FINAL REPORT

SEQUENTIAL AIR SAMPLER SYSTEM — ITS USE BY THE VIRGINIA DEPARTMENT OF HIGHWAYS & TRANSPORTATION

by

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(A Cooperative Organization Sponsored Jointly by the Virginia Department of Highways & Transportation and the University of Virginia)

Charlottesville, Virginia

February 1975
VHTRC 75-R33

1872

SUMMARY

The Department of Highways & Transportation needs an economical and efficient air quality sampling system for meeting requirements on air monitoring for proposed projects located in critical areas. Two sequential air sampling systems, the ERAI and the EMI, that appeared to be the answer to this need were evaluated. On the basis of analytical reliability, the EMI system is far superior to the ERAI; while on the basis of design, the ERAI is slightly better.

Since the availability of reliable air quality data is a far more important consideration than system design, it is recommended that the Department use the EMI sequential sampler system, after suitable modification of the system's enclosure for better security.

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INTRODUCTION

The air quality guidelines recently published by the Federal Highway Administration require on-site air quality data gathering and a high level of analysis for proposed high traffic volume facilities in areas with critical air quality problems.

From recent experience with air quality monitoring for the proposed Interstate 595 facility in Crystal City, Arlington, it has been concluded that this new requirement will entail a significant manpower commitment on the part of the Department unless a bag-sampling system that demands less attention than the presently used one is adopted for use.

There is a need for an air sampling system that is more reliable and economical than the present one. Such a system would enable one person to conduct air sampling at several sites on a given project thereby cutting the cost of monitoring tremendously. Two systems recently introduced on the market seem to provide this capability.

The author felt that before any of these systems could be recommended to the Department for use, it would be prudent to examine their reliability, performance, and overall convenience. It was for this purpose that the brief study described herein was conducted.

EVALUATION OF THE NEW AIR SAMPLING SYSTEMS

For the last two years, the Council has been using a homemade air system in its research projects. This system consists of a portable diaphragm pump connected to an aluminized Mylar™ airbag with teflon tubing, all of which is enclosed in a padlocked box made of heavy plywood. The system requires constant checking and a change of air bag after each hourly sample is collected. Although slightly inconvenient, it has proven to be adequate for the research projects conducted. However, for the type of continuous air quality monitoring (say, from 0600 to 2100 hours) that the Department is required to conduct for projects in critical areas, the system will be uneconomical to use, especially if several sampling sites are to be monitored simultaneously.

The two similar air sampling systems that have recently come on the market are designed to eliminate this problem. Each system has a dry-cell battery pack, several pumps connected to the same number of air bags, and an electronic timing circuit that is the heart of the system. This circuit enables the user to program the sampling sequence desired, after which the pumps are automatically activated to collect hourly samples in the preset time sequence. In both systems, all the components are contained in molded plastic drums.

In order to examine and evaluate these two air sampling systems, the author contacted their manufacturers, the Environment Resources Associates, Inc. (ERAI), of Portland, Oregon, and the Environmental Measurements, Inc. (EMI), of Annapolis, Maryland. Both firms agreed to furnish their sampling systems for a comparative examination and evaluation.

Comparison of Analytical Reliability

An important criterion an air sampling system must meet is analytical reliability; i.e., it must be able to collect air samples that will provide CO readings that agree reasonably well with known CO concentrations. In order to determine whether the two new systems provide this necessary reliability, they were programmed to collect several hourly air samples continuously, and were placed side by side with the Council's continuous CO monitoring instrument (GC-FID), so that they all would be simultaneously sampling the same air. Under this setup, the new sampling systems should give samples whose concentrations are comparable to those of the instrument.

The results obtained from one such comparison are shown in Table 1. The table shows that the ERAI system gave results inconsistent with the instrument results. At high CO concentrations, the ERAI results were about half of those obtained by the Council instrument; while at lower concentrations, the ERAI values were about 20% higher. This discrepancy was traced and found to be caused by the combined absorption and outgassing effects of the materials used in the pumps, air bags, and tubing of the ERAI system, which altered the composition of the air samples collected. In contrast, the EMI system appeared to yield results consistent with the Council instrument results, except at approximately 22 ppm CO, where it gave a concentration about 88% that of the instrument value. This deviation is just slightly below the preferable tolerance of 90%.

