EPA-600/4-76-059
December 1976

Environmental Monitoring Series

PERFORMANCE INVESTIGATION OF THE MANNING MODEL S-4000 PORTABLE WASTEWATER SAMPLER AND THE MODEL F-3000 DIPPER FLOWMETER

Environmental Monitoring and Support Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
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PERFORMANCE INVESTIGATION OF THE MANNING MODEL S-4000 PORTABLE WASTEWATER SAMPLER AND THE MODEL F-3000 DIPPER FLOWMETER

by

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FOREWORD

Environmental measurements are required to determine the quality of ambient waters and the character of waste effluents. The Environmental Monitoring and Support Laboratory - Cincinnati conducts research to:

Develop and evaluate techniques to measure the presence and concentration of physical, chemical, and radiological pollutants in water, wastewater, bottom sediments, and solid waste.

Investigate methods for the concentration, recovery, and identification of viruses, bacteria and other microbiological organisms in water. Conducts studies to determine the responses of aquatic organisms to water qualtiy.

Conduct an Agency-wide quality assurance program to assure standardization and quality control of systems for monitoring water and wastewater.

The Instrumentation Development Branch, EMSL, has provided functional designs relating to water quality instrumentation systems. This report, which investigates an automatic wastewater sampler and flowmeter, provides considerations for field personnel in acquiring samples for wastewater monitoring.

Dwight G. Ballinger
Director
Environmental Monitoring and Support Laboratory
Cincinnati

ABSTRACT

Performance of the Manning model S-4000 wastewater sampler and the model F-3000 flowmeter was investigated.

The S-4000 wastewater sampler was tested at temperatures of 2, 20, and 35C to determine accuracy and precision of the timer and sample volumes. The multiplexer function of delivering multiple aliquots per bottle was tested. Tests for ability to fill up to four bottles with the same sample were made. Battery endurance was determined. Discrete sample temperatures versus time were recorded under iced conditions to determine preservation capability. Field tests were performed to determine representative collection of suspended solids and ability of the unattended sampler to collect raw sewage samples over a 24-hour period.

The F-3000 flowmeter was tested within the laboratory for accuracy and precision of tracking, analog to digital conversion, deadband, and electronic drift caused by temperature change and battery decay. Accuracy of the flow chart and integrator was determined.

Manufacturer's claims were mostly confirmed, however improvement is warranted for some functions of the sampler and flowmeter.

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ACKNOWLEDGMENTS

The author thanks Manning Environmental Corporation for supplying electronic schematics of the sampler and flowmeter and for their prompt courteous reply to questions and problems that arose during the investigation. Thanks to Dr. D. F. Bender for performing chemical analysis on the field samples. My appreciation is extended to Mr. Anthony Clark, Superintendent of Clermont County Sewers, for permitting us to test the sampler at the Perintown Sewage Treatment Plant and to Mr. Ollie Cohorn, Operator, for his assistance at the plant. Technical advice given by Drs. R. N. Kinman and J. D. Eye, University of Cincinnati, and Mr. A. F. Mentink, EPA, is greatly appreciated.

SECTION 1

CONCLUSIONS

S-4000 SAMPLER

Accuracy and Precision

The timing function was accurate and precise. Average time per sample for a 24-hour run, set to collect one sample/hr, was 60.023 min/sample with a standard deviation of 0.014 min for the 24 samples. In tests made before the sampler was returned to the factory because of a malfunction, even better accuracy was achieved.

Approximate volume settings of up to 500 ml/sample are possible by adjusting the siphon tube in the measuring chamber. The quantity and precision of volumes collected were satisfactory, during this part of the investigation, and the standard deviation for 24 bottles ranged from 0.69 to 2.25 ml over 13 runs.

One deficiency was that the sampler's timer started counting before the main switch was turned on if the spout was stepped to the first bottle by making the battery connection instead of using the bottle-advance button. This impaired the time of the first cycle and the last sample was skipped. Additional bottles at the end of the run were skipped for each cycle time period that passed before the main switch was activated. When the sampler was stepped to the number one position with the bottle-advance button, operation was satisfactory.

