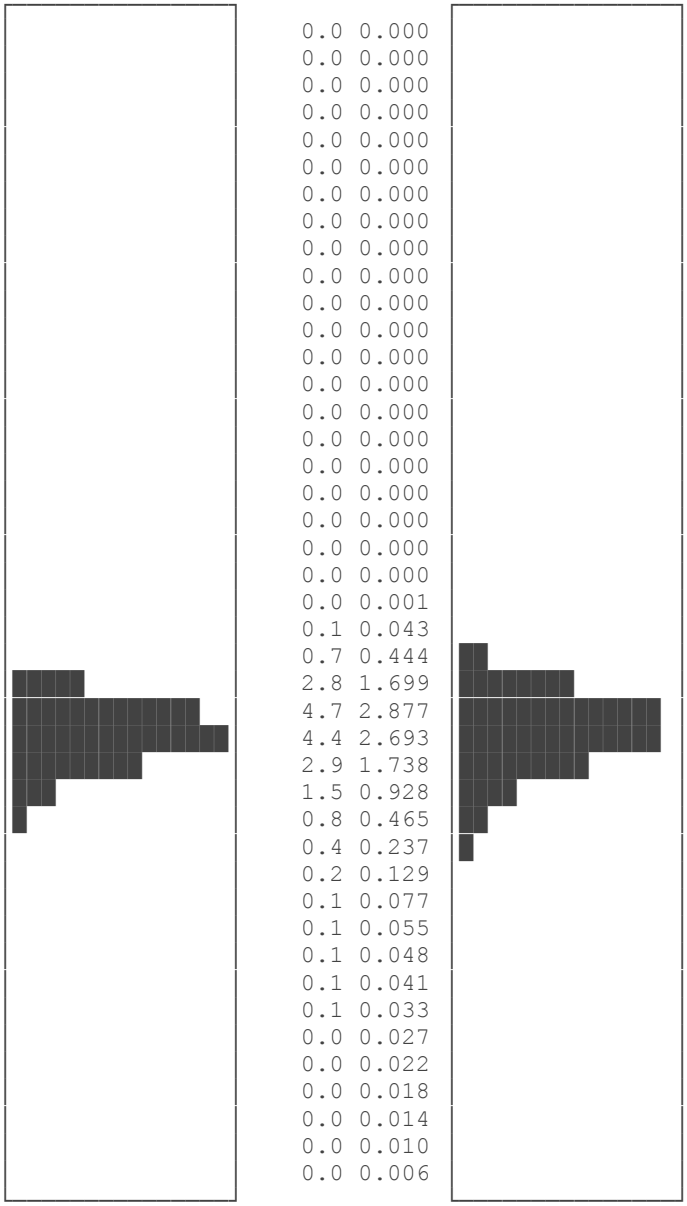
Location ID 15	Whenan Crusher	9/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 2 Analysis Time : 11:13:49 on 12-09-2013
Sampling Time : 11:13:47 on 12-09-2013

Measd nJ/m3	402	16	376	331	92	8
Twmy Fit :	395	16	387	325	93	8
EMax Fit :	395	17	387	324	93	8

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.000	
26.0	.79E-04	0.0 0.000		0.0 0.000	
31.7	.54E-04	0.0 0.000		0.0 0.000	
38.7	.37E-04	0.0 0.000		0.0 0.001	
47.2	.26E-04	0.0 0.008		0.1 0.043	
57.5	.18E-04	0.3 0.173		0.7 0.444	
70.1	.12E-04	2.0 1.223		2.8 1.699	
85.5	.87E-05	5.1 3.081		4.7 2.877	
104.3	.62E-05	5.6 3.391		4.4 2.693	
127.2	.44E-05	3.4 2.081		2.9 1.738	
155.1	.32E-05	1.5 0.894		1.5 0.928	
189.1	.24E-05	0.5 0.324		0.8 0.465	
230.7	.18E-05	0.2 0.114		0.4 0.237	
281.3	.13E-05	0.1 0.044		0.2 0.129	
343.0	.10E-05	0.0 0.021		0.1 0.077	
418.3	.78E-06	0.0 0.018		0.1 0.055	
510.0	.61E-06	0.1 0.040		0.1 0.048	
622.0	.48E-06	0.1 0.070		0.1 0.041	
758.4	.38E-06	0.1 0.051		0.1 0.033	
924.9	.30E-06	0.1 0.031		0.0 0.027	
1128	.24E-06	0.0 0.019		0.0 0.022	
1375	.19E-06	0.0 0.012		0.0 0.018	
1677	.15E-06	0.0 0.007		0.0 0.014	
2045	.12E-06	0.0 0.003		0.0 0.010	
2494	.10E-06	0.0 0.001		0.0 0.006	



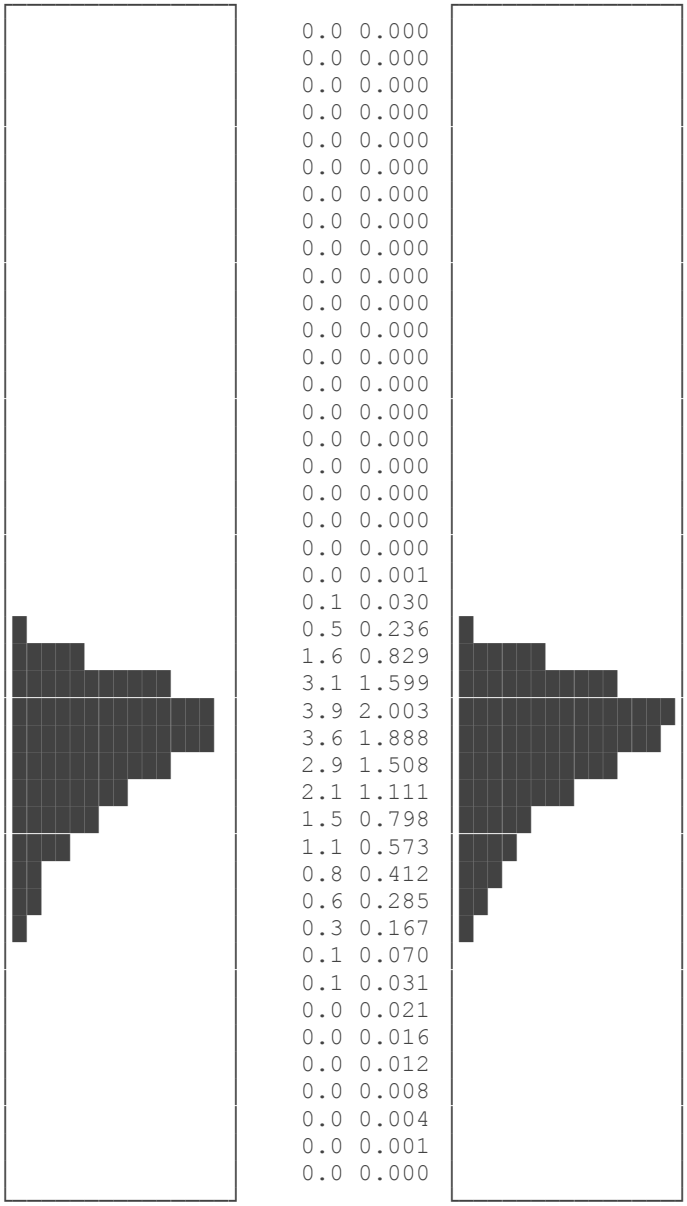
Location ID 15	Whenan Crusher	9/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 3 Analysis Time : 12:13:49 on 12-09-2013
Sampling Time : 12:13:48 on 12-09-2013

Measd nJ/m3	471	15	471	363	123	9
Twmy Fit :	453	18	444	375	123	9
EMax Fit :	464	19	455	382	123	9