Similar results were obtained when this comparison was repeated. Figure 1 shows a combined plot of all the ratios of sampler system to instrument results at different CO concentrations. Approximately 70% of the ERAI results, compared to 17% of the EMI values, are beyond the tolerable range of deviation. It is obvious that the EMI sampler system is superior to that of the ERAI as far as analytical reliability is concerned.

Table 1. Comparison of the Sampler Systems With the Council's Instrument

Time	Ambient CO Concentrations				
	Council Instrument (ppm)	ERAI (ppm)	ERAI/Instr.	EMI (ppm)	EMI/Instr.
0830-0930	21.7	11.0	0.50	19.0	0.88
0930-1030	14.8	7.5	0.51	14.0	0.95
1030-1130	8.1	7.5	0.93	8.0	0.99
1130-1230	5.3	6.0	1.13	5.5	1.03
1230-1330	6.3	6.5	1.03	6.0	0.95
1330-1430	7.7	7.1	0.92	7.5	0.97
1430-1530	5.5	6.8	1.24	5.5	1.00
1530-1630	4.9	5.7	1.16	5.0	1.02

Comparison of Design Features

There are some significant differences in the designs of the two air sampler systems that must be taken into consideration when choosing one for the Department's use.

As mentioned earlier, all the components for each of the systems are contained in molded, heavy duty plastic drums that externally resemble disposal cans. The drums protect the components from natural elements, specifically rain and strong sunlight. In Figures 2 and 3, the inside views of the ERAI system are shown, while in Figure 4 the EMI system is shown.

In Table 2, the various components of the sampling systems are described for easy comparison. Based on a rating scale such as:

Unacceptable 0
Inadequate 1
Adequate 2
Good 3
Excellent 4

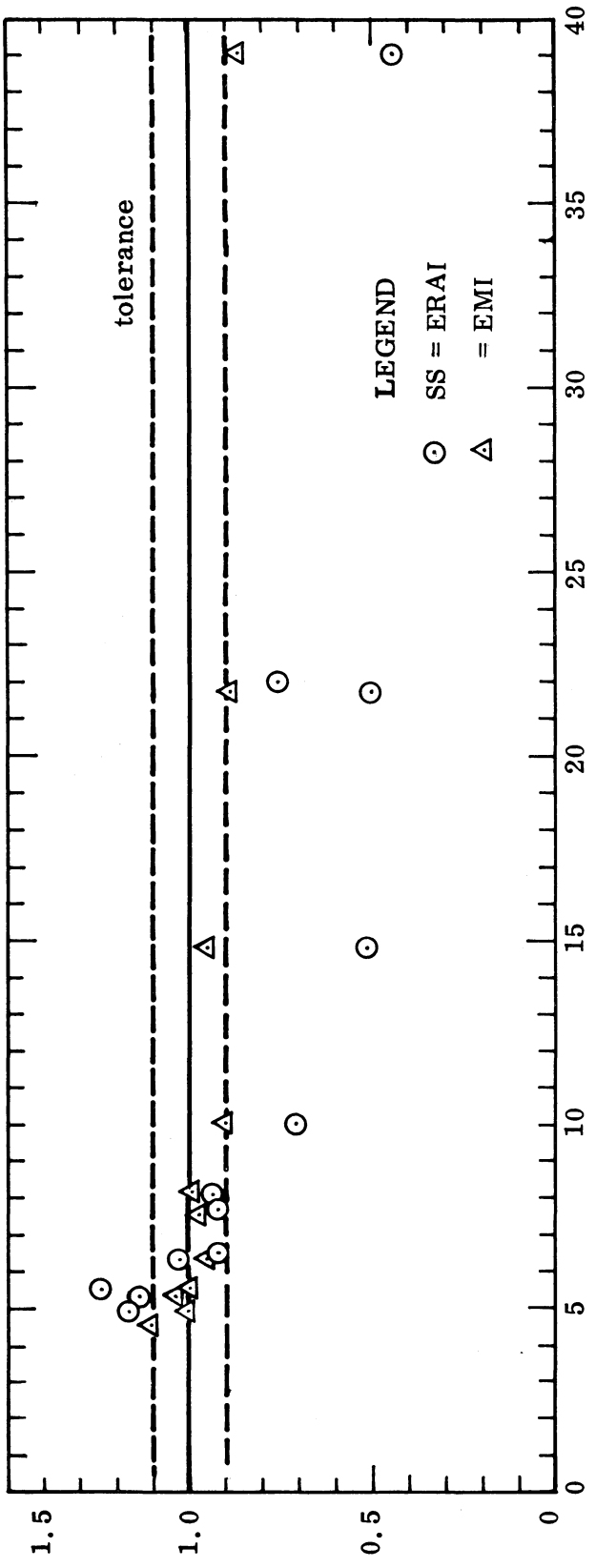

Figure 1. Relative analytical reliabilities of the two sampler systems as a function of CO concentrations. The SS/Inst. is the ratio of sampler system's to instrument's results.

