Title: Standard Operating Procedure for Measurement of Particulate Matter in Ambient Air by Orthogonal Light Scattering		
Procedure No: SOP-014	Revision No: 0 (new document)	Page No.: 1 of 10

1. INTRODUCTION AND SCOPE

The Grimm particulate monitor is used by Alberta Environment (AENV) in the Mobile Air Monitoring Laboratory (MAML). This monitor is used to collect real time particulate data, which will indicate the approximate levels of PM_{10}, $PM_{2.5}$ and PM_1 during emergency response events. This data is not included in provincial or national air quality databases. This method is capable of measurement updates at a rate of once every minute or faster.

This method adheres to the requirements of the current Air Monitoring Directive (AMD) drafted by AENV in 1989. In some cases the limits and specifications exceed the requirements of the current AMD. It should be considered that the current and any future amendments or drafts of the AMD will be used as the benchmark for requirements and criteria for ambient air monitoring practices conducted in the province of Alberta.

2. PRINCIPLE OF THE METHOD

The dust particles are measured by the physical principle of orthogonal light scattering. Here particles are illuminated by a laser light in an angle of 90 degrees. This unit uses light-scattering technology for single-particle counts. The scattered signal from the particle passing through the laser beam is collected at approximately 90° by a mirror and transferred to a recipient diode. The signal from the diode is amplified and fed to a multi-channel size classifier. This pulse height analyzer then classifies the peak signal of each channel. These counts of each channel are converted each minute in a mass distribution from which the different PM values are derived. See figures 1 & 2.

