Standard Operating Procedure for Dry Deposition Sampling:

Dry Deposition of Atmospheric Particles

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Revision 2

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1.0 Introduction - Principles of Dry Deposition Sampling

Pollution can exist in soil, in the waters of lakes, rivers and streams and in water below the ground. Pollution can also exist in the air, whether it is in the air close to the ground or in the air of the upper atmosphere. Probably every place it has been sought, some form of pollution has been found. "Pollution" is the everyday word used to describe material found anywhere in the environment that would not be there if it were not for mankind's activities. The technical term used to describe pollution is "anthropogenic", which means "man-made".

When the term "atmospheric dry deposition" is used, "atmospheric" refers to the place where pollution may reside and, unfortunately, the place from which pollution may be transferred. In fact, pollution may be transferred among several or all the components of land, water and air. "Dry deposition" refers to one pathway--there are several--through which pollution can be transferred from the component of air to a component of land or water.

This dry deposition pathway is not reserved for man alone. It is part of a natural global process of cycling that has always been there, only now anthropogenic matter--pollution--is being carried alongside natural matter. Dry deposition is defined as the deposition to land or water of particulate matter. If particles are attached to snow or suspended in rain droplets, then the term "wet deposition" is used to describe the process.

So dry deposition is one of several types of atmospheric deposition that occur. But whereas wet deposition is associated with a particular event--rainfall or snowfall--dry deposition can be thought of as occurring year round, even when another kind of deposition is also taking place

It would be difficult or impossible to collect dry deposition during a rainfall event, so the dry deposition sample surface is covered whenever it rains or snows. Doing this manually would require a constant vigil, especially on a cloudy day or overnight. So instead a sampler (the EAGLEII) is used that senses wet conditions and automatically covers the sampling surface until the sensor dries off.

The sampling surface itself is a 1 x 3 inch greased Mylar strip which has been previously mounted onto a clean PVC plate. This plate then holds the strips horizontally so that dry deposition can collect on the strips' greased surfaces. The grease is there to prevent particle bounce which can occur if only a hard surface is used. This collection technique is not unlike the collection of dust by an automobile windshield which is commonly seen even when there has been no precipitation. The grease used (L-Apiezon) is non-volatile, so the difference between before and after sampling weights of the strips is a measure of the amount of deposited material.

The plates on which the greased strips are mounted have a sharp leading edge and are kept pointing into the wind. The sharp leading edge is to provide a laminar or non-turbulent flow of air over the strips (turbulence increases dry deposition). The less turbulence a natural surface creates, the less the deposition. By using a surface which provides a laminar flow of air, the material collected on the strips will be a lowest approximation of the deposition at that sampling

location.
The plates are kept pointing into the wind by the large tail on the back of the EagleII. There are two reasons for this. One is to avoid reentrainment of material collected on the sampler which could redeposit on the strips. The other reason is to avoid turbulence created by the structure of the EagleII, which would increase deposition.

Sampling times vary, depending on the ultimate use of the strips. Short-term samples are generally exposed from eight to 72 hours. Short-term samples are usually taken only in urban areas, because of the large amount of dry deposition there. Long-term samples are generally exposed for one to four weeks. These longer sampling times are needed in some non-urban and rural areas, where there may be much lower amounts of dry deposition. The EagleII was designed with long-term sampling in mind.

2.0 Sample Collection: Atmospheric Particulate Dry Deposition

2.1 Preparation for Particle Dry Deposition Sampling

A list of equipment and supplies for field investigations is given in Appendix A. All Mylar strips, strip covers, strip sample box, SP Brand Five-Slide Mailer, dry deposition plates, plate holders and Rubbermaid plate containers are cleaned in double distilled methanol and deionized water in a seven-day procedure before use in sample collection. Apiezon grease-coated strips equilibrate for 24 hours in the strip sample box before weighing. After weighing the four strips are mounted onto each dry deposition plate with strip cover and Teflon-coated clips. Dry deposition plates are stored in the Rubbermaid sample container before and after sampling. Field blanks are also prepared for each sampling period; four preweighed grease-coated Mylar strips are mounted onto the dry deposition plate and kept in the Rubbermaid sample container during the sampling period.

