

Assessment of radon progeny dose conversion factors from measurements in the underground uranium mine at Olympic Dam

Technical Report 179

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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.

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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’, fws). 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 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 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 fws ~ 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 fp) 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 fp) in the presence of a nucleation mode.

For this study, the dose conversion factors (DCF) (defined as the effective dose per unit intake of 222Rn 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 fHE 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.

# Introduction

## 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 218Po and 214Po, 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 218Po), 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 218Po decays to the other radionuclides in the Uranium decay chain (214Pb, 214Bi, 214Po), they generally remain attached. The unattached fraction fp 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’.

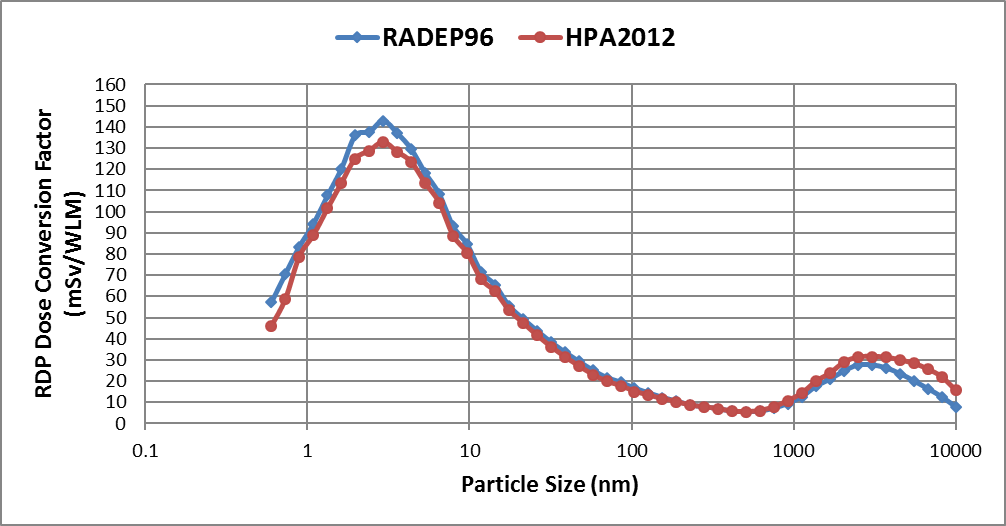
## Radon decay product dosimetric models

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 222Rn 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 m3 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

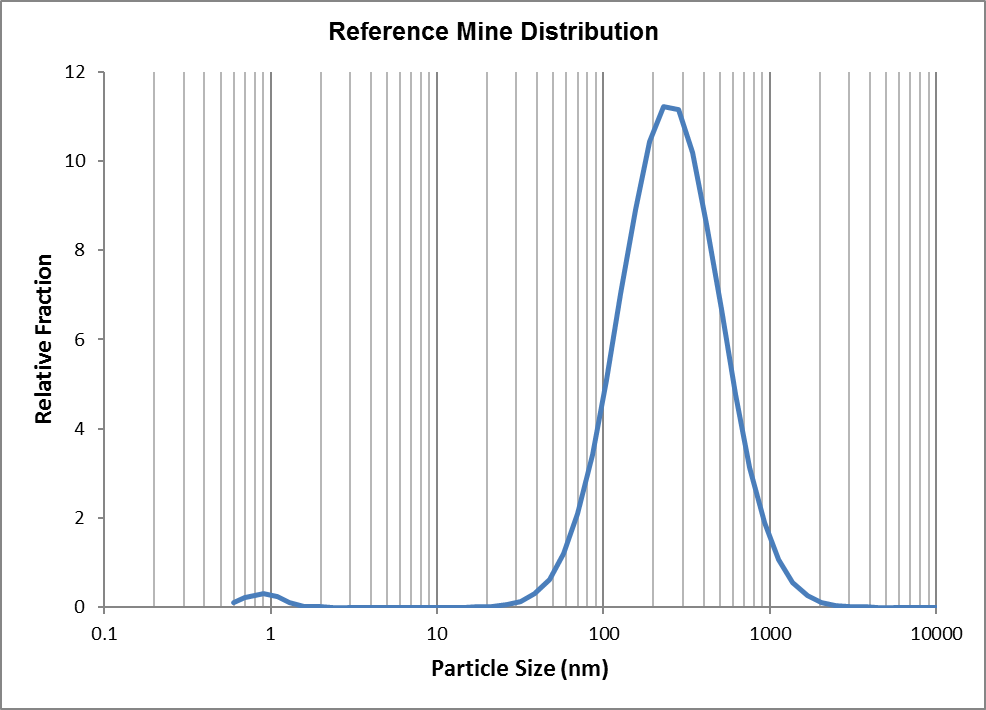


The results from these dosimetric models demonstrate the strong size dependence of the dose per unit exposure. The DCF values for ultrafine (unattached) radon progeny with activity diameters ~1 to 3 nm, are up to 20 times higher than for attached radon progeny, with diameters in the range 100 to 300 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.