These runs were made at temperatures of approximately 2, 20, and 35C, and no significant difference in accuracy or precision due to temperature change was noted.

Multiplexer

Multiplexer runs allow up to 5 aliquots to be placed in the same bottle. During some of these runs the first aliquot for the first bottle was skipped, but the rest of the bottles received the correct volume. Elapsed time for the first and second aliquots of the first bottle was not always accurate, but it was accurate and precise thereafter.

Multiple Bottles

The sampler can be programmed to fill four bottles in succession during each cycle. During some of the tests, the time of the first cycle was not accurate; for example, a run programmed to cycle every 180 min, took the first sample after 127.5 min. Quantity of sample and precision of volume were satisfactory.

Battery Endurance

Tests showed that battery power was sufficient for the most severe run that could be made. These tests included runs at 2, 20, and 35C. Light weight of the battery/sampler combination is desirable. If batteries are charged before each run and checked with a hydrometer there should be no problem.

Sample Preservation with Ice

Sample preservation tests made within an environmental chamber at 22 and 35C showed that sample temperatures did not reach 4C, as recommended by EPA.[1] Ice within the sampler did not last for 24 hr, but melted after 5 to 7 hr. Tests showed that better heat transfer from the samples was obtained when the lower portion of the bottle is covered with ice water instead of air. As ice melted, empty bottles floated and hit the stepping spout, and the remaining bottles were left empty. "O" rings were not strong enough to hold the bottles down, and it was necessary to tie the retainer with string.

Representative Sample

Tests were made at a sewage treatment plant influent, and there was no significant difference between Manning and isokinetic samples for nonfilterable solids (NFS) and total organic carbon (TOC). Samples collected at the effluent were not significantly different with regard to NFS. TOC samples of the effluent were slightly different from isokinetic. These results were analyzed statistically using the T-test at the 95 percent confidence level.

Reliability

The sampler performed satisfactorily when left unattended for 24-hour periods at both sewage treatment plant influent and effluent points. One discrepancy is that sample volume variation for the influent was higher (standard deviation = 7.79 ml) than volume variation for the effluent (standard deviation = 1.76 ml). There were also a few other times during the laboratory investigation when one of the 24 samples was too small. Present Manning samplers use a pressure sensing detector on the measuring chamber instead of the resistive sensor that was tested and this may have corrected this problem.

Miscellaneous Problems

During these tests both battery leads pulled apart at the clips where the leads are fastened to the battery terminals.

During chemical analysis of samples, two full plastic sample bottles fell from the lab bench and broke as if made of glass. This was because they were cold. Full warm bottles were dropped from a height of 3 ft and they did not break. Bottle cap inserts came out when they got wet, however the bottles did not leak when the inserts were left out.

CONCLUSIONS

F-3000 FLOWMETER

Tracking

No significant error in head readings from the liquid level dial were detected at temperatures of 2, 20, and 35C. The liquid level dial has 1/4-in. and 0.5-cm graduations, and these should be changed to a least 0.1 in. and 0.2 cm. Also the percent flow dial has numbers at 5-percent intervals but no graduation marks. There should be marks at 1 percent intervals. Markings on the percent flow chart should be at 5-percent intervals rather than 10. The chart arm has an error with time of about 15 min per instantaneous full-scale swing.

Analog to Digital Conversion

Analog to digital conversion (signal from flow rate pot to final output on counter) was linear at constant temperature, hence the electronic circuitry in this part of the instrument performed satisfactorily.

Drift

Electronic drift due to changing temperature from 2 to 35C averaged 1.1 percent.

No flowmeter drift was seen on the counter when the source voltage was changed from 12.9 to 11.5. Output variation at 100 percent of maximum flow was 1.02 to 1.053 cycles/min over the source voltage range of 12.9 to 11.5 volts.

Manning specifies an output of 1 cycle/min at maximum flow and this was 1 percent high.

Deadband

The most serious fault with the flowmeter was caused by deadband or backlash in the gearing. This error ranged from -11.63 to 6.14 percent of reading at 6 in. head on a 90° V notch weir when the instrument was calibrated at 15 in. full scale.