During sample plate set-up and removal, the operator must be very careful not to touch the greased strip surface. This is very important to maintain sample integrity. During sample collection the dry deposition plates are taken out from the Rubbermaid sample container and placed on each side of an automatic dry deposition sampler (EagleII--see Figures 1 and 2) about 2 meters above ground level.

2.2 Particulate Dry Deposition Sampling

During the course of this study atmospheric particles will be collected onto greased Mylar strips each with exposure area 10.3 cm^2, for a total of 41.2 cm^2 on each dry deposition plate. Two dry deposition plates are needed in one sampling period.

2.2.1 Taking Off Dry Deposition Plate Samples

2.2.1.1 Record total sampling time and open sampling time in minutes on the Eagle's log sheets (see Appendix A). These times can be determined by switching the middle switch up and down on the right side of the control box. The times will be displayed on the red display panel. The open time will be preceded by the letters "OPE" and the total time will be preceded by "TOTL". You may have to shade the control box to read the display on a sunny day. Record the rest of the

information required in the log sheet.

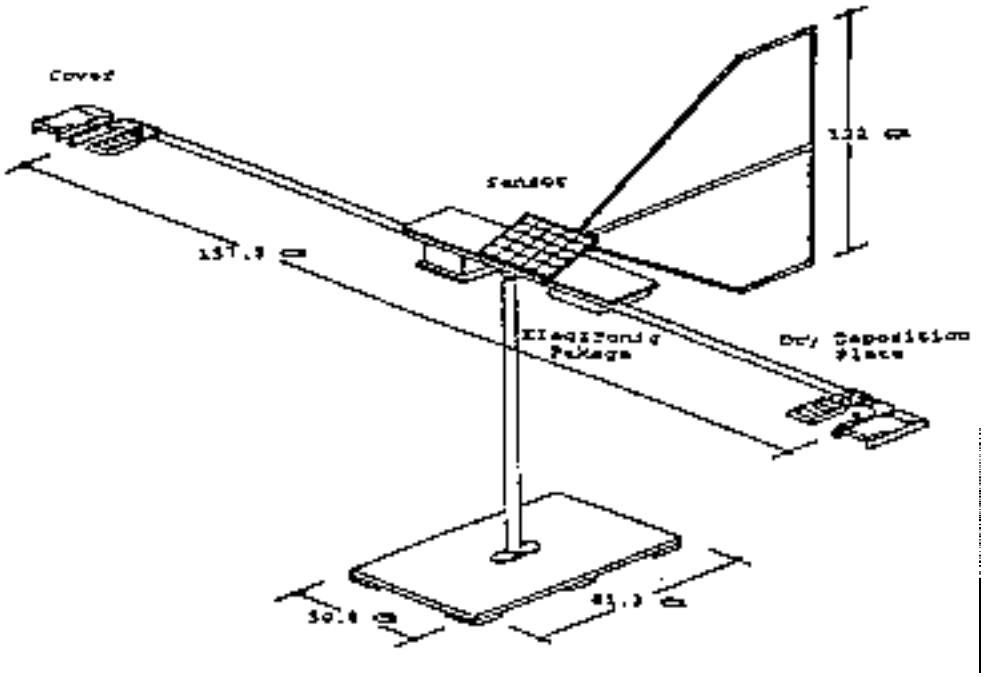

Figure 1. Drawing of Eagle II

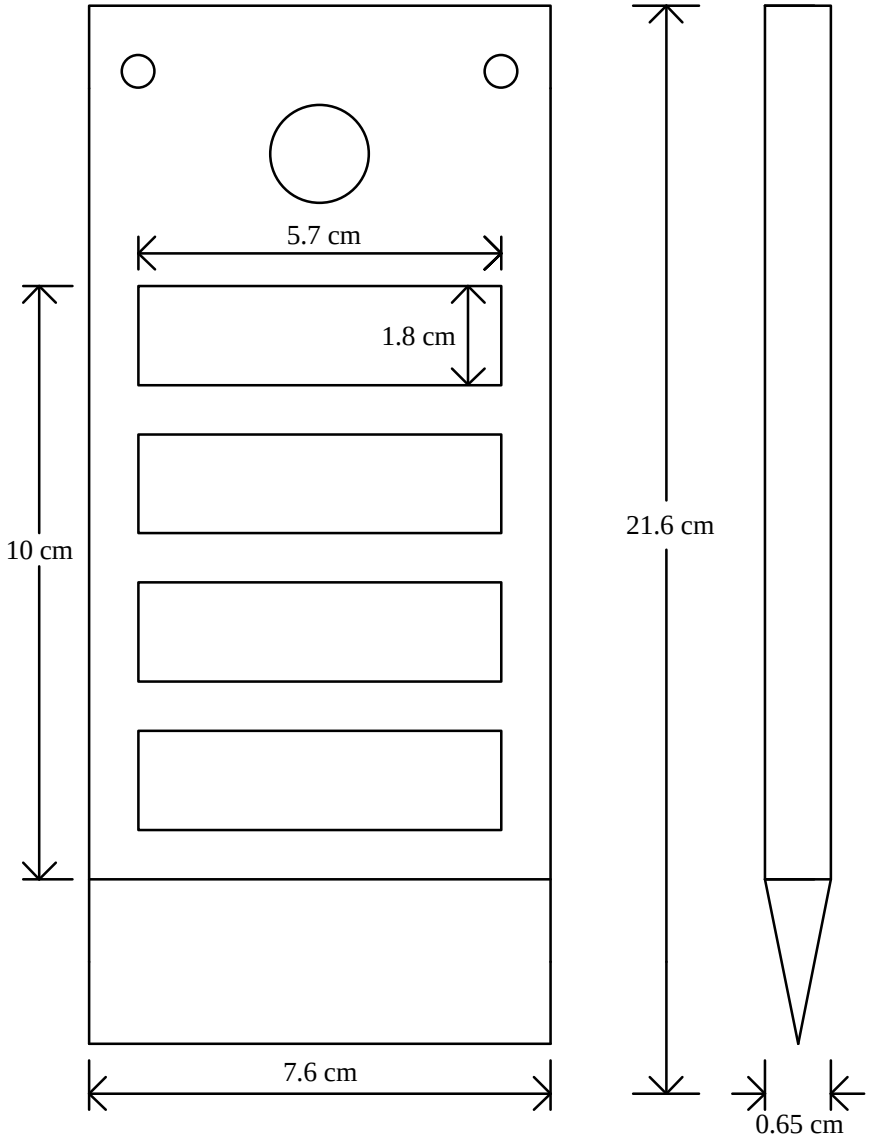

Figure 2. Top View of a Dry Deposition Plate

2.2.1.2 Put on particle-free gloves. Take down the dry deposition plates from both sides of the Eagle by unscrewing the nuts on the bolts. Be careful not to touch the surface of greased strips.