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.000	
26.0	.79E-04	0.0 0.000		0.0 0.000	
31.7	.54E-04	0.0 0.001		0.0 0.001	
38.7	.37E-04	0.0 0.020		0.1 0.030	
47.2	.26E-04	0.3 0.183		0.5 0.236	
57.5	.18E-04	1.3 0.717		1.6 0.829	
70.1	.12E-04	2.8 1.503		3.1 1.599	
85.5	.87E-05	3.8 2.010		3.9 2.003	
104.3	.62E-05	3.7 1.979		3.6 1.888	
127.2	.44E-05	3.0 1.606		2.9 1.508	
155.1	.32E-05	2.2 1.172		2.1 1.111	
189.1	.24E-05	1.5 0.815		1.5 0.798	
230.7	.18E-05	1.1 0.561		1.1 0.573	
281.3	.13E-05	0.7 0.390		0.8 0.412	
343.0	.10E-05	0.5 0.275		0.6 0.285	
418.3	.78E-06	0.4 0.191		0.3 0.167	
510.0	.61E-06	0.2 0.107		0.1 0.070	
622.0	.48E-06	0.1 0.040		0.1 0.031	
758.4	.38E-06	0.0 0.019		0.0 0.021	
924.9	.30E-06	0.0 0.011		0.0 0.016	
1128	.24E-06	0.0 0.005		0.0 0.012	
1375	.19E-06	0.0 0.002		0.0 0.008	
1677	.15E-06	0.0 0.000		0.0 0.004	
2045	.12E-06	0.0 0.000		0.0 0.001	
2494	.10E-06	0.0 0.000		0.0 0.000	



Location ID 15	Whenan Crusher	9/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 4 Analysis Time : 13:13:49 on 12-09-2013
Sampling Time : 13:13:48 on 12-09-2013

Measd nJ/m3	524	16	514	424	135	8
Twmy Fit :	510	19	501	427	136	8
EMax Fit :	517	20	508	431	137	8

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS dC dC/ClogdDp	TWOMEY ANALYSIS RESULTS	EMAX ANALYSIS dC dC/ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.000	
26.0	.79E-04	0.0 0.000		0.0 0.000	
31.7	.54E-04	0.0 0.000		0.0 0.000	
38.7	.37E-04	0.0 0.000		0.0 0.000	
47.2	.26E-04	0.0 0.003		0.0 0.017	
57.5	.18E-04	0.2 0.089		0.5 0.244	
70.1	.12E-04	1.6 0.776		2.6 1.196	
85.5	.87E-05	5.0 2.363		5.3 2.454	
104.3	.62E-05	6.8 3.206		5.8 2.716	
127.2	.44E-05	5.3 2.484		4.4 2.041	
155.1	.32E-05	2.9 1.364		2.7 1.248	
189.1	.24E-05	1.3 0.629		1.5 0.704	
230.7	.18E-05	0.6 0.276		0.8 0.394	
281.3	.13E-05	0.3 0.126		0.5 0.227	
343.0	.10E-05	0.1 0.067		0.3 0.137	
418.3	.78E-06	0.1 0.051		0.2 0.085	
510.0	.61E-06	0.1 0.065		0.1 0.051	
622.0	.48E-06	0.1 0.055		0.1 0.031	
758.4	.38E-06	0.1 0.029		0.0 0.022	
924.9	.30E-06	0.0 0.014		0.0 0.016	
1128	.24E-06	0.0 0.006		0.0 0.011	
1375	.19E-06	0.0 0.002		0.0 0.007	
1677	.15E-06	0.0 0.000		0.0 0.004	
2045	.12E-06	0.0 0.000		0.0 0.001	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 15	Whenan Crusher	9/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 5 Analysis Time : 14:13:49 on 12-09-2013
Sampling Time : 14:13:48 on 12-09-2013

Measd nJ/m3	607	16	600	460	151	12
Twmy Fit :	571	22	561	477	152	12
EMax Fit :	590	24	579	489	152	12

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.000	
26.0	.79E-04	0.0 0.000		0.0 0.000	
31.7	.54E-04	0.0 0.000		0.0 0.000	
38.7	.37E-04	0.0 0.000		0.0 0.001	
47.2	.26E-04	0.0 0.009		0.1 0.040	
57.5	.18E-04	0.4 0.178		1.0 0.409	
70.1	.12E-04	2.5 1.060		3.6 1.488	
85.5	.87E-05	5.9 2.468		6.1 2.506	
104.3	.62E-05	6.9 2.913		6.1 2.495	
127.2	.44E-05	5.2 2.190		4.4 1.811	
155.1	.32E-05	3.0 1.263		2.7 1.121	
189.1	.24E-05	1.5 0.641		1.6 0.656	
230.7	.18E-05	0.7 0.315		0.9 0.386	
281.3	.13E-05	0.4 0.161		0.6 0.235	
343.0	.10E-05	0.2 0.094		0.4 0.150	
418.3	.78E-06	0.2 0.075		0.2 0.102	
510.0	.61E-06	0.2 0.093		0.2 0.070	
622.0	.48E-06	0.2 0.081		0.1 0.048	
758.4	.38E-06	0.1 0.042		0.1 0.035	
924.9	.30E-06	0.0 0.018		0.1 0.025	
1128	.24E-06	0.0 0.006		0.0 0.016	
1375	.19E-06	0.0 0.001		0.0 0.009	
1677	.15E-06	0.0 0.000		0.0 0.003	
2045	.12E-06	0.0 0.000		0.0 0.001	
2494	.10E-06	0.0 0.000		0.0 0.000	

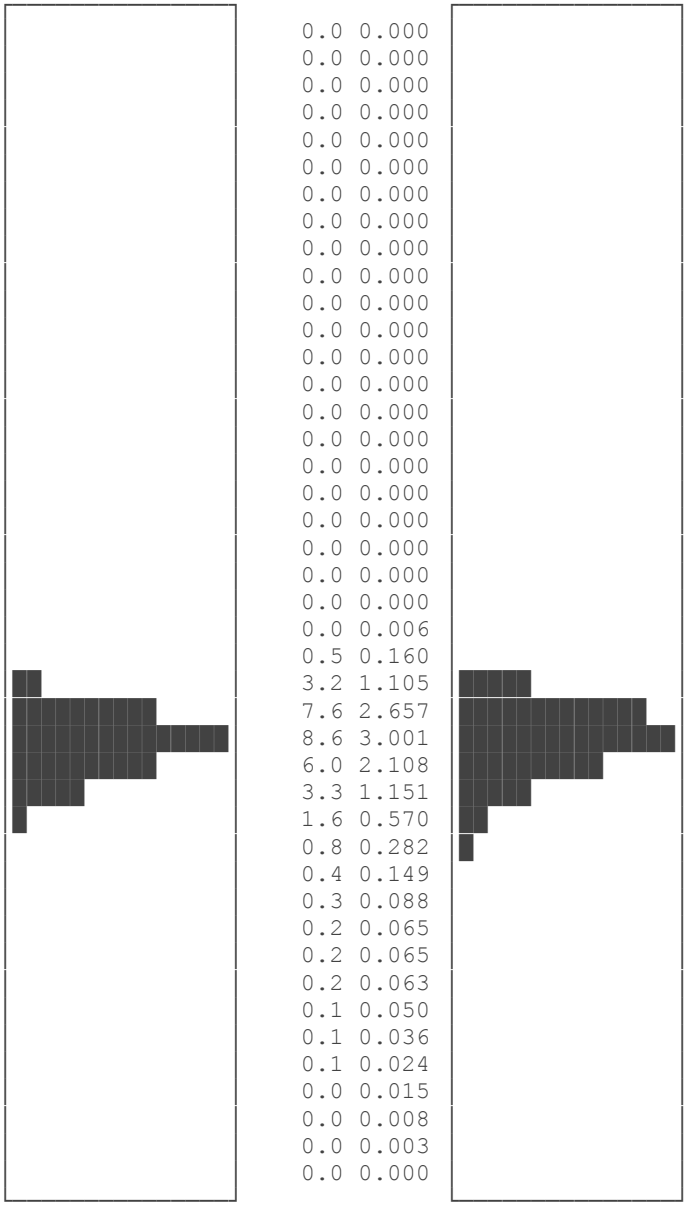
Location ID 15	Whenan Crusher	9/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 6 Analysis Time : 15:13:50 on 12-09-2013
Sampling Time : 15:13:48 on 12-09-2013