## 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

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## 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.

## 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.

# Methods

## 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 (fp) 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 (fws). 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, fws, fp and AMTD.

Additional measurements were conducted at each site to determine other factors that may influence, the PAEC, fp, 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).

## Description of Measurements

### Single screen determination of PAEC and unattached fraction.

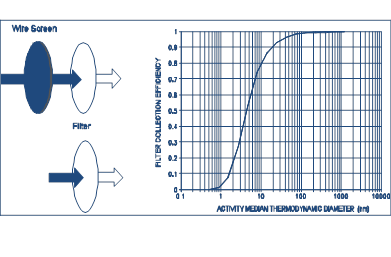
A total of 36 grab sample measurements were conducted at 31 sites using both an open face sampler and a single wire screen sampler, with the alpha activity analysed using the modified Tsivoglou method (Thomas, 1970) to determine total PAEC for each sample and the wire screen fraction of PAEC. The single 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 PAECWS is principally due to the unattached RDP. The second filter holder had an open face filter which collected both the attached and unattached components (PAECF). 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, fws were estimated by the equation;

fws = 1.5 x PAECWS  
 PAECF

For RDP with an ultrafine mode at ~1 nm and no nucleation mode, then fp ~ fws.

Figure 2.1 Single Screen Sampler configuration and wire screen penetration

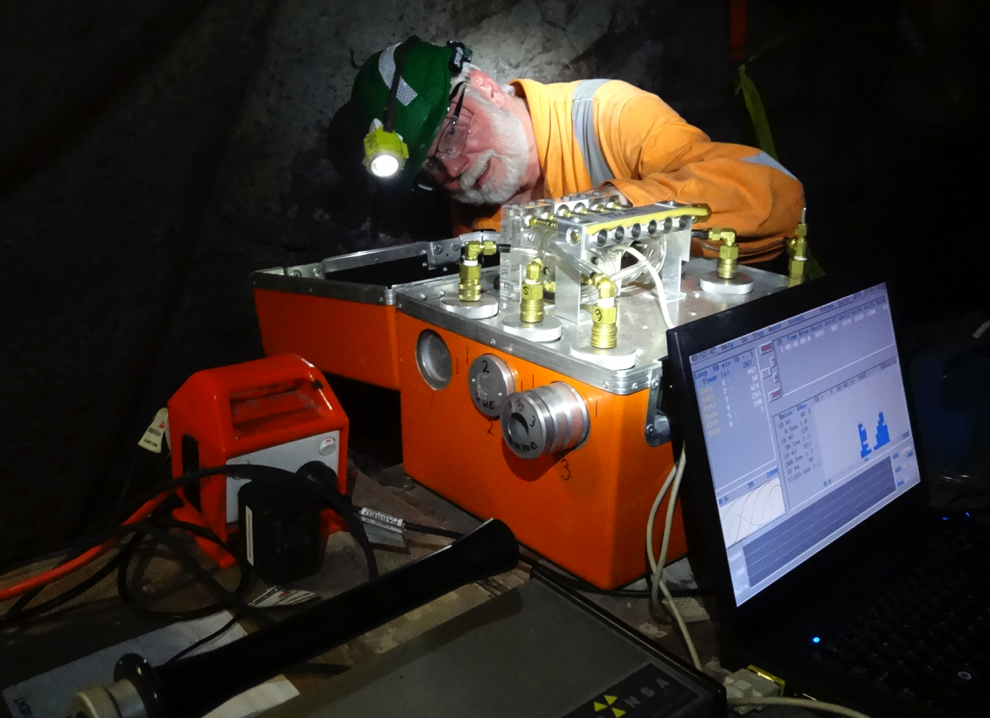


### Continuous Diffusion Battery assessment of PAEC, fp and AMTD

### 2.2.2.1 Measurement of RDP Size Distribution

The potential alpha energy concentration (PAEC), the unattached fraction of PAEC (fp) 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, fp 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 fHE 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)