2.2.1.3 Place these two dry deposition plates back into the Rubbermaid sample container along side the field blank. Slide the plates sideways into slots with the sharp edge pointed into the thin slot. Take the Rubbermaid sample box out from the field blank storage box and take it (or send it) back to the Illinois Institute of Technology Air Quality Lab (IITAQL).

2.2.1.4 The rain sensor has to be cleaned at each sample change. Use a Polyester/Cellulose Blend Wiper wetted with deionized water to gently wipe-off the surface of the rain sensor.

2.2.2 Setting up Dry Deposition Plate Samples

2.2.2.1 Turn on the control box (see Figure 3) on the automatic dry deposition sampler by switching up the third switch on right side of the control box (turn it off by switching down).

2.2.2.2 Examine the timer in the control unit by switching the middle switch up and down (see Figure 3) to ensure the correct counting of total sampling time and open sampling time (exact exposure time) of the dry deposition plates. One can ensure the correct running of the timer by comparing the minutes shown on the display with a watch (normal counting test is around two to three minutes).

2.2.2.3 Perform a wet test by putting a little bit of water on the Eagle sensor (see Figure 1) to make sure the Eagle covers on both sides close when the sensor is wet and reopen when it is dry.

2.2.2.4 Put on particle-free gloves. Take dry deposition plates out from Rubbermaid plate container (which are been prestored into the sample holder in the Rubbermaid sample container) and place one plate on each side of the automatic dry deposition sampler using two ¼ inch bolts and nuts.

2.2.2.5 Reset the timer by pressing the red button (press and hold the button for five seconds), which is the first button on the right side of the control box.