Measd nJ/m3	693	20	685	567	175	17
Twmy Fit :	680	26	668	569	178	17
EMax Fit :	687	27	675	572	179	16

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.000	
26.0	.79E-04	0.0 0.000		0.0 0.000	
31.7	.54E-04	0.0 0.000		0.0 0.000	
38.7	.37E-04	0.0 0.000		0.0 0.000	
47.2	.26E-04	0.0 0.001		0.0 0.006	
57.5	.18E-04	0.1 0.045		0.5 0.160	
70.1	.12E-04	1.8 0.644		3.2 1.105	
85.5	.87E-05	7.1 2.511		7.6 2.657	
104.3	.62E-05	10.2 3.605		8.6 3.001	
127.2	.44E-05	7.3 2.580		6.0 2.108	
155.1	.32E-05	3.4 1.204		3.3 1.151	
189.1	.24E-05	1.3 0.454		1.6 0.570	
230.7	.18E-05	0.5 0.161		0.8 0.282	
281.3	.13E-05	0.2 0.061		0.4 0.149	
343.0	.10E-05	0.1 0.029		0.3 0.088	
418.3	.78E-06	0.1 0.025		0.2 0.065	
510.0	.61E-06	0.2 0.059		0.2 0.065	
622.0	.48E-06	0.3 0.109		0.2 0.063	
758.4	.38E-06	0.2 0.070		0.1 0.050	
924.9	.30E-06	0.1 0.032		0.1 0.036	
1128	.24E-06	0.0 0.013		0.1 0.024	
1375	.19E-06	0.0 0.004		0.0 0.015	
1677	.15E-06	0.0 0.001		0.0 0.008	
2045	.12E-06	0.0 0.000		0.0 0.003	
2494	.10E-06	0.0 0.000		0.0 0.000	



Location ID 15	Whenan Crusher	9/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 7 Analysis Time : 16:13:50 on 12-09-2013
Sampling Time : 16:13:49 on 12-09-2013

Measd nJ/m3	689	18	697	534	174	20
Twmy Fit :	662	25	650	552	176	20
EMax Fit :	679	27	667	564	177	20

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS dC dC/ClogdDp	TWOMEY ANALYSIS RESULTS	EMAX ANALYSIS dC dC/ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.000	
26.0	.79E-04	0.0 0.000		0.0 0.000	
31.7	.54E-04	0.0 0.000		0.0 0.000	
38.7	.37E-04	0.0 0.000		0.0 0.000	
47.2	.26E-04	0.0 0.006		0.1 0.024	
57.5	.18E-04	0.4 0.152		0.9 0.329	
70.1	.12E-04	2.8 1.029		4.0 1.422	
85.5	.87E-05	7.0 2.544		7.3 2.597	
104.3	.62E-05	8.3 3.020		7.4 2.622	
127.2	.44E-05	6.0 2.197		5.2 1.848	
155.1	.32E-05	3.3 1.198		3.1 1.085	
189.1	.24E-05	1.6 0.569		1.7 0.598	
230.7	.18E-05	0.7 0.261		0.9 0.332	
281.3	.13E-05	0.3 0.127		0.5 0.194	
343.0	.10E-05	0.2 0.072		0.4 0.125	
418.3	.78E-06	0.2 0.062		0.3 0.094	
510.0	.61E-06	0.3 0.103		0.3 0.090	
622.0	.48E-06	0.4 0.135		0.2 0.083	
758.4	.38E-06	0.2 0.081		0.2 0.064	
924.9	.30E-06	0.1 0.036		0.1 0.045	
1128	.24E-06	0.0 0.012		0.1 0.029	
1375	.19E-06	0.0 0.003		0.0 0.016	
1677	.15E-06	0.0 0.000		0.0 0.006	
2045	.12E-06	0.0 0.000		0.0 0.001	
2494	.10E-06	0.0 0.000		0.0 0.000	

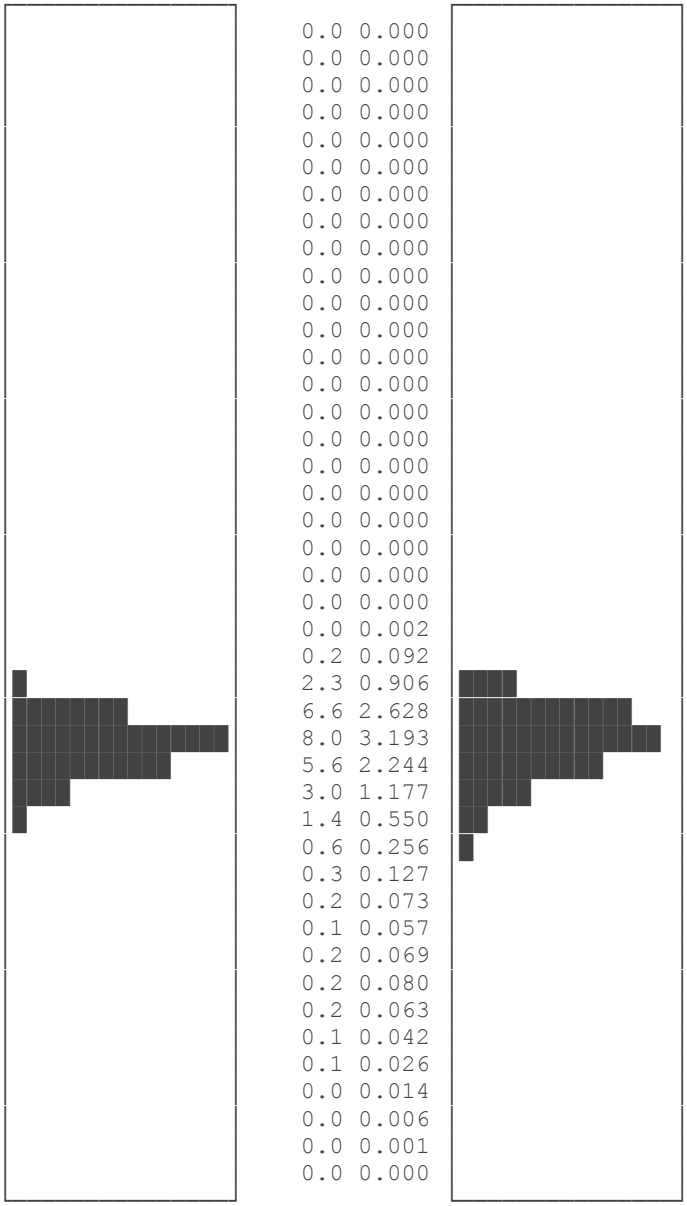
Location ID 15	Whenan Crusher	9/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 8 Analysis Time : 17:13:50 on 12-09-2013
Sampling Time : 17:13:49 on 12-09-2013

Measd nJ/m3	622	16	597	495	156	16
Twmy Fit :	592	22	582	498	159	16
EMax Fit :	605	23	594	505	160	16