the ERAI system (average 2.4 points) rates slightly better than the EMI system (average 2.0 points) when every component is considered. The better rating of the former can be attributed mainly to its enclosure design, which provides security and easy handling. It must be mentioned that the ratings in Table 2 for the various components were based solely on designs and did not include the undesirable effects of materials used on the air samples. If the latter were in the rating, the ERAI system would have rated zero (or unacceptable) for pump and air bag. These were omitted here since the poor rating previously given to the ERAI system for analytical reliability already reflects this undesirable effect.

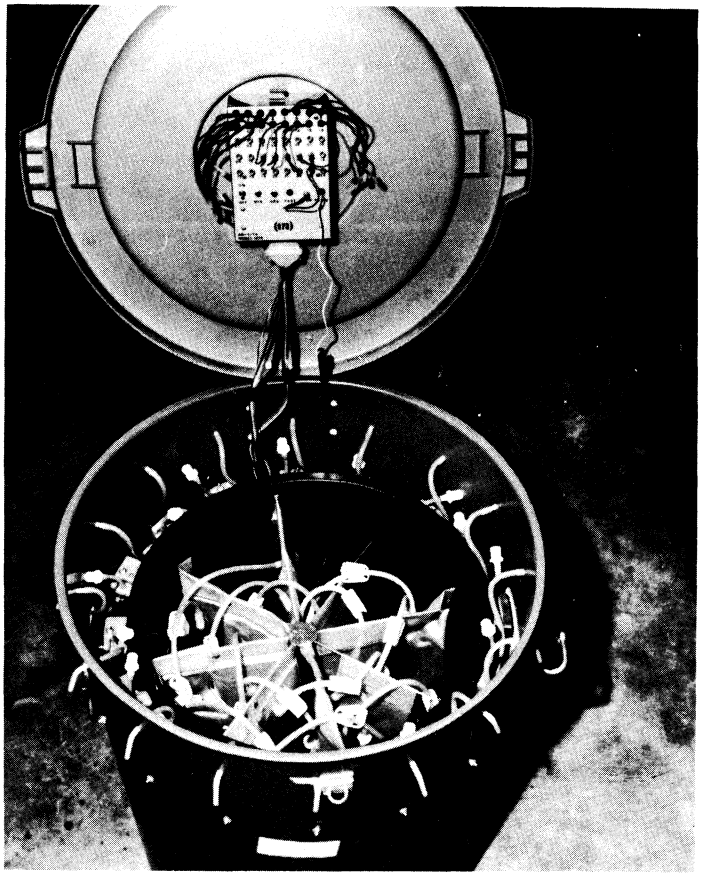

Figure 2. An inside view of the ERAI sequential air sampler system showing, among other things, the electronic timing circuit attached to the inner side of a hinged cover.