2.2.2.6 Place the Rubbermaid sample container (which contains the field blank) into the field blank storage box.

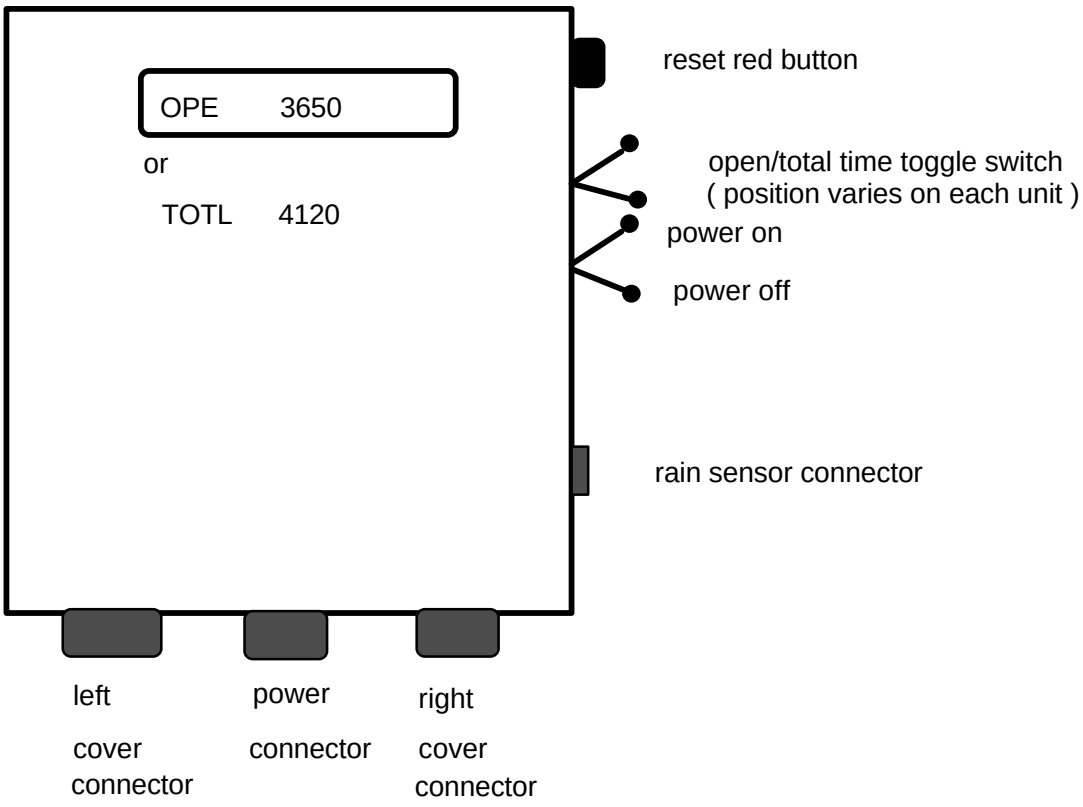

FIGURE 2 CONTROL BOX

Figure 3. Dry Deposition Sampler Control Box

2.2.3 Taking Blanks

Field blanks will be taken during each sampling period of this study. To take a field blank, four preweighed grease-coated Mylar strips will be mounted onto the dry deposition plate and put it in the Rubbermaid sample container along with the sample plates. Unlike the sample plates, the field blank will stay in the Rubbermaid sample container during the entire sampling period. All Field blanks have to be labeled appropriately. Field blanks are given the designation BK after the sample number, such that the field blank is labeled:<site>-01BK. For example the field blank taken with Sample 9 from IIT site will be labeled IIT-8BK.

3.0 Sample Transport

Samples should be transported to the Illinois Institute of Technology Air Quality Lab (IITAQL) immediately after sampling. Samples should be stored in sealed Rubbermaid sample containers during transport. In case the samples cannot be taken to IITAQL immediately after sampling, store the samples at room temperature away from any possible contaminate sources until shipment. Send the sample log sheet along with each of the samples collected. When a sample log sheet is completed, make a photocopy of the sheet, and keep the photocopy in the three-ring binder provided.

Ship samples to:

Dr. Thomas M. Holsen
Associate Professor
10 West 33rd Street
Department of Chemical and Environmental Engineering
Illinois Institute of Technology
Chicago, IL 60616-3793

4.0 Troubleshooting

When troubleshooting the EagleII, follow "secure the sample first" principle. Ideally, no work should be done with samples in place.

When the EagleII is turned off then on again, both covers should cover then uncover the sample area.