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.000	
26.0	.79E-04	0.0 0.000		0.0 0.000	
31.7	.54E-04	0.0 0.000		0.0 0.000	
38.7	.37E-04	0.0 0.000		0.0 0.000	
47.2	.26E-04	0.0 0.000		0.0 0.002	
57.5	.18E-04	0.0 0.011		0.2 0.092	
70.1	.12E-04	0.9 0.350		2.3 0.906	
85.5	.87E-05	5.4 2.199		6.6 2.628	
104.3	.62E-05	9.7 3.931		8.0 3.193	
127.2	.44E-05	7.2 2.922		5.6 2.244	
155.1	.32E-05	3.1 1.262		3.0 1.177	
189.1	.24E-05	1.0 0.412		1.4 0.550	
230.7	.18E-05	0.3 0.124		0.6 0.256	
281.3	.13E-05	0.1 0.040		0.3 0.127	
343.0	.10E-05	0.0 0.017		0.2 0.073	
418.3	.78E-06	0.0 0.015		0.1 0.057	
510.0	.61E-06	0.1 0.051		0.2 0.069	
622.0	.48E-06	0.3 0.139		0.2 0.080	
758.4	.38E-06	0.2 0.089		0.2 0.063	
924.9	.30E-06	0.1 0.034		0.1 0.042	
1128	.24E-06	0.0 0.010		0.1 0.026	
1375	.19E-06	0.0 0.002		0.0 0.014	
1677	.15E-06	0.0 0.000		0.0 0.006	
2045	.12E-06	0.0 0.000		0.0 0.001	
2494	.10E-06	0.0 0.000		0.0 0.000	



Location ID 21	65 Rail Workshop	10/12/13

Rn Progeny Particle Size Spectrometer

Logged at 21:58:46 on 01-21-2014

BATTERY SPECIFICATIONS

Stage	No/Scrns	Mesh	Scrn Dia	Flow	Effic	BGcpm
1	0	Flter	3.8	0.80	0.127	0.00
2	1	100	0.7	0.80	0.108	0.00
3	1	100	3.8	0.80	0.130	0.00
4	10	100	3.8	0.80	0.130	0.00
5	80	100	3.8	0.80	0.130	0.00
6	0		0.0	0.70	0.220	0.00

Battery Inlet Tube (cm) = 0.00 Battery Outlet Tube (cm) = 4.00

SCREEN SPECIFICATIONS

Label	Mesh No.	Wire Dia. (microns)	Thickness (microns)	Solid Frac %	Comments
A	100	112.00	215.00	31.00	ARL 100 Mesh Screen
B	200	35.00	80.00	29.00	ARL 200 Mesh Screen
C	400	24.00	53.00	30.00	ARL 400 Mesh Screen
D	635	20.00	50.00	35.00	EML 635 Mesh Screen
F	Flter	0.00	0.00	0.00	Filter
T	Tube	0.00	0.00	0.00	ARL Cyl Tube Battery

IMPACTOR SPECIFICATIONS

Impactor Curve Fits with Simoid Fit

Stage	Dp50 (nm)	Dp50LB (nm)	Dp50UB (nm)	Slope	Intrcpt	Flow (lpm)	Effic	BGcpm
1	500.00	450.00	550.00	1.230	2.020	0.7	0.220	0.00

DECONVOLUTION ANALYSIS

Twomey Algorithm : Y No of Iterations : 1000 Twomey Speed : 0.70
EMax Algorithm : Y Max Iterations : 2000 Converg Criteria : 100[ppm]
No of Size Ranges : 43
Smallest Diameter : 0.60 (nm)
Largest Diameter : 2493.90 (nm)

PARAMETER SPECIFICATIONS

Effective Energy (Mev) = 7.200
Convrsn Factor (per WL) = 130000
Acquisition Time (secs) = 3600
Particle Density (g/cm3) = 1.00

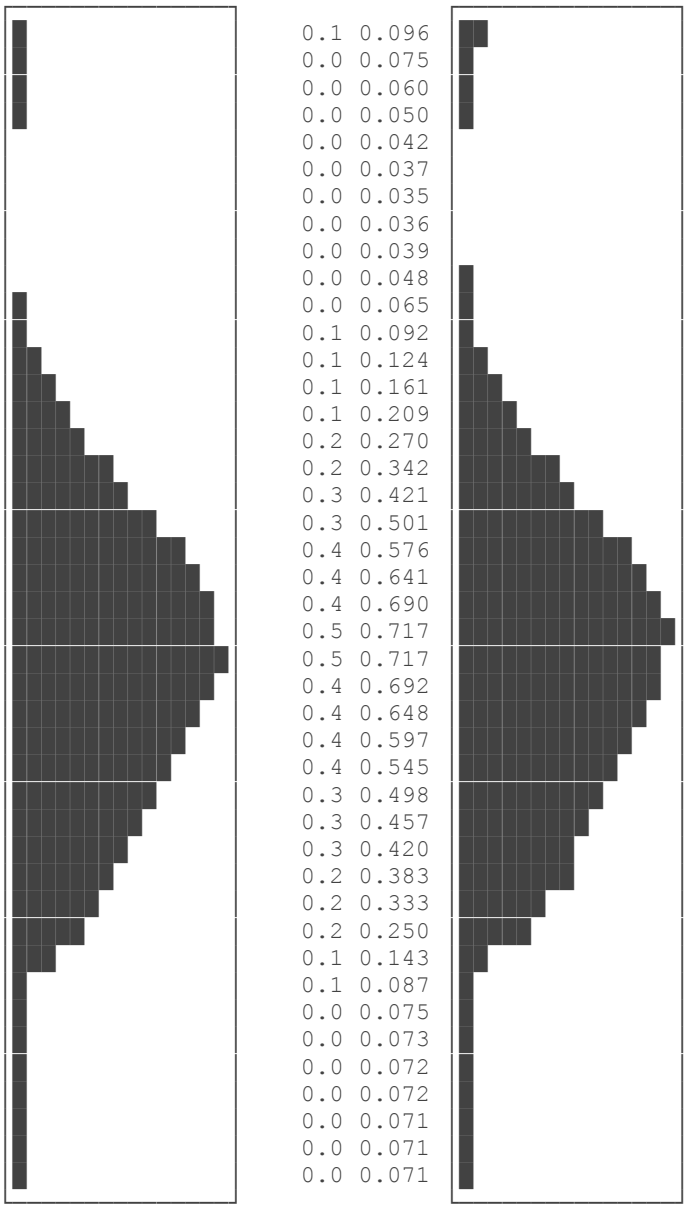
Location ID 21	65 Rail Workshop	10/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 1 Analysis Time : 21:58:56 on 01-21-2014
Sampling Time : 13:34:25 on 12-10-2013

Measd nJ/m3	154	18	138	94	31	10
Twmy Fit :	154	18	138	94	31	10
EMax Fit :	154	18	138	94	31	10

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.1 0.091		0.1 0.096	
0.7	.59E-01	0.1 0.077		0.0 0.075	
0.9	.44E-01	0.0 0.065		0.0 0.060	
1.1	.33E-01	0.0 0.056		0.0 0.050	
1.3	.25E-01	0.0 0.047		0.0 0.042	
1.6	.18E-01	0.0 0.041		0.0 0.037	
2.0	.12E-01	0.0 0.037		0.0 0.035	
2.4	.86E-02	0.0 0.036		0.0 0.036	
2.9	.58E-02	0.0 0.037		0.0 0.039	
3.6	.39E-02	0.0 0.044		0.0 0.048	
4.4	.27E-02	0.0 0.059		0.0 0.065	
5.3	.18E-02	0.1 0.084		0.1 0.092	
6.5	.12E-02	0.1 0.118		0.1 0.124	
7.9	.82E-03	0.1 0.160		0.1 0.161	
9.6	.55E-03	0.1 0.213		0.1 0.209	
11.8	.37E-03	0.2 0.278		0.2 0.270	
14.3	.25E-03	0.2 0.351		0.2 0.342	
17.5	.17E-03	0.3 0.428		0.3 0.421	
21.3	.12E-03	0.3 0.503		0.3 0.501	
26.0	.79E-04	0.4 0.573		0.4 0.576	
31.7	.54E-04	0.4 0.633		0.4 0.641	
38.7	.37E-04	0.4 0.680		0.4 0.690	
47.2	.26E-04	0.5 0.708		0.5 0.717	
57.5	.18E-04	0.5 0.714		0.5 0.717	
70.1	.12E-04	0.5 0.695		0.4 0.692	
85.5	.87E-05	0.4 0.657		0.4 0.648	
104.3	.62E-05	0.4 0.606		0.4 0.597	
127.2	.44E-05	0.4 0.552		0.4 0.545	
155.1	.32E-05	0.3 0.499		0.3 0.498	
189.1	.24E-05	0.3 0.452		0.3 0.457	
230.7	.18E-05	0.3 0.409		0.3 0.420	
281.3	.13E-05	0.2 0.370		0.2 0.383	
343.0	.10E-05	0.2 0.327		0.2 0.333	
418.3	.78E-06	0.2 0.261		0.2 0.250	
510.0	.61E-06	0.1 0.162		0.1 0.143	
622.0	.48E-06	0.1 0.093		0.1 0.087	
758.4	.38E-06	0.0 0.074		0.0 0.075	
924.9	.30E-06	0.0 0.070		0.0 0.073	
1128	.24E-06	0.0 0.069		0.0 0.072	
1375	.19E-06	0.0 0.068		0.0 0.072	
1677	.15E-06	0.0 0.068		0.0 0.071	
2045	.12E-06	0.0 0.069		0.0 0.071	
2494	.10E-06	0.0 0.070		0.0 0.071	