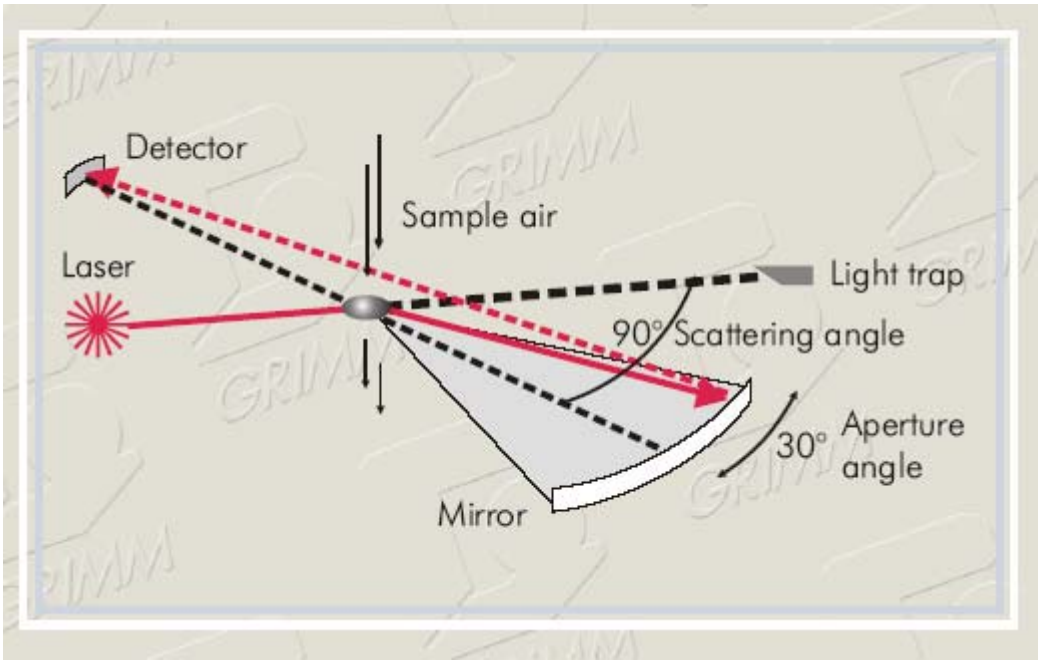

Figure 1 – Grimm detector principle

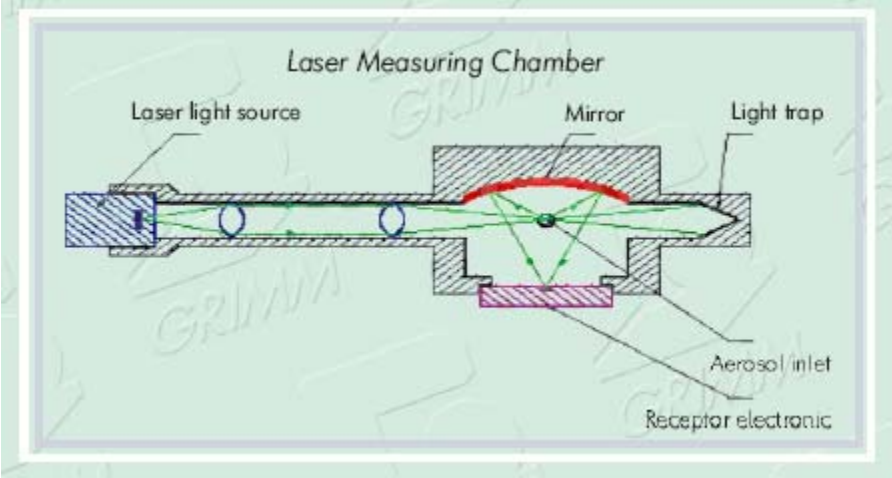

Figure 2 – Grimm Measurement Chamber

3. MEASUREMENT RANGE AND SENSITIVITY

Measurement range: Simultaneous measurement of PM_{10}, $PM_{2.5}$ and PM_1 with a mass range of 0.1 to >1500 µg/m
Particle counts: 1 to 2,000,000 particle/liter
Sample flow: 72 l/h, volume controlled
Reproducibility: 3 % in max. range
Temperature range: 0.3 to +80 °C

4. INTERFERENCES

The following are available commercial analyzers suitable for use in this method and are currently in use in the AENV network:

- Grimm Portable Dust Monitor model 1.105

This list does not exclude the use of other equipment that has received the USEPA Reference and Equivalent Method designation.

5. EQUIPMENT AND APPARATUS

Measured results can be interfered with by the deposition of dust particles or aerosols on one or more of the important optical surfaces. The Grimm Dust Monitor provides a particulate-free stream of air over every optical surface in the instrument to minimize this interference (Grimm, 1996).

Although light scattering is often highly correlated with mass concentrations, the relationship depends on several variables and may be different from location to location and for different seasons of the year. The light scattered per µg/m^3 depends on geometric particle diameter, real and imaginary parts of the refractive index, and particle shape (USEPA, 1998).

Certain relatively large particles will not be properly classified by the Grimm Dust Monitor – specifically, those larger than the largest sized channel. These very large particles will therefore be calculated incorrectly by the algorithm equation (Grimm, 1996).

Light scattering is often very high at relative humidities exceeding 80% because small particles grow to sizes that scatter light more efficiently as they acquire liquid water. As a result, at ambient temperatures and high humidities, mass

concentrations tend to be overestimated, especially when particles have a large soluble component. (USEPA, 1998).

6. PRECISION AND ACCURACY

The analytical results obtained by the dust monitor's optical system can be directly compared with the actual gravimetric mass of particulates captured on the final filter, thereby providing an empirical correlation of the highest possible quality, accuracy, and precision (Grimm, 1996).

7. SITE REQUIREMENTS

Site location for particulate samplers should be determined according to the intended application of the monitoring data. Unobstructed sites should be chosen with the following characteristics:

- There must be unrestricted access to the sampler and site during the monitoring period and the site and equipment must be safely accessible in all weather conditions for the duration of monitoring operations.
- There must be unrestricted airflow in an arc of at least 270° around the sampler and no obstructions in the source direction of prime interest.
- Avoid topographic hollows where air circulation is restricted.
- Interference from buildings and trees must be avoided. There must be no trees or structures closer than a distance of two times the height of the obstruction from the sampler or a distance of 20 meters, whichever is greater.
- The sampler must be elevated above the expected maximum flood stage in areas subject to flooding.
- The sample inlet must be kept within 2 to 7 meters from the surface, unless the project terms of reference specifically require measurements above these limits.
- Adequate safeguards must be taken to ensure security of monitoring equipment.