4.1 Cover is Loose

The cover can become loose under normal operating conditions after a few months' time. (This problem is being addressed in the next Eagle design, the EagleIII.) Two set screws hold the cover in place. These set screws require an allen key in order to be loosened. One set screw is located on the top and one on the side of the cover pivot shaft. (See Figure 4)

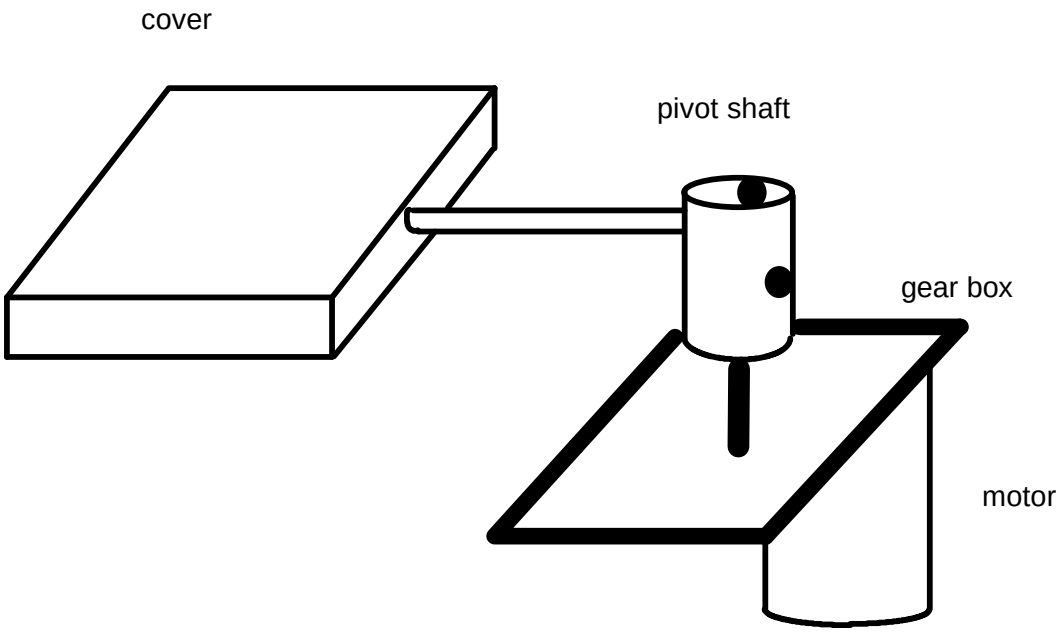

Figure 4. Top and Side View of Plate Cover

4.1.1 Top Set Screw

Rarely needs adjustment and should only be touched if care is taken to ensure that all parts of the cover and the brass shaft on which it is mounted have proper clearance to rotate.

4.1.2 Side Set Screw

This set screw is trouble-prone. Through wear and tear, the set screw wears down the flat part of the cover pivot shaft, and the cover develops greater-than-normal play. Normal play is ½ inch of play back and forth (1 inch total) at the end of the cover farthest away from the cover pivot shaft..

4.1.3 Cover Inspection

1) Make sure there is no sample in place.
2) Turn the EagleII off (the on/off switch down).
3) Turn it on long enough to move the covers about halfway, then turn off again.
4) Gently move the covers back and forth to check play. If play is less than 1 inch, turn the EagleII on and take no further action. If play is greater than 1 inch, then call for assistance since the cover may need to be removed and the flat on the cover pivot shaft filed.

4.1.4 Cover Adjustment

The sides of the covers should be about ¼ inch above the sampling surfaces. If a cover is too low, it may touch and ruin a sample. If too high, the cover will not protect the sample. Covers should be horizontal, which can be gauged by the eye.

To adjust a cover:

1) Call for assistance.
2) If the cover is not horizontal, loosen the top set screw and gently tilt the cover until level. Then tighten the set screw.
3) If the cover has been determined to be too high or too low, loosen the side set screw and move the cover into a position where the bottom of the cover sides are about ¼ inch above a dummy plate. This will require the covers be moved above the sampling area, which is accomplished with the on/off switch. Turn it off (down). Turn it on (up). When the covers move into the desired position, turn the switch off again. The cover-to-sampling-plate clearance can now be seen.
4) Before resuming normal operation, turn the switch off then on again to make sure the cover rotates freely, is not loose and does not contact the dummy plate.

4.2 Cover Will Not Move

Call for assistance.