Location ID 21	65 Rail Workshop	10/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 2 Analysis Time : 21:59:05 on 01-21-2014
Sampling Time : 15:34:26 on 12-10-2013

Measd nJ/m3	161	24	145	145	35	12
Twmy Fit :	188	23	163	133	37	12
EMax Fit :	175	21	152	125	37	12

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.002		0.0 0.026	
2.4	.86E-02	0.2 0.205		0.7 0.952	
2.9	.58E-02	1.1 1.376		0.6 0.745	
3.6	.39E-02	0.1 0.121		0.0 0.005	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.000	
26.0	.79E-04	0.0 0.000		0.0 0.000	
31.7	.54E-04	0.0 0.000		0.0 0.000	
38.7	.37E-04	0.0 0.000		0.0 0.000	
47.2	.26E-04	0.0 0.000		0.0 0.000	
57.5	.18E-04	0.0 0.033		0.0 0.042	
70.1	.12E-04	0.8 1.005		0.7 0.905	
85.5	.87E-05	3.2 4.096		2.4 3.290	
104.3	.62E-05	2.5 3.194		2.3 3.155	
127.2	.44E-05	0.6 0.769		1.0 1.291	
155.1	.32E-05	0.1 0.092		0.3 0.339	
189.1	.24E-05	0.0 0.008		0.1 0.077	
230.7	.18E-05	0.0 0.001		0.0 0.018	
281.3	.13E-05	0.0 0.000		0.0 0.005	
343.0	.10E-05	0.0 0.000		0.0 0.002	
418.3	.78E-06	0.0 0.000		0.0 0.002	
510.0	.61E-06	0.0 0.000		0.0 0.005	
622.0	.48E-06	0.0 0.000		0.0 0.012	
758.4	.38E-06	0.0 0.000		0.0 0.012	
924.9	.30E-06	0.0 0.000		0.0 0.010	
1128	.24E-06	0.0 0.000		0.0 0.009	
1375	.19E-06	0.0 0.000		0.0 0.012	
1677	.15E-06	0.0 0.000		0.0 0.021	
2045	.12E-06	0.0 0.002		0.1 0.070	
2494	.10E-06	0.6 0.702		0.4 0.600	

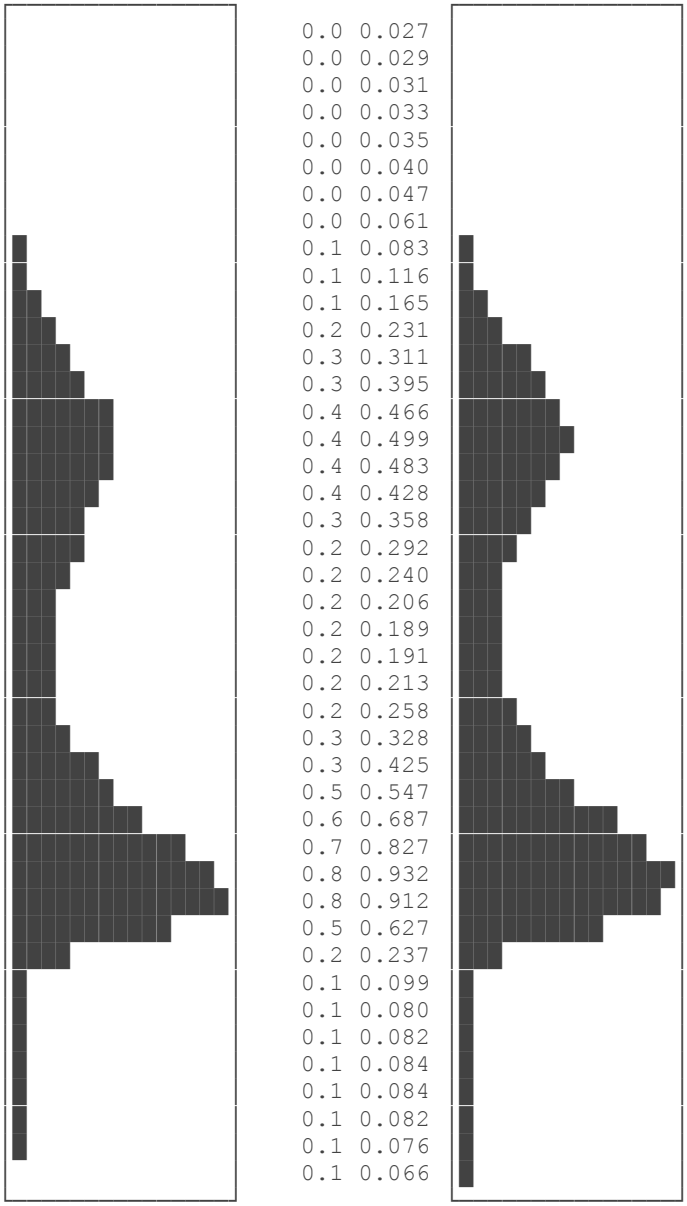
Location ID 21	65 Rail Workshop	10/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 3 Analysis Time : 21:59:14 on 01-21-2014
Sampling Time : 17:34:26 on 12-10-2013

Measd nJ/m3	195	28	170	118	58	17
Twmy Fit :	196	28	170	118	58	17
EMax Fit :	195	28	170	118	58	17

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.037		0.0 0.027	
0.7	.59E-01	0.0 0.036		0.0 0.029	
0.9	.44E-01	0.0 0.036		0.0 0.031	
1.1	.33E-01	0.0 0.037		0.0 0.033	
1.3	.25E-01	0.0 0.038		0.0 0.035	
1.6	.18E-01	0.0 0.042		0.0 0.040	
2.0	.12E-01	0.0 0.049		0.0 0.047	
2.4	.86E-02	0.1 0.063		0.0 0.061	
2.9	.58E-02	0.1 0.086		0.1 0.083	
3.6	.39E-02	0.1 0.121		0.1 0.116	
4.4	.27E-02	0.1 0.167		0.1 0.165	
5.3	.18E-02	0.2 0.223		0.2 0.231	
6.5	.12E-02	0.2 0.295		0.3 0.311	
7.9	.82E-03	0.3 0.378		0.3 0.395	
9.6	.55E-03	0.4 0.446		0.4 0.466	
11.8	.37E-03	0.4 0.481		0.4 0.499	
14.3	.25E-03	0.4 0.474		0.4 0.483	
17.5	.17E-03	0.4 0.435		0.4 0.428	
21.3	.12E-03	0.3 0.378		0.3 0.358	
26.0	.79E-04	0.3 0.319		0.2 0.292	
31.7	.54E-04	0.2 0.268		0.2 0.240	
38.7	.37E-04	0.2 0.230		0.2 0.206	
47.2	.26E-04	0.2 0.208		0.2 0.189	
57.5	.18E-04	0.2 0.204		0.2 0.191	
70.1	.12E-04	0.2 0.217		0.2 0.213	
85.5	.87E-05	0.2 0.250		0.2 0.258	
104.3	.62E-05	0.3 0.307		0.3 0.328	
127.2	.44E-05	0.3 0.389		0.3 0.425	
155.1	.32E-05	0.4 0.499		0.5 0.547	
189.1	.24E-05	0.5 0.632		0.6 0.687	
230.7	.18E-05	0.6 0.780		0.7 0.827	
281.3	.13E-05	0.8 0.912		0.8 0.932	
343.0	.10E-05	0.8 0.951		0.8 0.912	
418.3	.78E-06	0.6 0.727		0.5 0.627	
510.0	.61E-06	0.2 0.288		0.2 0.237	
622.0	.48E-06	0.1 0.099		0.1 0.099	
758.4	.38E-06	0.1 0.072		0.1 0.080	
924.9	.30E-06	0.1 0.072		0.1 0.082	
1128	.24E-06	0.1 0.075		0.1 0.084	
1375	.19E-06	0.1 0.076		0.1 0.084	
1677	.15E-06	0.1 0.075		0.1 0.082	
2045	.12E-06	0.1 0.071		0.1 0.076	
2494	.10E-06	0.1 0.063		0.1 0.066	



