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Project Summary

Snow/Rain Collector Sampler

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This report describes a new instrument for collecting chemically accurate precipitation (liquid and frozen) samples and measuring precipitation rate and quantity. The design goals include the ability to operate in a wide range of weather conditions at remote and unattended monitoring sites for at least seven days, be easily operated by non-technical personnel, provide for convenient sample and data transport, exclude dryfall, and operate from a limited power source. The design features and fabrication of each subassembly are discussed. The results of field tests are provided, with particular emphasis on chemical measurements. Finally, recommendations for future improvements based on these test results are provided.

This Project Summary was developed by EPA's Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The study of precipitation chemistry implies the ability to collect chemically accurate precipitation samples. In general, precipitation chemistry varies from location to location so geographically disbursed collection is necessary. Geographical dispersion implies a collection device that will operate continuously and unattended. Such a device must be able to determine when precipitation is occurring and, during non-precipitating periods, prevent contamination of collecting surfaces. Additionally, both liquid and frozen precipitation will be of interest so the instrument must have the ability to sense, collect and melt frozen precipitation for convenient storage.

Instrument Description

Overview

The precipitation gauge and collector is a computer controlled electro-mechanical device for collecting chemically accurate precipitation samples and measuring precipitation quantity and rate. It is designed to operate unattended for periods of up to one week from a 12 volt DC power source. The device includes a start of event sensor that detects the onset of precipitation, a collector funnel that is automatically uncovered during precipitation, a liquid measurement apparatus referred to as the accumulator, removable bottles for storage and transfer of precipitation samples, a mechanism for transferring liquid from the accumulator to the storage bottles, and a controller to supervise the actions of the instrument and collect data. The end of a precipitation event is determined when the accumulator has not become full within a predetermined time period. The controller records the time of start and end of precipitation events and the time of every filling of the accumulator. It also records status events such as door open, heater use, sample bottle number, and instrument exception information such as low power voltage and failure of the instrument to behave as expected. The majority of the

instrument workings are contained within an insulated 28 x 13 x 13 enclosure. Provision has been made to heat the start of event sensor, collector, and interior of the enclosure in order to collect frozen precipitation.

Sub Assemblies

Accumulator

The accumulator is a removable subassembly that is designed to detect a .01 inch increment of precipitation and to transfer that increment into storage bottles. It consists of a collection tube of a known volume, a lower normally closed pinch valve that traps liquid in the collection tube, an upper normally open pinch valve that allows precipitation to enter the collection tube and optical sensors that detect the presence of liquid. The controller operates the accumulator by monitoring the liquid detectors during a precipitation event. When it observes that both detectors see liquid at the top of the collection tube it forces a sample needle and vacuum needle through a storage bottle septum by means of the injector assembly, opens the lower pinch valve and turns on the vacuum pump to suck the increment of precipitation into the storage bottle. The controller determines that a precipitation event has ended when no liquid has collected in the accumulator for a programmable interval of time.

Carrousel Assembly

The carrousel is a removable subassembly provided to hold the storage bottles and to position them under the injector. The carrousel is designed to allow the storage bottles to be installed and removed as a unit. The rack of bottles may be transferred without need to keep track of the bottles on an individual basis. The carrousel assembly consists of a turntable that accepts a rack of eight 500 ml bottles, a motor to drive the turntable, a motor heater and a connector. Locator pins and a locator pin detector switch enable the controller to determine the position of the turntable.

Collector

The collector consists of an eight inch diameter aluminum funnel coated with Halar to prevent sample contamination. To preserve cleanliness the collector is covered between precipitation periods. The bottom of the funnel is connected to the accumulator. The controller servos the heaters at 3°C during precipitation events when ambient temperatures are below freezing.

Cover Assembly

The cover assembly is provided to prevent contamination from entering the collector during non-precipitating periods. The start of event sensor is mounted on the top of the cover. A mercury bead tilt sensor is mounted to a cover mounting arm. The controller uses that sensor to determine that the cover has moved when an open or close command is given and to detect when the cover is approaching its destination in order to turn off the cover motor. The cover is entirely coated with Halar for cleanliness.

Injector

The injector is a removable subassembly that is designed to transfer liquid from the accumulator to the storage bottles. It consists of a solenoid that forces a dual needle assembly through a septum in the cap of the storage bottles, a heater to prevent liquid from freezing in the needles and switch that enables the controller to detect when the needles are retracted. The septa are cut from a special high tear strength silicone elastomer to withstand up to 64 penetrations. One of the needles is plumbed to a vacuum pump and the other to the bottom of the accumulator. The controller transfers liquid from the accumulator to the storage bottles by plunging the needles through the septum and applying suction to the bottle by turning on the vacuum pump for a predetermined time period. As a safety feature the controller will not automatically operate the needles when the enclosure door is open.

Start-of-Event Sensor

The start of event sensor (SOES) functions by detecting the lowered resistance of a printed circuit board grid pattern when the grid becomes wet. AC excitation of the grid prevents long term degradation due to electrolysis. A heater and control electronics within the SOES housing keep the temperature of the grid above 3°C in order to detect frozen precipitation. A short chimney reduces the chance that frozen precipitation will bounce out of the SOES before it melts. The capability to force the SOES heater on is provided so that the grid may be dried at the end of a precipitation event.

Materials

Chemistry and material compatibility questions made material selection one of the most important aspects of the sampler's design. Fortunately, the choices were considerably simplified by selecting from a list of materials already deemed acceptable for handling NADP samples.

All wetted surfaces were fabricated from materials included on this NADP list with one exception. The collector funnel and cover were coated with Halar ECTFE, a copolymer of ethylene and chlorotrifluoroethylene. It gives an inert, stable surface that should avoid the potential problems of pinholes and porosity sometimes seen with Teflon coatings. Both silicone and pvc tubing were tested in the accumulator. The former was selected based on less variation in its inside diameter and less tendency to take a set in the pinch valves.

The materials were assessed in two ways: 1) laboratory testing of samples, and 2) chemical performance tests of the completed instrument.

Results and Discussion

The field tests were conducted in two modes. In the first procedure, 500 ml of a fairly clean water standard was prepared and stored in a polyethylene sample bottle. At the start of the sampling week 200 ml was poured into the collector and processed by the instrument into sample bottle #8. At the end of the week, the procedure was repeated and the liquid was passed into sample bottle #7. The standard and two blanks, along with whatever precipitation that was collected in the other sample bottles, were sent to the laboratory for analysis. We were looking for differences in species concentrations between the standard and the blanks. The second procedure involved using a not so clean water standard, in this case tap water. We were looking for the loss of species.

Conclusions

The instrument described herein performed satisfactorily during field testing. It demonstrated the ability to operate in a cold winter mountain environment while powered by four automobile batteries. The removable carrousel of sample bottles proved to be easy to replace and transport. It is doubtful that the instrument can be reproduced in quantity for $2,500. That figure will probably cover the cost of instrument components and assembly, but not test, product support, and profit.

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The complete report, entitled "Snow/Rain Collector Sampler," (Order No. PB91-167601/AS; Cost: $15.00, subject to change) will be available only from:
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