**ARPANSA 5-Stage Diffusion Battery and Single Stage Impactor**

3

4

5

Filterr

Filter

2

6

Filter

Filter

1

10

100

1000

0.0

0.2

0.4

0.6

0.8

1.0

ACTIVITY MEDIAN THERMODYNAMIC DIAMETER (nm)

6

5

4

2

3

1

1

## 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).

# Grab Sampling Measurement Results

## 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 (fws), 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 fws 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 | fws | 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 |
| 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 | 1. 000 | 2 000 |

# Diffusion Battery Results

## 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



## 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 fp value was determined from the fraction in the ultrafine mode of each size distribution. The fHE 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 | fHE(%) | fp(%) | fws (%) | 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, fp) 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 | GMu | GSDu | Percentu | GMa | GSDa | Percenta | 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 | | | | | | | | |

### 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 (GMN = 27.6 nm) and accumulation (GMA = 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 | | fHE | GMn | GSDn | Pcntu | GMa | GSDa | Pcnta |
|  |  | **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 |

### 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 (GMN = 28 nm) and a more prominent accumulation mode (GMA = 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 | | %fHE | GMn | GSDn | Pcntn | GMa | GSDa | Pcnta |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 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 |

### 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 (GMU = 0.6 nm) and an accumulation mode (GMA = 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 | | fHE | GMu | GSDu | Pcntu | GMa | GSDa | Pcnta |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 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 |

### 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 GMN = 42 nm and a more prominent accumulation mode at GMA = 182 nm.

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



Table 4.7 Location Averages at 39Blue102 site

| Time | Date | PAEC% | | fHE | GMu | GSDu | Pcntu | GMa | GSDa | Pcnta |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 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 |

### 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 GMA = 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 | fHE | GMa | GSDa | Pcnta |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 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 |

### 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 | | fHE | GMu | GSDu | Pcntu | GMa | GSDa | Pcnta | GMc | GSDc | Pcntc |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 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 |

### 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 | | fHE | GMu | GSDu | Pcntu | GMa | GSDa | Pcnta | GMc | GSDc | Pcntc |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 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 |

### 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 GMN~38 nm and an accumulation mode at GMA~180 nm.

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



Table 4.11 Location Averages 36Yellow 419

| Time | Date | PAEC | | fHE | GMu | GSDu | Pcntu | GMa | GSDa | Pcnta |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | 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 |  |  |  |  |  |  |  |  |  |

# 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**

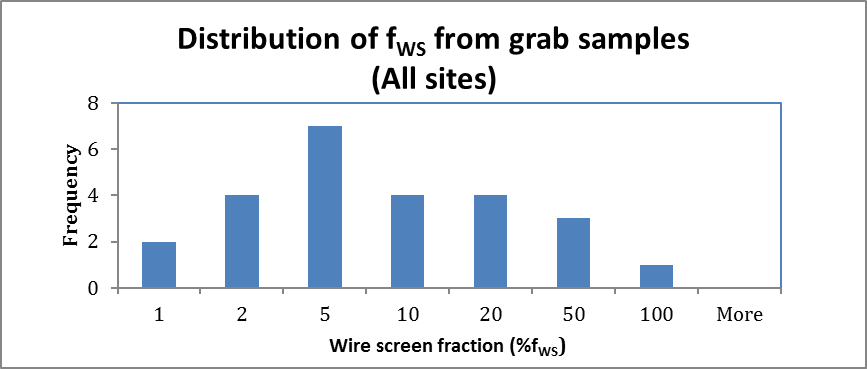
| Time | RADEP96 | | HPA2012 | |
| --- | --- | --- | --- | --- |
| mSv/(J.h.m-3) | mSv/WLM | mSv/(J.h.m-3) | mSv/WLM |
| 10:55:25 AM | 5550 | 19.5 | 5139 | 18.0 |
| 11:55:25 AM | 4991 | 17.5 | 4626 | 16.2 |
| 12:55:25 PM | 5326 | 18.7 | 4916 | 17.2 |
| 13:55:25 PM | 4988 | 17.5 | 4598 | 16.1 |
| 15:55:25 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 |

# Discussion of Results

## 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 fws 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 fws values across 26 valid grab samples. The mean fws value across all sites was 10.7% and the geometric mean was 5.3%.

Figure 6.1 Distribution of wire screen fraction fws 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 fws values in the range 14% to 60%. Sites with high equilibrium ratios (F > 0.7) had fws values in the range 0.4% to 5%.