Location ID 25	32RB5	11/12/13

Rn Progeny Particle Size Spectrometer

Logged at 21:37:43 on 01-21-2014

BATTERY SPECIFICATIONS

Stage	No/Scrns	Mesh	Scrn Dia	Flow	Effic	BGcpm
1	0	Flter	3.8	0.80	0.127	0.00
2	1	100	0.7	0.80	0.108	0.00
3	1	100	3.8	0.80	0.130	0.00
4	10	100	3.8	0.80	0.130	0.00
5	80	100	3.8	0.80	0.130	0.00
6	0	0.0	0.70	0.220	0.00	

Battery Inlet Tube (cm) = 0.00 Battery Outlet Tube (cm) = 4.00

SCREEN SPECIFICATIONS

Label	Mesh No.	Wire Dia. (microns)	Thickness (microns)	Solid Frac %	Comments
A	100	112.00	215.00	31.00	ARL 100 Mesh Screen
B	200	35.00	80.00	29.00	ARL 200 Mesh Screen
C	400	24.00	53.00	30.00	ARL 400 Mesh Screen
D	635	20.00	50.00	35.00	EML 635 Mesh Screen
F	Flter	0.00	0.00	0.00	Filter
T	Tube	0.00	0.00	0.00	ARL Cyl Tube Battery

IMPACTOR SPECIFICATIONS

Impactor Curve Fits with Simoid Fit

Stage	Dp50 (nm)	Dp50LB (nm)	Dp50UB (nm)	Slope	Intrcpt	Flow (lpm)	Effic	BGcpm
1	500.00	450.00	550.00	1.230	2.020	0.7	0.220	0.00

DECONVOLUTION ANALYSIS

Twomey Algorithm : Y No of Iterations : 1000 Twomey Speed : 0.70
EMax Algorithm : Y Max Iterations : 2000 Converg Criteria : 100[ppm]
No of Size Ranges : 43
Smallest Diameter : 0.60 (nm)
Largest Diameter : 2493.90 (nm)

PARAMETER SPECIFICATIONS

Effective Energy (Mev) = 7.200
Convrsn Factor (per WL) = 130000
Acquisition Time (secs) = 21600
Particle Density (g/cm3) = 1.00

Location ID 25	32RB5	11/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 1 Analysis Time : 21:37:51 on 01-21-2014
Sampling Time : 16:37:48 on 12-11-2013

Measd nJ/m3	12	5	10	7	5	5
Twmy Fit :	15	5	10	7	5	5
EMax Fit :	14	4	10	7	5	5

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.001		0.0 0.001	
3.6	.39E-02	0.0 0.593		0.0 0.696	
4.4	.27E-02	0.3 4.143		0.2 3.912	
5.3	.18E-02	0.0 0.787		0.0 0.674	
6.5	.12E-02	0.0 0.197		0.0 0.186	
7.9	.82E-03	0.0 0.086		0.0 0.097	
9.6	.55E-03	0.0 0.006		0.0 0.011	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.000	
17.5	.17E-03	0.0 0.000		0.0 0.000	
21.3	.12E-03	0.0 0.000		0.0 0.000	
26.0	.79E-04	0.0 0.000		0.0 0.000	
31.7	.54E-04	0.0 0.000		0.0 0.000	
38.7	.37E-04	0.0 0.000		0.0 0.000	
47.2	.26E-04	0.0 0.000		0.0 0.000	
57.5	.18E-04	0.0 0.000		0.0 0.000	
70.1	.12E-04	0.0 0.000		0.0 0.000	
85.5	.87E-05	0.0 0.000		0.0 0.000	
104.3	.62E-05	0.0 0.000		0.0 0.000	
127.2	.44E-05	0.0 0.000		0.0 0.000	
155.1	.32E-05	0.0 0.000		0.0 0.001	
189.1	.24E-05	0.0 0.000		0.0 0.008	
230.7	.18E-05	0.0 0.008		0.0 0.054	
281.3	.13E-05	0.0 0.128		0.0 0.263	
343.0	.10E-05	0.1 0.923		0.0 0.800	
418.3	.78E-06	0.1 1.390		0.1 1.051	
510.0	.61E-06	0.0 0.122		0.0 0.381	
622.0	.48E-06	0.0 0.007		0.0 0.137	
758.4	.38E-06	0.0 0.007		0.0 0.146	
924.9	.30E-06	0.0 0.017		0.0 0.219	
1128	.24E-06	0.0 0.046		0.0 0.320	
1375	.19E-06	0.0 0.108		0.0 0.433	
1677	.15E-06	0.0 0.240		0.0 0.555	
2045	.12E-06	0.0 0.593		0.0 0.701	
2494	.10E-06	0.1 2.204		0.1 0.961	

Location ID 28	36 Yellow 419	12/12/13

Rn Progeny Particle Size Spectrometer

Logged at 09:55:25 on 12-12-2013

BATTERY SPECIFICATIONS

Stage	No/Scrns	Mesh	Scrn Dia	Flow	Effic	BGcpm
1	0	Flter	3.8	0.80	0.127	0.00
2	1	100	0.7	0.80	0.108	0.00
3	1	100	3.8	0.80	0.130	0.00
4	10	100	3.8	0.80	0.130	0.00
5	80	100	3.8	0.80	0.130	0.00
6	0	0.0	0.70	0.220	0.00	

Battery Inlet Tube (cm) = 0.00 Battery Outlet Tube (cm) = 4.00

SCREEN SPECIFICATIONS

Label	Mesh No.	Wire Dia. (microns)	Thickness (microns)	Solid Frac %	Comments
A	100	112.00	215.00	31.30	ARL 100 Mesh Screen
B	200	35.00	80.00	29.10	ARL 200 Mesh Screen
C	400	24.00	53.00	30.20	ARL 400 Mesh Screen
D	635	20.00	50.00	34.50	EML 635 Mesh Screen
F	Flter	0.00	0.00	0.00	Filter
T	Tube	0.00	0.00	0.00	ARL Cyl Tube Battery

IMPACTOR SPECIFICATIONS

Impactor Curve Fits with Simoid Fit

Stage	Dp50 (nm)	Dp50LB (nm)	Dp50UB (nm)	Slope	Intrcpt	Flow (lpm)	Effic	BGcpm
1	500.00	450.00	550.00	1.230	2.020	0.7	0.220	0.00

DECONVOLUTION ANALYSIS

Twomey Algorithm : Y No of Iterations : 1000 Twomey Speed : 0.70
EMax Algorithm : Y Max Iterations : 2000 Converg Criteria : 100[ppm]
No of Size Ranges : 43
Smallest Diameter : 0.60 (nm)
Largest Diameter : 2493.90 (nm)