Overall Accuracy and Precision

Error ranged from ±11.6 percent of reading at low flows to 0-3 percent at the calibration point (full scale). These tests showed that most of the error and lack of precision was due to backlash in the gearing.

An additional source of error is incorporated if the instrument is used with primary flow measuring devices that do not exactly follow $H^{5/2}$, $H^{3/2}$ or, the Manning equation. For example, slight error will be incorporated when the instrument is used with small parshall flumes. For permanent installations a cam or forms of electronics, such as a functional amplifier or microprocessor, that follow the exact equation for the primary device should be required.

SECTION 2

RECOMMENDATIONS

S-4000 SAMPLER

These tests showed that the timing function is accurate and precise. Perfect accuracy was obtained at first and after the instrument was returned to the company for a repair, it was off 1.4 sec/hr. This is satisfactory for most sampling operations, and quality control should be maintained at the factory to keep the timer accurate.

The sampler must be wired so that the timer cannot start before the main switch is actuated. It should not make any difference whether the spout is stepped to the first bottle with the advance button or by connecting the battery to the sampler. An additional button may be required that synchronizes all circuits to zero at the start of a run.

There is a need to synchronize the start of sampling on both multiplexer and multiple-bottle sample runs. The first sample should contain the correct number of aliquots, and it should start being collected at the set time. It should be possible to set the sampler so that the first sample is taken immediately with proper increments of time thereafter or the first sample should start exactly after the set time increment has elapsed.

The device should be able to cool samples to 4C and maintain them for 24 hours at that temperature, therefore a larger ice space, clearance between bottles for ice water to flow, and better insulation are required. It is necessary to secure sample bottles better so that they do not float as the ice melts.

Excessive variation in sample volume was noted during raw sewage collection and a few other times during these tests. Precise volume is important for composite samples and flow-proportional samples. This problem may have been solved since Manning changed from a resistive to a pressure sensing level detector.

Clips used to fasten battery leads to the terminals should be sturdier.

Cold plastic bottles should be more ductile so that they do not break if accidentally dropped.

F-3000 FLOWMETER

It is recommended that the liquid level dial graduations be made smaller, 0.1 in. instead of 1/4 in. and 0.2 cm instead of 1/2 cm. The percent dial should include graduations, and they should be 1 percent apart. Markings on the percent flow chart should be changed from 10 to 5 percent, and it is recommended that the chart be synchronized properly with time by slightly relocating the pivot point for the pen arm.

Better quality control should be maintained at the factory so that the counter cycles exactly once/min at full scale instead of 1.01 times/min.

Deadband or backlash due to play between the gears must be eliminated. This could be accomplished by installing antibacklash gears that incorporate springs or by using forms of electronics such as a functional amplifier or microprocessor that have no gears and cams. The latter modification is recommended.

Overall accuracy which is ±11.6 percent at low flows (most of which is caused by backlash) must be improved. Instrumentation for detecting head and converting head to flow should approach near perfect accuracy and precision. Fabrication and installation of the primary flow measuring device may inherently incorporate a slight error, but the present state of the art in electronics can assure that the instrument used for detecting head and recording flow is accurate and precise.

Flow measuring equipment installed at permanent installations should incorporate the exact equation for the primary device.

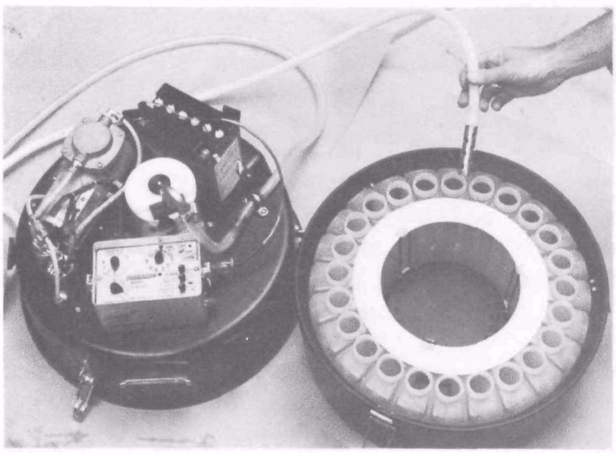
The flowmeter incorporates a desiccant. Mechanisms and electronics should be designed to perform satisfactorily in all humidity conditions without a desiccant. Desiccants in field equipment are easily forgotten and therefore they are seldom recharged.