Figure 6.2 Measured wire screen fractions at all grab sampling sites

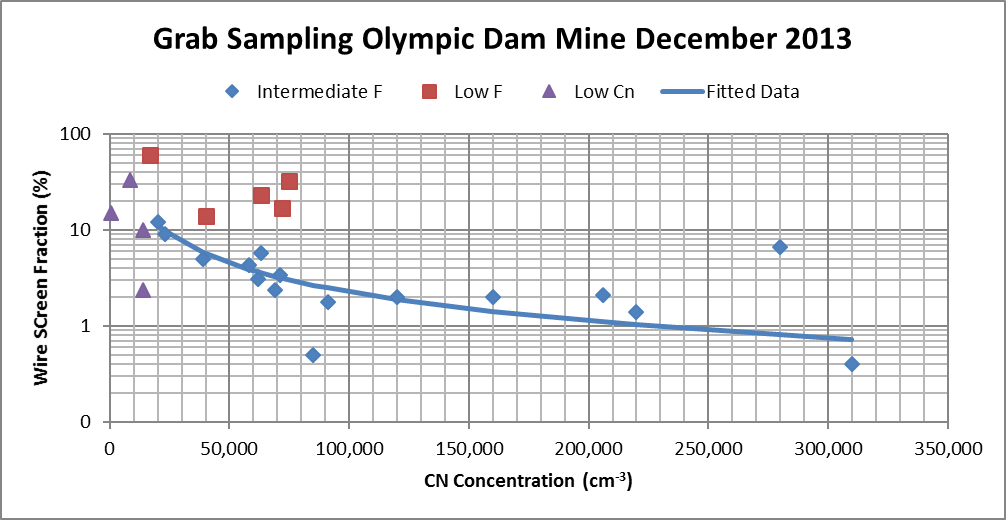
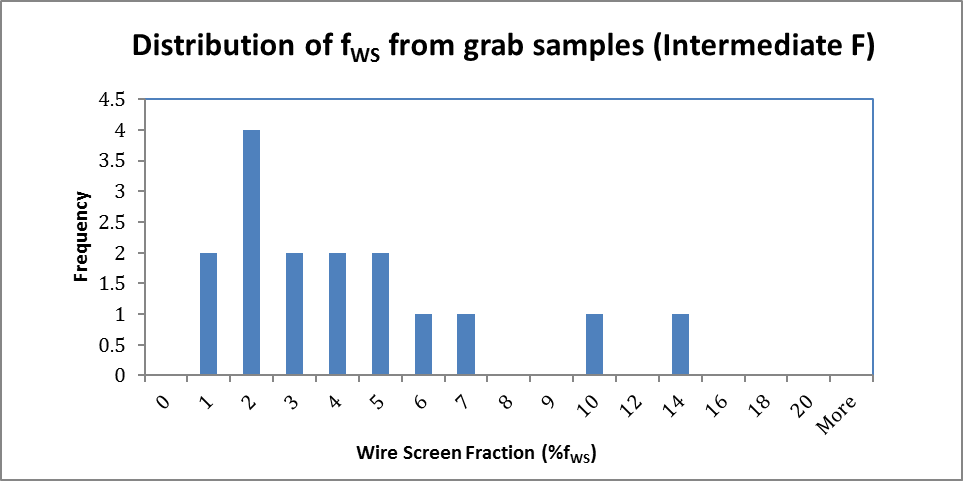


Table 6.1 Summary of results of grab sample measurements at sites in Olympic Dam mine

| ID | Location | PAEC | 1SD | RADON | 1SD | fws | 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 fws values, excluding those sites with very low F or low CN. The mean value of fws for these sites was 3.9% and the geometric mean was 2.7%.

Figure 6.3 Distribution of wire screen fraction fws at grab sampling sites



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

Table 6.2 Summary of measured parameters at CDB sampling sites

| ID No | Location | PAEC | | Radon\* | fws | fp | 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 | 1. 075 |

## 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 fp can be estimated with the semi‑empirical equations

**fp ~ 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 fws not fp. The determination of fp 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 fws 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 fws 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