- The site must be inspected for unsafe conditions.
- Particulate monitors must be located well away from obvious local sources of sample contamination such as areas of high vehicle activity, dusty roads, roof top flues and vents, or close to local wood burning sources, unless monitoring is being conducted primarily to capture the impact of such sources.
- A roof top mounted sampler must be a minimum of 2 meters away from a wall or parapet. If the sampler is installed on a building that is lower than surrounding structures, then the “two times the height” rule for local obstruction is used (AENV, 2002).

8. INSTALLATION REQUIREMENTS

The start-up procedure for the Grimm Dust Monitor is detailed in the operating manual. The following is a brief list of the procedures necessary before sampling:

- The instrument is never to be operated without a Final Filter installed (see Section 7.3 of the Grimm Dust Monitor operating manual for the Final Filter exchange procedure).
- A power supply or battery energy source must be in place prior to operating the instrument (if using a battery, refer to Section 3.1.3 and 3.1.4 of the operating manual for installation).
- Before operating the instrument, the Total Sample Air Volume and the calculated Final Filter tare weight must be reset to zero (see Section 3.1.8 of the operating manual).
- Before entering into its operating mode the instrument will undertake and complete a 30 second self test.

9. OPERATIONAL REQUIREMENTS

9.1 Operation

Normally after the self test has been satisfactorily completed, the real particulate measurements will start. Every six seconds during actual measurements the data indicated on the LCD is updated. The initial short

delay in establishing a stable analyzer output display on the unit's LCD arises because the mean value time- weighted average calculation results tend to vary greatly during the initial minute of data gathering and reduction. After the first minute the measurement will almost always stabilize (Grimm, 1996).

The analyzer should never by switched off when it is actually involved in particulate monitoring operations because it will interpret the switching off as a simple power interruption. In such a situation, the unit will restart independently after the power returns and simply resume its previous measurement series without either a current update as to the weight of the material captured on its Final Filter, or by clearing the stored median values of the previous measurement series. These two outcomes will cause a loss of data or otherwise corrupt it (Grimm, 1996).

In the event there is a loss of power, and if the instrument doesn't start when power is restored, the power source should be disconnected. Subsequently, restoring the power source should cause the unit to restart (Grimm, 1996).

The results from the optical measurements do not identify, quantify, or recognize the local particulate or aerosol density. To compare the particulate concentrations (determined by the scattering of the light in the laser beam) with the actual mass of the dust collected on the Final Filter in the unit, the filter must be weighed. The Gravimetric Factor determined by this procedure is stored in the analyzer, providing it with the capability of providing it with a relevant mass based particulate concentration (see Section 3.5.1 of the operating manual for Gravimetric Factor calculation).

Refer to the operating manual for detailed operational instructions.

9.2 Maintenance

The following is a brief list of the required maintenance for various components:

- Cases - If the case, keyboard, or LCD ever needs cleaning, a dry cloth should be used, as these components should be protected from liquids.
- Sample air inlet - Every time a new Final Filter is installed in the Dust Monitor, the instrument's sample inlet should be cleaned.

- Final Filter holder - Every time the Final Filter is replaced, the holder must be cleaned. This is done with a Q-tip or any similar tool. Any contamination that cannot be removed with this procedure must be cleared using a clean and suitable solvent.

Refer to Section 7 of the operating manual for detailed maintenance instructions.

9.3 Data Collection from the Grimm

- Install the Grimm Program on your computer
  - Use the Control Panel 'Install Remove Program'.