4.2.1 Only One Cover Moves

Check the two wires that connect to the motor. If both connections are good, then either a motor is bad or a connector has become corroded. Replace the motor. 1) Remove the two machine screws that hold the motor to the underside of the pivot shaft gear box. 2) Disconnect the two wires. 3) Install the new motor and reconnect the two wires, disregarding the polarity, since the motor functions either way.

4.2.2 Neither Cover Moves

Perhaps the EagleII has lost power. See the instructions under "No power."

4.3 No Power

4.3.1 If the display is not lit when the on/off switch is on (up), it is likely that there is no power. Two related conditions will cause this. Either one or both of the fuses in the power box are blown, or a power connector is shorting. When a power connector shorts, it will blow a fuse in the power box.

4.3.2 Check power box. Disconnect the power connector from the power box.

Warning: The connectors used on the EagleII are kept in place by a lock ring which only makes a one-quarter turn; care should be taken not to over twist the lock ring, as this will damage the connector. Use a multi-meter set on "DC Volts" to measure the DC Volts output of the power box. If output is 17 VDC, then proceed to check the power connectors. If there is no output, then remove the four machine screws holding down the cover of the power box and remove the cover.

Warning: Unplug the power box before opening it. Use the multi-meter set on "Ohms" to see which fuse is bad. With the multi-meter on "Ohms", put the red and black leads together and zero the needle on the meter. This may not be necessary on some models, for example models with digital readouts. Now put one lead on each end of the fuse to be checked. If the fuse is good, the readout will indicate 0 ohms. If bad, the readout will show infinity. This may be done safely with the fuse in place. After replacing any faulty fuse with one of the same Amp rating (on fuse), replace cover, plug it back in, then check again to see if output is 17 VDC. The power box should work at this point. Before connecting the power connector from the EagleII, both power connectors should be checked for signs of corrosion.

4.3.3 Check power connectors. Disconnect the one power connector from the power box and the other from the control box.

Warning: The connectors used on the EagleII are kept in place by a lock ring which only makes a one-quarter turn; care should be taken not to over twist the lock ring, as this will damage the connector. Use a multi-meter set on "Ohms" to determine if there is continuity from one to the other connector. This is done just like checking a fuse (see preceding paragraph). Zero the multi-meter. Put one lead on one electrode of the connector that goes to the power box. Put the other lead on an electrode of the connector that goes to the control box. If the meter shows infinity, then try touching the lead to the other electrode of the control box connector. If the meter again shows infinity, then there is no continuity between the two connectors and a connector is bad and needs to be replaced. If there is continuity (meter reads 0 ohms), then check across the two electrodes of each connector. If there is continuity, then a connector is bad and needs to be replaced, and the bad connector is probably causing the fuses in the power box to fail. Over twisting the connectors can cause the same problems experienced from a corroded connector.

4.4 Power Cord Wrapping Around Support Pole

The slip ring bearing has a shaft which protrudes into the support pole. The bearing is designed so that while the top rotates, the bottom is stationary. The shaft on the bottom of the bearing has to be secured. If it is not, the bottom and top will rotate together. The power cord which goes to the power box is attached to the bottom of the bearing and will therefore be dragged around and around the support pole. An undue strain would be placed on the power box connector. To avoid this condition, a hole is drilled through the support pole and bearing shaft. A machine screw and nut is placed through this hole.

Note: The hole was not drilled through the exact center of the shaft and pole. If the screw is removed and the shaft turned 180°, the screw will probably not fit back in. This also means that a pole and shaft come as a matched pair, since they were drilled at the same time. *Shafts and poles are not interchangeable*. If a problem arises where the screw will not fit in, a wire or nail can be used to temporarily solve this problem until a nut and bolt can be used.

4.5 No Timer/No Display

If the display is lit, but the timer does not function, or if there is no display but power comes to the control box, call for assistance. The microprocessor in the control box may need to be replaced.

4.6 EagleII is Loose

Each EagleII has a hold down peculiar to the site, but each must be monitored for excess looseness which may cause damage in a high wind to itself, other instruments or may pose a hazard to people. Call for assistance.

4.7 Samples Covered, No Rain

This can occur in very humid conditions, such as when the weather is in a transition period, or when the rain sensor connector has shorted. The connector shorting due to corrosion will make the covers cover the samples. The sensor itself operates on the principle that when rain hits its surface,

a short occurs that makes the covers cover the sample. The sensor connector needs to be replaced. Call for assistance.