**fws~ 2300/ Z**

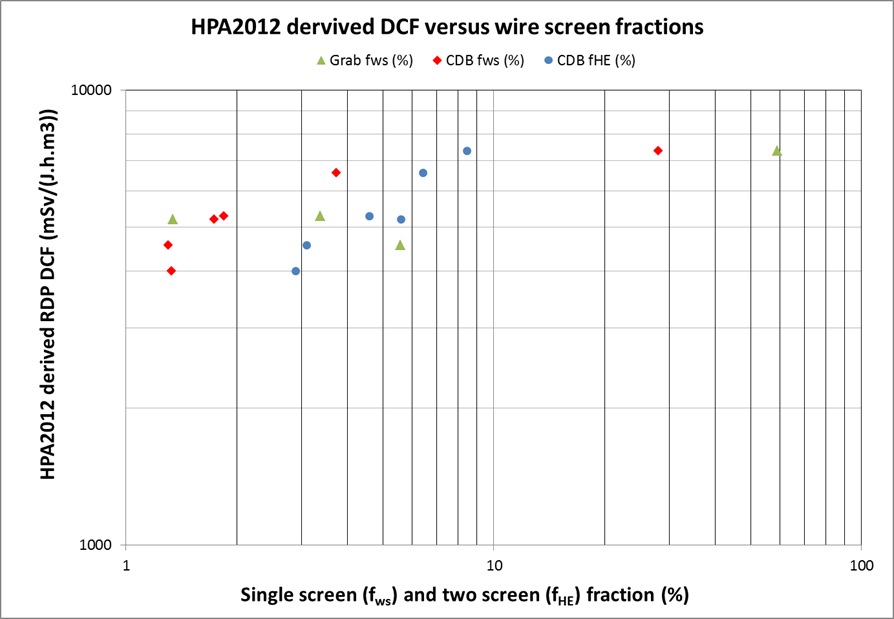
where Z is the CN concentration (cm-3).

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.

## Correlations between unattached fraction and dose conversion factors

Some dosimetric models during the 1980’s parameterised the DCF in terms of the AMTD and fp (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

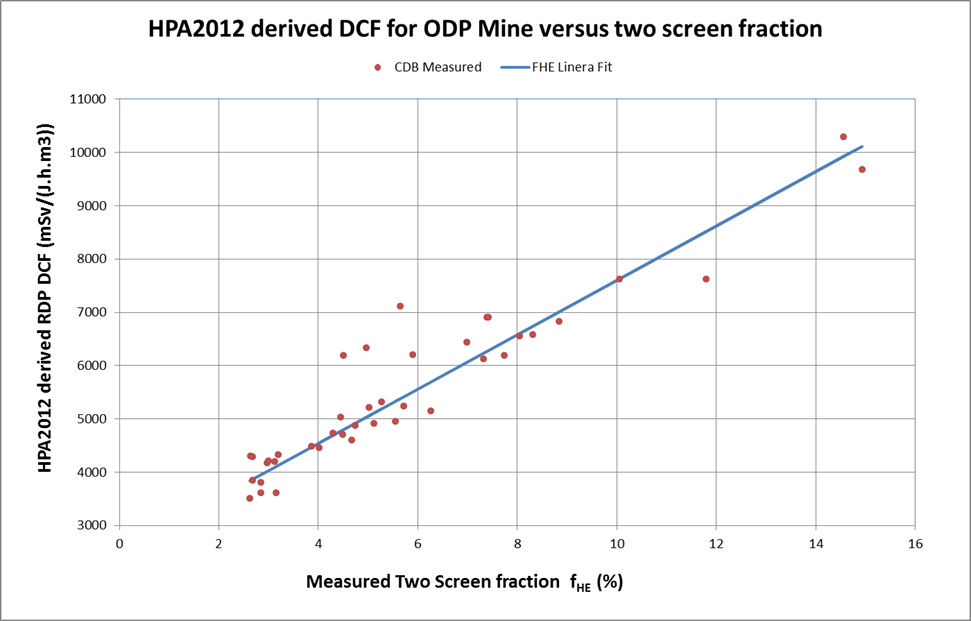


However, the second stage of the CDB operates as a 2-screen sampler (Solomon, 1997) with a collection efficiency optimised to match the particle size dependence of the DCF. As expected, Figure 6.5 shows there is a clear linear correlation between the fHE values and the size weighted DCF values based 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 fHE;

**DCF (mSv/(J.h.m-3)) = 2500 + 510 \* fHE (%)**

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

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## 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 fHE | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 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 | fws | 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 |