These recommendations are meant to be objective and hopefully investigations of this nature will help improve wastewater samplers in general. The S-4000 sampler and F-3000 flowmeter performed satisfactorily for the most part and should be adequate for general sampling.

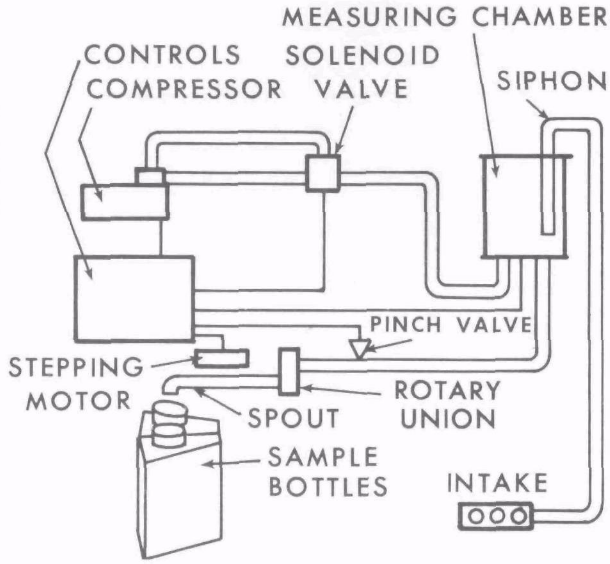
SECTION 3

DESCRIPTION OF SAMPLER AND FLOWMETER

The model S-4000 sampler pictured in Figure 1 weighs 40 lb (18.6 Kg.) including a YUASA (model 12N12A-4A) 12-volt battery and tray of 24 sample bottles (500 ml each).



a) Photograph of sampler



b) Schematic diagram.

Figure 1. S-4000 sampler (courtesy Manning Environmental Corp.).

Intake tubing is 3/8 in. ID reinforced tygon; it is 22 ft long and terminates at a plexiglass measuring chamber. Sampling cycles are initiated from either an internal timer or an external contact closure that originates from a flowmeter. Twenty-four discrete bottles can be filled at intervals of 15 min to 24 hr. Multiplexing allows each bottle to be composited of from one to five samples. It is also possible to fill four consecutive bottles one right after another, a capability that permits the addition of different preservatives to the same sample. Controls are all solid state electronics, and they incorporate a quartz crystal controlled oscillator and digital logic to provide the sampling intervals. The sequence of events during sampler operation is as follows (refer to Figure 1b). The controller initiates a cycle; the solenoid valve is positioned so that the compressor clears the intake line for a few seconds; the solenoid valve changes position and a sample is sucked into the measuring chamber; an electronic level sensor within the measuring chamber sends a signal to the control that changes the solenoid valve position so that excess sample is forced out of the siphon; the pinch valve opens and the measured amount of sample is forced into the sample bottle; the pinch valve closes and compressed air clears the intake line; the compressor turns off, and the spout steps to the next bottle. This completes one cycle.

Figure 2 dipicts the F-3000 flowmeter and Figure 3 is an electromechanical schematic that illustrates its operation. The unit must be installed upstream from a primary device, such as a weir or flume. It can also be installed on a circular pipe if its diameter, slope, and roughness factor are known. The dipper tracks the level of the liquid above the primary device, and the voltage from the level pot is fed into a variable gain amplifier that allows selection of maximum head over a four-to-one range (Figure 3). Output of the variable gain amplifier controls a servo system that causes a cam follower to rotate proportional to percent flow rate, according to the characteristic curve of the cam being used. The cam follower is mechanically coupled to a pen arm that records percent flow rate, a dial that reads percent flow rate, and a potentiometer (flow rate pot). The output of the flow rate pot is proportional to percent flow rate and this signal is integrated and fed to a digital pulse circuit that controls a totalizing mechanical counter. The counter adds one count for each flow increment equivalent to maximum (100%) flow. In addition to the counter, another digital circuit allows for the accumulation of a multiple (switch selectable) number of maximum flow units. When this preset number of maximum flow units is reached, a switch closes and this signal can be used to start a cycle on the S-4000 sampler. The flowmeter can, therefore, be used with the sampler to make it flow proportional on a constant-sample-volume, variable-time basis.