PARAMETER SPECIFICATIONS

Effective Energy (Mev) = 7.200
Convrsn Factor (per WL) = 130000
Acquisition Time (secs) = 3600
Particle Density (g/cm3) = 1.00

Location ID 28	36 Yellow 419	12/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 1 Analysis Time : 10:55:26 on 12-12-2013
Sampling Time : 10:55:25 on 12-12-2013

Measd nJ/m3	273	17	311	218	93	8
Twmy Fit :	299	20	289	224	92	8
EMax Fit :	293	18	284	225	92	8

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.000		0.0 0.003	
17.5	.17E-03	0.0 0.015		0.1 0.059	
21.3	.12E-03	0.3 0.239		0.4 0.347	
26.0	.79E-04	1.1 0.918		0.9 0.745	
31.7	.54E-04	1.6 1.277		1.0 0.850	
38.7	.37E-04	1.2 0.978		0.9 0.700	
47.2	.26E-04	0.7 0.587		0.6 0.525	
57.5	.18E-04	0.4 0.359		0.5 0.417	
70.1	.12E-04	0.3 0.261		0.5 0.380	
85.5	.87E-05	0.3 0.241		0.5 0.401	
104.3	.62E-05	0.3 0.276		0.6 0.477	
127.2	.44E-05	0.5 0.371		0.7 0.607	
155.1	.32E-05	0.7 0.546		1.0 0.792	
189.1	.24E-05	1.0 0.825		1.2 1.020	
230.7	.18E-05	1.5 1.203		1.5 1.250	
281.3	.13E-05	1.9 1.553		1.7 1.370	
343.0	.10E-05	1.8 1.436		1.4 1.139	
418.3	.78E-06	0.6 0.500		0.5 0.447	
510.0	.61E-06	0.0 0.021		0.1 0.048	
622.0	.48E-06	0.0 0.001		0.0 0.006	
758.4	.38E-06	0.0 0.000		0.0 0.004	
924.9	.30E-06	0.0 0.000		0.0 0.004	
1128	.24E-06	0.0 0.000		0.0 0.004	
1375	.19E-06	0.0 0.000		0.0 0.003	
1677	.15E-06	0.0 0.000		0.0 0.003	
2045	.12E-06	0.0 0.000		0.0 0.002	
2494	.10E-06	0.0 0.000		0.0 0.001	

Location ID 28	36 Yellow 419	12/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 2 Analysis Time : 11:55:27 on 12-12-2013
Sampling Time : 11:55:25 on 12-12-2013

Measd nJ/m3	529	27	536	424	176	11
Twmy Fit :	538	28	524	428	176	11
EMax Fit :	537	27	523	429	176	11

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.001		0.0 0.004	
14.3	.25E-03	0.0 0.011		0.1 0.025	
17.5	.17E-03	0.2 0.067		0.2 0.098	
21.3	.12E-03	0.5 0.216		0.5 0.230	
26.0	.79E-04	0.9 0.414		0.8 0.366	
31.7	.54E-04	1.2 0.546		1.0 0.450	
38.7	.37E-04	1.3 0.573		1.1 0.480	
47.2	.26E-04	1.2 0.544		1.1 0.486	
57.5	.18E-04	1.2 0.514		1.1 0.499	
70.1	.12E-04	1.1 0.512		1.2 0.538	
85.5	.87E-05	1.2 0.550		1.4 0.613	
104.3	.62E-05	1.4 0.632		1.6 0.724	
127.2	.44E-05	1.7 0.761		1.9 0.869	
155.1	.32E-05	2.1 0.935		2.3 1.037	
189.1	.24E-05	2.5 1.139		2.7 1.206	
230.7	.18E-05	3.0 1.331		3.0 1.332	
281.3	.13E-05	3.1 1.398		2.9 1.316	
343.0	.10E-05	2.4 1.094		2.2 0.974	
418.3	.78E-06	0.8 0.350		0.7 0.322	
510.0	.61E-06	0.0 0.015		0.1 0.026	
622.0	.48E-06	0.0 0.000		0.0 0.003	
758.4	.38E-06	0.0 0.000		0.0 0.001	
924.9	.30E-06	0.0 0.000		0.0 0.001	
1128	.24E-06	0.0 0.000		0.0 0.001	
1375	.19E-06	0.0 0.000		0.0 0.001	
1677	.15E-06	0.0 0.000		0.0 0.001	
2045	.12E-06	0.0 0.000		0.0 0.001	
2494	.10E-06	0.0 0.000		0.0 0.001	

Location ID 28	36 Yellow 419	12/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 3 Analysis Time : 12:55:27 on 12-12-2013
Sampling Time : 12:55:26 on 12-12-2013

Measd nJ/m3	624	32	610	472	187	12
Twmy Fit :	613	34	596	480	187	12
EMax Fit :	619	34	602	484	187	12

Dp (nm)	DiffCoeff cm2/sec	TWOMEY ANALYSIS dC dC/ClogdDp	TWOMEY ANALYSIS RESULTS	EMAX ANALYSIS dC dC/ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.002		0.0 0.005	
17.5	.17E-03	0.1 0.029		0.1 0.050	
21.3	.12E-03	0.4 0.165		0.5 0.211	
26.0	.79E-04	1.1 0.445		1.2 0.455	
31.7	.54E-04	1.8 0.689		1.6 0.626	
38.7	.37E-04	1.9 0.750		1.7 0.663	
47.2	.26E-04	1.8 0.687		1.6 0.628	
57.5	.18E-04	1.5 0.606		1.5 0.592	
70.1	.12E-04	1.4 0.562		1.5 0.588	
85.5	.87E-05	1.4 0.566		1.6 0.625	
104.3	.62E-05	1.6 0.620		1.8 0.703	
127.2	.44E-05	1.8 0.723		2.1 0.815	
155.1	.32E-05	2.2 0.869		2.4 0.952	
189.1	.24E-05	2.7 1.046		2.8 1.092	
230.7	.18E-05	3.1 1.214		3.1 1.197	
281.3	.13E-05	3.2 1.275		3.0 1.181	
343.0	.10E-05	2.6 1.006		2.3 0.882	
418.3	.78E-06	0.9 0.334		0.8 0.302	
510.0	.61E-06	0.0 0.016		0.1 0.027	
622.0	.48E-06	0.0 0.000		0.0 0.003	
758.4	.38E-06	0.0 0.000		0.0 0.002	
924.9	.30E-06	0.0 0.000		0.0 0.001	
1128	.24E-06	0.0 0.000		0.0 0.001	
1375	.19E-06	0.0 0.000		0.0 0.001	
1677	.15E-06	0.0 0.000		0.0 0.001	
2045	.12E-06	0.0 0.000		0.0 0.001	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 28	36 Yellow 419	12/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 4 Analysis Time : 13:55:27 on 12-12-2013
Sampling Time : 13:55:26 on 12-12-2013

Measd nJ/m3	659	31	649	520	200	11
Twmy Fit :	654	32	638	525	199	11
EMax Fit :	658	32	642	528	199	11