## 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

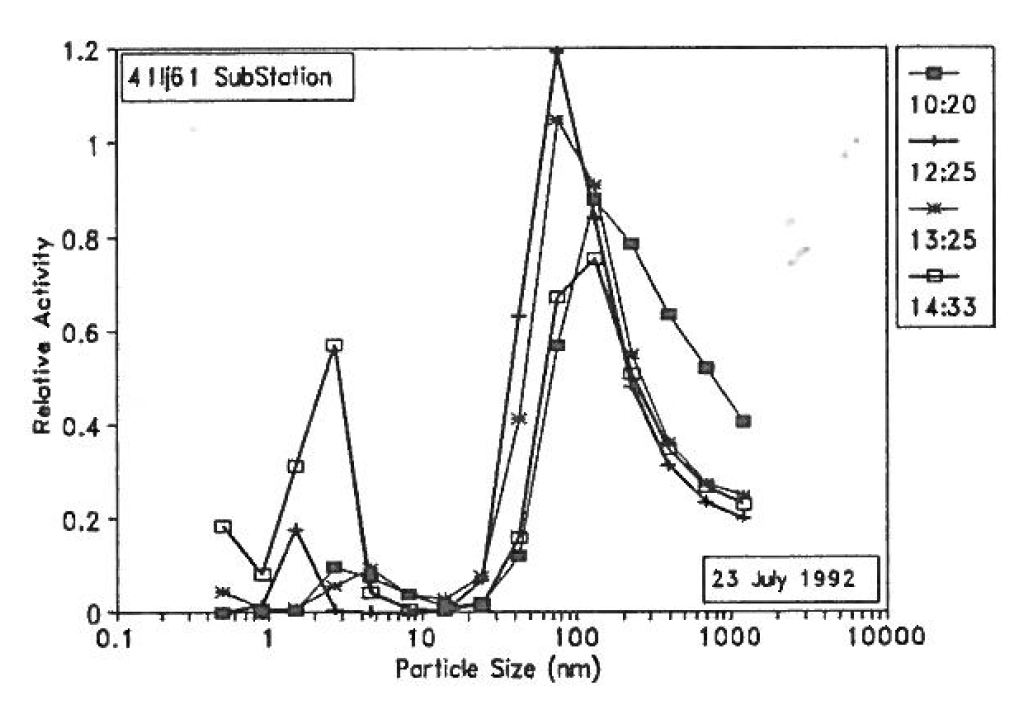
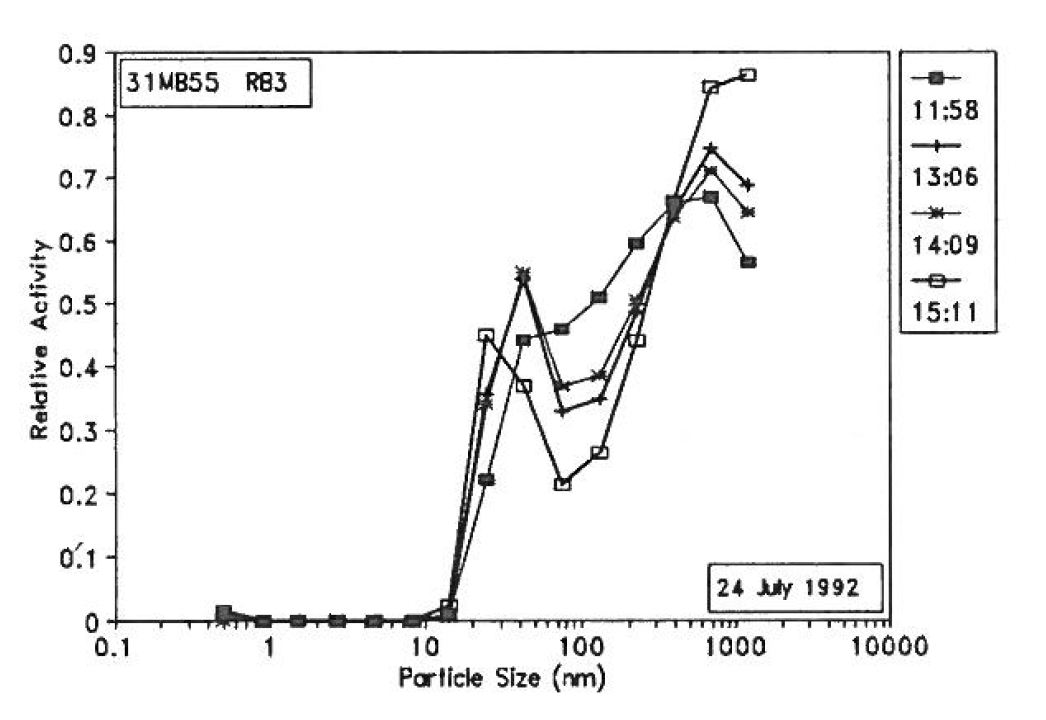


Figure 6.6 Size distribution at 31MB55 from 1992 measurements

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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 | %fws | PAEC | GMU | GMN | GMA | 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 |

# 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 (fws) 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 (fp) 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 fws and CN, with the data fitting a function of the form fws ~ 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 Dp50 of 4 nm was not a good measure of the ultrafine mode (unattached fraction, fp) 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 Dp50 of 4 nm was not a good measure of the ultrafine mode (unattached fraction, fp) 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.