- Set up the program for use
  - From the **Options** Menu choose **Dust Monitor**
    - select Environmental mode and Normal mode (1 minute).
  - From the **Options** Menu choose **System**
    - Dust Monitor Model select 1.105
    - Dust Monitor Version number select 4.30E
  - From the **Options** menu choose **Save Parameter**

- Read the data from the memory card.
  - From the **File** menu choose **New File.**
  - Name the file keeping the .DM suffix (note the program will use the first 3 characters you enter here and add an A,B,C etc. for each file stored during a downloading session).
  - Click on the Read Memo Card button
  - Enter the correct location number (01, unless you change it on the sampler)
  - Click on the Read memocard button. You should hear the sampler reset and a message should be displayed on the Grimm front panel. Downloading can take several minutes depending on how much data is stored at that location.
  - A list of events should appear with different Start/Stop times
  - Select the one you want to save in the file you have created. This procedure will have to be repeated for each sampling event.
  - Hit cancel to return to program from Reading memory card window.

- Export the data
  - From the **File** menu select **Export Data**.
  - Choose the files you have created above.
  - Click on OK
  - Leave the defaults selected in the 'Export Data to an ASCII File' window.
  - Click on Start Export.

- Open the file using EXCEL (open Excel first).
  - Choose delimited button, select space and semicolon as delimiters.

10. CALIBRATION

To complete a calibration in the field, the following procedure should be adhered to:

1. Remove the Final Filter from the analyzer's filter holder. Clean the housing in the filter holder with a Q-tip. Also clean the air inlet if necessary, as described in Section 7.1.2 of the operating manual.
2. Weigh a new filter (at least three times) and record its mean tare weight.
3. Place the new, weighed filter directly above the opening of the large O-ring in the filter holder housing, being very careful not to cut or remove the small O-ring. Close the filter holder housing; and using a screwdriver, be certain it is tightly closed.
4. Switch on the Dust Monitor and answer the question "FILTER CHANGED?" by depressing the [+] key for "yes" in order for the analyzer to set the current filter content weight to zero.
5. Initiate and complete the particulate measurements at each desired location. Note that for an interruption of any particular test series followed by a subsequent restart of measurement operations at a different location, the operator should answer the analyzer's filter question by depressing the [-] key for "no".
6. The operator can read the current calculated Final Filter weight (indicated on the unit's LCD in the standby mode) by pressing the [Mean/Weight]

and the [+] keys. This information may also be requested via the RS-232C interface.

7. When a measurement test series has been completed and the analyzer indicates that there is a relatively high weight of material accumulated on the Final Filter, the operator can switch the instrument into the standby mode, and turn if off.
8. Finally the operator should remove the Final Filter and weigh it (at least three successive times to ensure adequate gravimetric precision). The difference between the current weight and the Final Filter's tare weight will be the mass of the collected dust or particulates.
9. Calculate the Gravimetric Factor as described in Section 3.5.1 of the operating manual (Grimm, 1996).

11. APPLICABLE DOCUMENTS

- **EM-014a** Grimm Labortechnik Ltd. *Manual for the Dust Monitor model 1.104, 1.105 & 1.106.* January, 1996.

12. LITERATURE REFERENCES

- United States Environmental Protection Agency (USEPA). *Guidance for Using Continuous Monitoring in $PM_{2.5}$ Networks.* May, 1998.
- Grimm Labortechnik Ltd. *Manual for the Dust Monitor model 1.104, 1.105 & 1.106.* January, 1996.
- Alberta Environment (AENV). *Ambient Air Sampling for Particulate concentration (Gravimetric), Organics, and Heavy Metals. Version 1.0,* September, 2002.

13. REVISION HISTORY

Revision 0 (new document)

Reviewed Dec 29, 2010

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Procedure No: SOP-014	Revision No: 0 (new document)	Page No.: 10 of 10

14. APPROVAL

Approved by: **Harry Benders** **Date: June 3, 2008**

Title: **Air Monitoring Team Leader**