Three cams are incorporated within the flowmeter, but each is used singly and represents one characteristic curve. The desired cam is easily rotated into position with a screwdriver. The standard set of cams includes characteristic curves for: 1) V-notch weirs ($H^{5/2}$); 2) flumes and rectangular weirs ($H^{3/2}$); and 3) circular pipes.

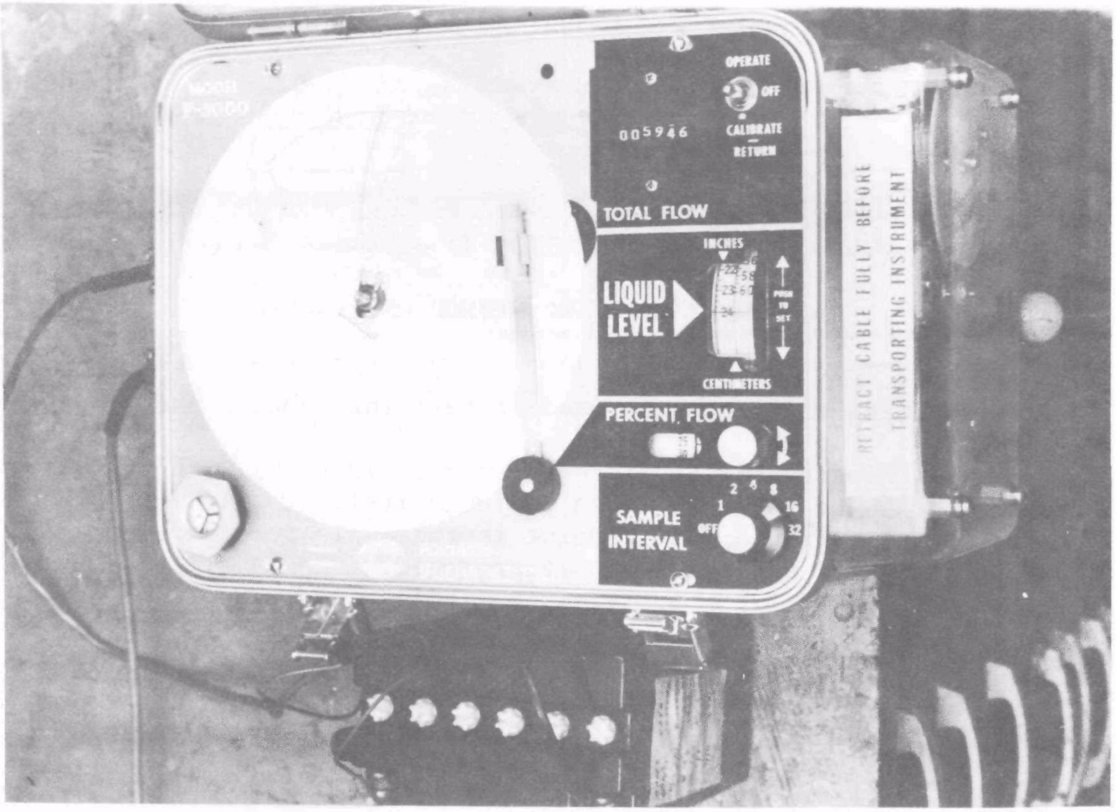


Figure 2. Model F-3000 flowmeter.