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#### Theory of operation of wire screen diffusion battery.

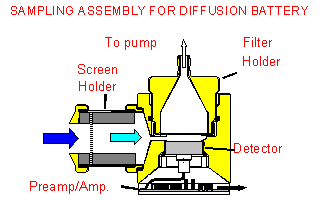
ARPANSA Wire Screen Diffusion Battery

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 | Dp50 |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | (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 ED, is supplemented by terms for interception efficency ER, impaction efficiency Ei and diffusional interception efficiency EDR (Reineking and Porstendorfer 1986). The penetration through n identical wire screens is given by,

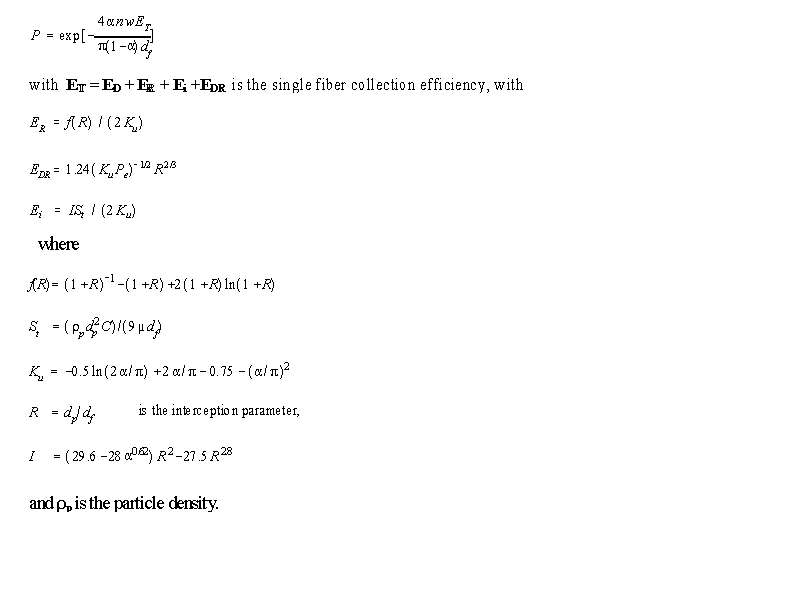
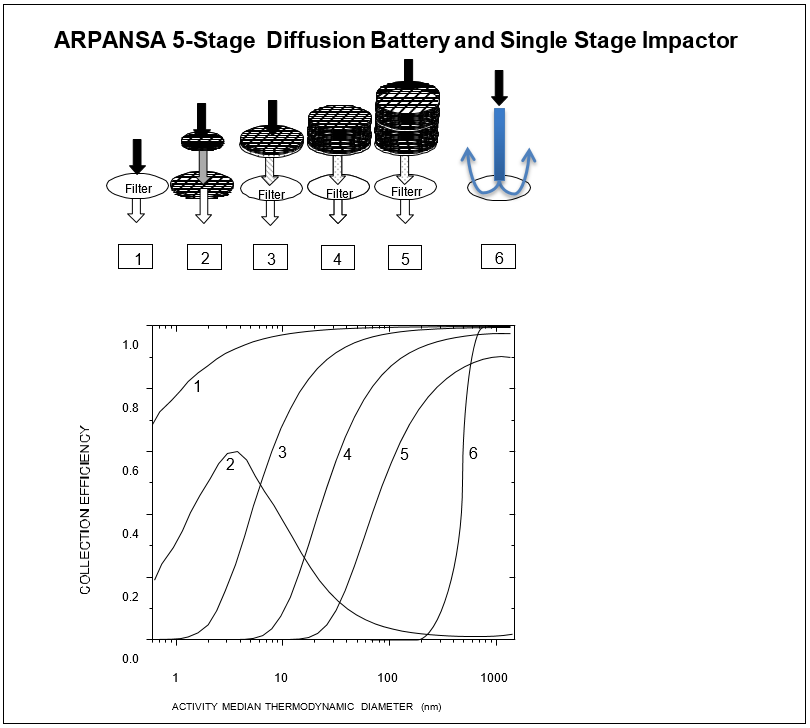


Figure A.2 ARPANSA 5 stage wire screen diffusion battery and single stage impactor



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),

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

where Zi are the observed stage penetrations, Aj are the size interval activity fractions and Pij is the penetration matrix for the jth particle size through the ith 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

where Njp+1 and Njp are the estimates of the jth size interval activity from the p+1th and pth estimate, respectively.