5.0 Quality Assurance and Quality Control

Field blanks will be collected to ensure samples are being collected and extracted in a contaminant-free manner. Split samples will also be collected and analyzed. See the *Standard Operating Procedures for Preparation, Handling and Extraction of Dry Deposition Plates* for details.

If you have any questions, at any time, please do not hesitate to call Jeff Lu or John Kelly at the Illinois Institute of Technology (312) 567-3553. If you cannot reach someone at the lab phone during business hours, call Prof. Tom Holsen at (312) 567-3559 and leave a message on his machine. We will get back to you as soon as possible.

6.0 Contact List

For questions or problems send a message or call:

Jeff Lu
IIT Air Quality Lab.
(312) 567-3553 (lab)
(312) 791-9649 (home, leave message)

or

Dr. Thomas M. Holsen
Associate Professor
10 West 33rd Street
Department of Chemical and Environmental Engineering
Illinois Institute of Technology
Chicago, IL 60616-3793
Tel (312) 567-3559(leave message)
Fax (312) 567-3548
E-Mail ENVEHOLSEN@MINNA.IIT.EDU

Appendix A. Sample Log Sheet

EAGLE SAMPLE LOG SHEET		**DATE**	
SAMPLE NUMBER			
SAMPLE LOCATION			
WEATHER CONDITIONS (CIRCLE ONE)	SUNNY	RAINY	CLOUDY
COVER STATUS (CIRCLE ONE)	OPEN	CLOSED	
OPEN TIME, MIN			
TOTAL TIME, MIN			
RESET TIMER?*	YES	NO	
WET TEST RESULTS (CIRCLE ONE)	COVER THEN UNCOVER	NO RESPONSE	OTHER (EXPLAIN BELOW)
* RESET TIMER ONLY WHEN STARTING A NEW SAMPLE			
COMMENTS			

How to fill out the Eagle's log sheet:

Example 1. In this example it is a sunny September 13, 1994, so the site operator enters 09/13/94 into the date, and circles sunny in the weather conditions row. Since it is a sunny day the plate covers should be open and operator should circle open in the cover status row. The open time and the total time should then be recorded. These times can be determined by switching the middle switch up and down on the right side of the control box. The times will be displayed on the red display panel. The open time will be preceded by the letters "OPE" and the total time will be preceded by "TOTL". You may have to shade the control box to read the display on a sunny day. A wet test should then be performed by putting a little bit of water on the Eagle sensor (see Figure 1) to make sure the Eagle covers on both sides close when the sensor is wet

and reopen when it is dry. Any comments can be entered at the bottom of the log sheet.

Appendix B. Parts List

- One power box (gray; input 120 VAC, output 17 VDC; one 10 amp fuse, one 5 amp fuse)
- One control box (white; includes a display, sensor connector, two motor/position-sensor connectors, power connector, on/off switch, total-time/open-time switch, red reset switch, 2 blue relays for the two motors, black microprocessor).
- One base
- One support pipe
- One support pipe screw (prevents rotation of slip ring bearing shaft)
- Four set screws
- Two cover motors
- Two cover motor gear boxes
- Two covers (left and right)
- Tail
- One sensor (for rain and snow)
- One sensor holder (mounted on tail)
- One slip ring bearing (allows free rotation of upper section, while maintaining a continuous connection to power supply)
- Two power connectors (one to power box, one to control box; two-pin connectors)
- Two motor/position-sensor connectors (on control box; six-pin connectors)
- One sensor connector (on control box)
- Four position sensors (two for each cover; not to be confused with rain sensor)
- Two sampling plates (dry deposition plates)
- One sample blank

Appendix C. Terminology

Sampling area: Where plates get mounted

Cover mount shaft: Horizontal brass shaft from cover

Cover pivot shaft: Vertical steel shaft on which cover pivots to the closed and open positions

Closed cover: The cover is over the sampling area, sampling has been discontinued during a rain or snow event; the timer continues to count total time, but stops counting open time until the cover is again in the open position.

Open cover: The cover is not over the sampling area, the EagleII is in sampling mode; the timer counts open time as well as total time

Dry deposition: Deposition to land or water of particulate matter, both man-made and natural

Anthropogenic: Man-made material found in the environment