Dp (nm)	DiffCoeff cm2/sec	dC	dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC	dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0	0.000		0.0	0.000	
0.7	.59E-01	0.0	0.000		0.0	0.000	
0.9	.44E-01	0.0	0.000		0.0	0.000	
1.1	.33E-01	0.0	0.000		0.0	0.000	
1.3	.25E-01	0.0	0.000		0.0	0.000	
1.6	.18E-01	0.0	0.000		0.0	0.000	
2.0	.12E-01	0.0	0.000		0.0	0.000	
2.4	.86E-02	0.0	0.000		0.0	0.000	
2.9	.58E-02	0.0	0.000		0.0	0.000	
3.6	.39E-02	0.0	0.000		0.0	0.000	
4.4	.27E-02	0.0	0.000		0.0	0.000	
5.3	.18E-02	0.0	0.000		0.0	0.000	
6.5	.12E-02	0.0	0.000		0.0	0.000	
7.9	.82E-03	0.0	0.000		0.0	0.000	
9.6	.55E-03	0.0	0.000		0.0	0.000	
11.8	.37E-03	0.0	0.000		0.0	0.000	
14.3	.25E-03	0.0	0.002		0.0	0.004	
17.5	.17E-03	0.1	0.020		0.1	0.027	
21.3	.12E-03	0.2	0.089		0.3	0.103	
26.0	.79E-04	0.6	0.239		0.7	0.243	
31.7	.54E-04	1.2	0.426		1.1	0.405	
38.7	.37E-04	1.6	0.578		1.5	0.539	
47.2	.26E-04	1.8	0.666		1.7	0.630	
57.5	.18E-04	1.9	0.711		1.9	0.696	
70.1	.12E-04	2.0	0.746		2.1	0.756	
85.5	.87E-05	2.1	0.790		2.3	0.825	
104.3	.62E-05	2.3	0.853		2.5	0.904	
127.2	.44E-05	2.5	0.934		2.7	0.990	
155.1	.32E-05	2.8	1.027		2.9	1.075	
189.1	.24E-05	3.0	1.115		3.1	1.142	
230.7	.18E-05	3.2	1.169		3.2	1.162	
281.3	.13E-05	3.0	1.121		2.9	1.073	
343.0	.10E-05	2.3	0.829		2.1	0.756	
418.3	.78E-06	0.7	0.274		0.7	0.247	
510.0	.61E-06	0.0	0.014		0.1	0.021	
622.0	.48E-06	0.0	0.000		0.0	0.002	
758.4	.38E-06	0.0	0.000		0.0	0.001	
924.9	.30E-06	0.0	0.000		0.0	0.001	
1128	.24E-06	0.0	0.000		0.0	0.001	
1375	.19E-06	0.0	0.000		0.0	0.001	
1677	.15E-06	0.0	0.000		0.0	0.001	
2045	.12E-06	0.0	0.000		0.0	0.001	
2494	.10E-06	0.0	0.000		0.0	0.000	

Location ID 28	36 Yellow 419	12/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 6 Analysis Time : 15:55:28 on 12-12-2013
Sampling Time : 15:55:26 on 12-12-2013

Measd nJ/m3	711	41	714	531	205	13
Twmy Fit :	712	44	690	542	204	13
EMax Fit :	715	43	693	546	204	13

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.000		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.000	
7.9	.82E-03	0.0 0.000		0.0 0.000	
9.6	.55E-03	0.0 0.000		0.0 0.000	
11.8	.37E-03	0.0 0.000		0.0 0.000	
14.3	.25E-03	0.0 0.001		0.0 0.005	
17.5	.17E-03	0.1 0.028		0.2 0.058	
21.3	.12E-03	0.6 0.207		0.8 0.271	
26.0	.79E-04	1.8 0.609		1.8 0.591	
31.7	.54E-04	2.7 0.916		2.3 0.774	
38.7	.37E-04	2.7 0.909		2.3 0.762	
47.2	.26E-04	2.2 0.743		2.0 0.671	
57.5	.18E-04	1.7 0.591		1.8 0.594	
70.1	.12E-04	1.5 0.507		1.7 0.564	
85.5	.87E-05	1.5 0.490		1.7 0.584	
104.3	.62E-05	1.6 0.531		1.9 0.649	
127.2	.44E-05	1.9 0.626		2.2 0.752	
155.1	.32E-05	2.3 0.774		2.6 0.883	
189.1	.24E-05	2.9 0.964		3.0 1.023	
230.7	.18E-05	3.4 1.159		3.4 1.133	
281.3	.13E-05	3.7 1.249		3.4 1.127	
343.0	.10E-05	2.9 0.986		2.5 0.844	
418.3	.78E-06	0.9 0.304		0.9 0.286	
510.0	.61E-06	0.0 0.012		0.1 0.024	
622.0	.48E-06	0.0 0.000		0.0 0.003	
758.4	.38E-06	0.0 0.000		0.0 0.001	
924.9	.30E-06	0.0 0.000		0.0 0.001	
1128	.24E-06	0.0 0.000		0.0 0.001	
1375	.19E-06	0.0 0.000		0.0 0.001	
1677	.15E-06	0.0 0.000		0.0 0.001	
2045	.12E-06	0.0 0.000		0.0 0.001	
2494	.10E-06	0.0 0.000		0.0 0.000	

Location ID 28	36 Yellow 419	12/12/13

Species PAEC ANALYSIS RESULTS

Calculation No : 7 Analysis Time : 16:55:28 on 12-12-2013
Sampling Time : 16:55:27 on 12-12-2013

Measd nJ/m3	721	40	710	567	207	14
Twmy Fit :	726	40	706	568	207	14
EMax Fit :	725	40	705	568	207	14

Dp (nm)	DiffCoeff cm2/sec	dC dC/ ClogdDp	TWOMEY ANALYSIS RESULTS	dC dC/ ClogdDp	EMAX ANALYSIS RESULTS
0.6	.77E-01	0.0 0.001		0.0 0.000	
0.7	.59E-01	0.0 0.000		0.0 0.000	
0.9	.44E-01	0.0 0.000		0.0 0.000	
1.1	.33E-01	0.0 0.000		0.0 0.000	
1.3	.25E-01	0.0 0.000		0.0 0.000	
1.6	.18E-01	0.0 0.000		0.0 0.000	
2.0	.12E-01	0.0 0.000		0.0 0.000	
2.4	.86E-02	0.0 0.000		0.0 0.000	
2.9	.58E-02	0.0 0.000		0.0 0.000	
3.6	.39E-02	0.0 0.000		0.0 0.000	
4.4	.27E-02	0.0 0.000		0.0 0.000	
5.3	.18E-02	0.0 0.000		0.0 0.000	
6.5	.12E-02	0.0 0.000		0.0 0.001	
7.9	.82E-03	0.0 0.001		0.0 0.002	
9.6	.55E-03	0.0 0.005		0.0 0.007	
11.8	.37E-03	0.0 0.015		0.1 0.020	
14.3	.25E-03	0.1 0.042		0.1 0.048	
17.5	.17E-03	0.3 0.098		0.3 0.101	
21.3	.12E-03	0.6 0.188		0.5 0.182	
26.0	.79E-04	0.9 0.305		0.9 0.288	
31.7	.54E-04	1.3 0.433		1.2 0.407	
38.7	.37E-04	1.7 0.556		1.6 0.527	
47.2	.26E-04	2.0 0.662		1.9 0.638	
57.5	.18E-04	2.3 0.749		2.2 0.737	
70.1	.12E-04	2.5 0.820		2.5 0.821	
85.5	.87E-05	2.6 0.876		2.7 0.891	
104.3	.62E-05	2.8 0.920		2.9 0.947	
127.2	.44E-05	2.9 0.953		3.0 0.989	
155.1	.32E-05	2.9 0.976		3.1 1.017	
189.1	.24E-05	3.0 0.985		3.1 1.025	
230.7	.18E-05	2.9 0.972		3.0 1.003	
281.3	.13E-05	2.7 0.908		2.8 0.913	
343.0	.10E-05	2.2 0.726		2.0 0.680	
418.3	.78E-06	1.1 0.351		0.9 0.283	
510.0	.61E-06	0.2 0.051		0.1 0.042	
622.0	.48E-06	0.0 0.005		0.0 0.007	
758.4	.38E-06	0.0 0.002		0.0 0.005	
924.9	.30E-06	0.0 0.002		0.0 0.004	
1128	.24E-06	0.0 0.002		0.0 0.004	
1375	.19E-06	0.0 0.001		0.0 0.004	
1677	.15E-06	0.0 0.001		0.0 0.004	
2045	.12E-06	0.0 0.001		0.0 0.004	
2494	.10E-06	0.0 0.001		0.0 0.003	