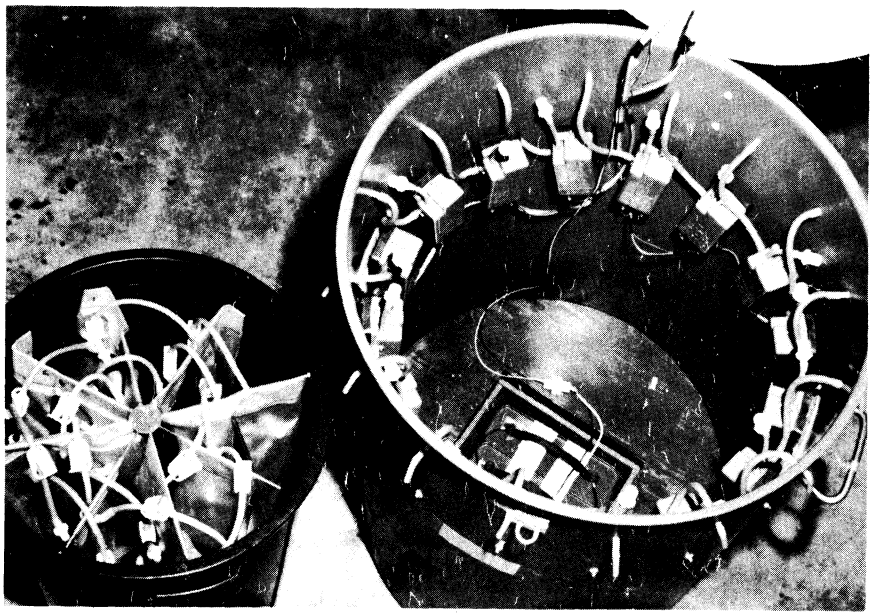

Figure 3. Another inside view of the ERAI sequential air sampler system. The inner can, which provides neat support of the vinyl air bags through a radial wire frame, is shown removed from the outer can so as to expose the diaphragm pumps and battery pack.

Figure 4. An inside view of the EMI sequential air sampler system. The electronic timing circuit is fastened to the inner side of an unhigned cover, which has a hollow chamber where the piston pumps are located (not shown here). Note that this system does not have an inner can to provide neat arrangement of the aluminized nylon bags.

Table 2. Comparison of the Various Components of the Sequential Air Sampler Systems

Component	System	Features	Comment	Rating
System Enclosure	ERAI	1. Has hinged cover 2. The cover can be locked	1. A hinged cover is desirable for easy handling 2. A locked system deters vandalism	4
	EMI	1. has unhigned cover 2. A metal ring clamp is used to secure the cover to the drum	1. The cover would cause slight inconveniency 2. The cover cannot be locked 3. The ring clamp breaks easily	1
Electronic Timing Circuit	ERAI	1. Has push buttoms for setting real time, in hours, and minutes 2. The timing circuit automatically turns back to zero hour when power is turned off 3. A probe is used for testing time, to the hour	1. The second feature saves time in programming 2. The probe is inconvenient to work with	2
	EMI	1. Has push bottoms for setting real time, in hours and minutes 2. Numeric display of time, in hours and minutes is provided by light-emitting diodes 3. Provide switching selection of 3 different pump flow rates	1. The numeric display of time is convenient 2. Switch selection of flow rates makes it easier to set system up	3
Pumps	ERAI	1. Of rubber diaphragm nature 2. Flow rate can be adjusted on the top of each pump	1. The rubber diaphragm was found to absorb CO 2. No identical adjustments are applicable to all pumps 3. Air sample collected in bag still connected to pump not running may backflow	2
	EMI	1. Of piston nature 2. Valve mechanism that prevents back flow of collected air sample	1. Sealing in collected sample is necessary to prevent changes in CO concentration in the sample	2
Air Bags	ERAI	1. Uses 2-liter vinyl bags, equipped with a rubber hose and molded plastic clamp 2. Bags are supported by a radial wire frame securely fastened to an inner drum	1. The bag and hose have been found to interact with CO 2. The support makes the system neat, however it is troublesome when taking bags out	2
	EMI	1. Uses any type of aluminized plastic bags equipped with valve 2. Uses bags up to 10-liter capacity	1. Free choice of bags to use	2
Battery	ERAI	1. Uses 6-volt lantern batteries	1. Provides 300 hours continuous operation	2
	EMI	1. Uses 6-volt lantern batteries	1. Provides 300 hours continuous operation	2

CONCLUSION AND RECOMMENDATION

Conclusion

In this brief study, the two sequential air sampling systems were evaluated for their analytical reliability and design features. The ERAI system is slightly better in design than the EMI system mainly because its enclosure provides better security and easy handling. Since a sampling system will be left out in the field when functioning, its security is very important. However, when analytical reliability is considered, the EMI system is far superior to the ERAI system. This is because the materials used in the pumps, bags, and connecting tubing for the ERAI system affect the CO composition of the air samples, either by absorption and/ or outgassing.

Recommendation

In view of the fact that air pollution is an area where public resistance and litigation are more than a possibility, one would definitely prefer reliability even at the expense of convenience. Therefore, it is definitely recommended that the EMI system be adopted for Department use. However, the Equipment Division should modify the enclosure design by replacing the original ring clamp with a suitable lock system and hinging the cover to the container.