Expectation Maximisation Algorithm (EMax)

Similarly, the EMax algorithm uses the iterative rule

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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#### Detailed hourly outputs for all CDB locations

|  |  |  |
| --- | --- | --- |
| **Location ID 1** | **420 Drill Maintenance Workshop** | **2/12/13** |

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║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 Wire Dia. Thickness Solid Frac Comments

No. (microns) (microns) %

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 Dp50LB Dp50UB Slope Intrcpt Flow Effic BGcpm

(nm) (nm) (nm) (lpm)

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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.009 │ │ 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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.000 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.005 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.044 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp RESULTS

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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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp RESULTS

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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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp RESULTS

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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 │ │

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

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║Rn Progeny Particle Size Spectrometer║

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**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 Wire Dia. Thickness Solid Frac Comments

No. (microns) (microns) %

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 Dp50LB Dp50UB Slope Intrcpt Flow Effic BGcpm

(nm) (nm) (nm) (lpm)

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

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.003 │ │

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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.009 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.005 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.001 │ │

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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.005 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.001 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp RESULTS

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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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp RESULTS

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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 │ │

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| **Location ID 9** | **420 Auto Workshop** | **4/12/13** |

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║Rn Progeny Particle Size Spectrometer║

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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 Wire Dia. Thickness Solid Frac Comments

No. (microns) (microns) %

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 Dp50LB Dp50UB Slope Intrcpt Flow Effic BGcpm

(nm) (nm) (nm) (lpm)

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

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp RESULTS

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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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp RESULTS

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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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp 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 │ │

└───────────────┘ └───────────────┘

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp 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 │ │

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| **Location ID 8** | **39 Blue 102** | **6/12/13** |

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║Rn Progeny Particle Size Spectrometer║

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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 Wire Dia. Thickness Solid Frac Comments

No. (microns) (microns) %

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 Dp50LB Dp50UB Slope Intrcpt Flow Effic BGcpm

(nm) (nm) (nm) (lpm)

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

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.001 │ │

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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.005 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 │ │ 0.1 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.000 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.1 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.001 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.001 │ │ 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 │ │

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| **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 2030 746 23

Dp DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 │ │ 0.1 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 │ │

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| **Location ID 15** | **Whenan Crusher** | **9/12/13** |

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║Rn Progeny Particle Size Spectrometer║

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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 Wire Dia. Thickness Solid Frac Comments

No. (microns) (microns) %

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 Dp50LB Dp50UB Slope Intrcpt Flow Effic BGcpm

(nm) (nm) (nm) (lpm)

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

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.000 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.000 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.000 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.000 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.000 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.000 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.000 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.000 │ │ 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 │ │

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| **Location ID 21** | **65 Rail Workshop** | **10/12/13** |

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║Rn Progeny Particle Size Spectrometer║

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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 Wire Dia. Thickness Solid Frac Comments

No. (microns) (microns) %

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 Dp50LB Dp50UB Slope Intrcpt Flow Effic BGcpm

(nm) (nm) (nm) (lpm)

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

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp 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 │█ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.002 │ │ 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 │██ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp 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 │█ │

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| **Location ID 25** | **32RB5** | **11/12/13** |

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║Rn Progeny Particle Size Spectrometer║

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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 Wire Dia. Thickness Solid Frac Comments

No. (microns) (microns) %

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 Dp50LB Dp50UB Slope Intrcpt Flow Effic BGcpm

(nm) (nm) (nm) (lpm)

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

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.001 │ │ 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 │███ │

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| **Location ID 28** | **36 Yellow 419** | **12/12/13** |

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║Rn Progeny Particle Size Spectrometer║

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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 Wire Dia. Thickness Solid Frac Comments

No. (microns) (microns) %

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 Dp50LB Dp50UB Slope Intrcpt Flow Effic BGcpm

(nm) (nm) (nm) (lpm)

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

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.003 │ │

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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.001 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp RESULTS

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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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS 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 0.002 │ │ 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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp RESULTS

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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 │ │

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| **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 DiffCoeff dC dC/ TWOMEY ANALYSIS dC dC/ EMAX ANALYSIS

(nm) cm2/sec ClogdDp RESULTS ClogdDp RESULTS

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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 │ │

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