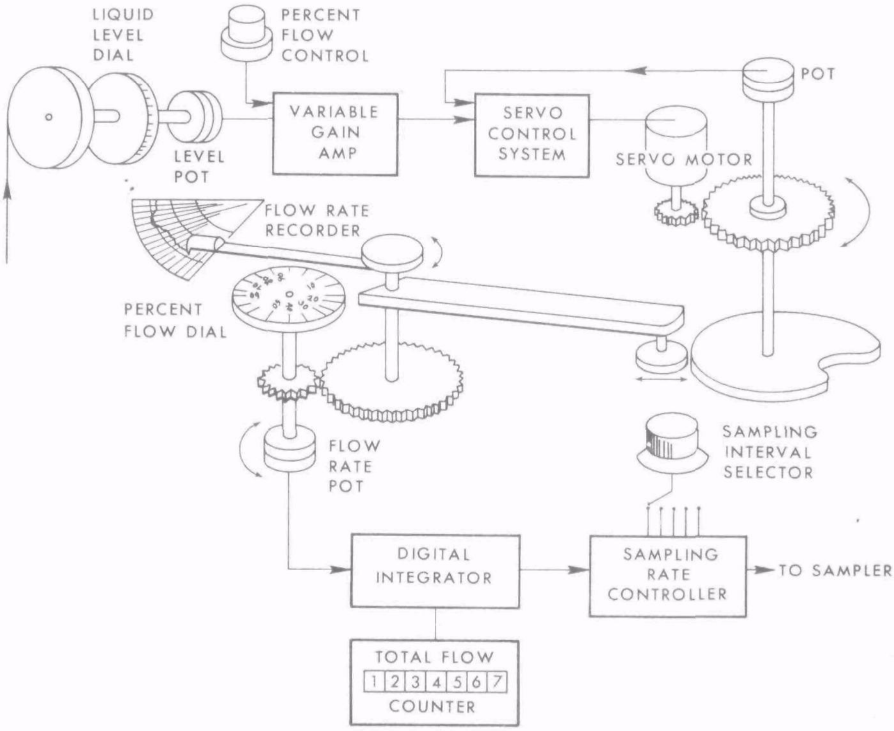


Figure 3. Electromechanical schematic of dipper flowmeter (courtesy Manning Environmental Corp.).

SECTION 4

EQUIPMENT USED AND METHOD OF TESTING

The following equipment was used to test the sampler and flowmeter:

1. Honeywell Electronik 15 recorder (span to 12 volts with supression).
2. Esterline Angus recorder (span to 100 volts).
3. Honeywell Electronik 16, 12-point thermocouple recorder.
4. Keithley (model 616) digital electrometer.
5. Universal Electronics regulated, variable, power supply (model C22-2).
6. Simpson (model 379) battery tester.
7. YUASA Syringe Hydrometer (model 404-14A).
8. EPCO (model 6130) water current meter.
9. Webber Manufacturing Company, Inc., environmental chamber.
10. Matheson thermometer, -1 to 51C, 1/10 division.
11. Starett 24" Vernier Height Gage.
12. Flotec Inc. (model F4P1-3100) Pump with Reliance 1/3 Hp., 1725 RPM motor and Scrambler (model PM1) variable speed control).
13. BARCO Portable Master Meter, range 0-50 (meter no. BR-L0500-00-01).
14. Barco Venturi (model 1/2" - 402, V1, BR-12402-08-31).
15. Marshalltown pressure gage 0-30 psi.
16. Various graduates and flasks.

Testing took place in the laboratory at ambient conditions, within an environmental chamber at temperatures of 2, 20, and 35C and in the field at a small wastewater treatment plant located at Perintown, Ohio. A typical laboratory "set-up" is pictured in Figure 4.

Sampler performance was tested initially without the flowmeter. The Honeywell recorder was connected to the sampler pump leads and used as an event recorder to determine the accuracy and precision of the sampler's timing function. Its ability to preserve samples under iced conditions was determined by placing thermocouples in eight of the 24 bottles at locations shown in Figure 5. Thermocouples were fastened to a small plexiglass insert that kept them centrally located within the sample bottles. Temperatures were traced on a Honeywell 12-point temperature recorder.

Field tests on the S-4000 sampler were made in Perintown, Ohio. Figure 6, a flow diagram of the perintown sewage treatment plant, shows the sampler locations.

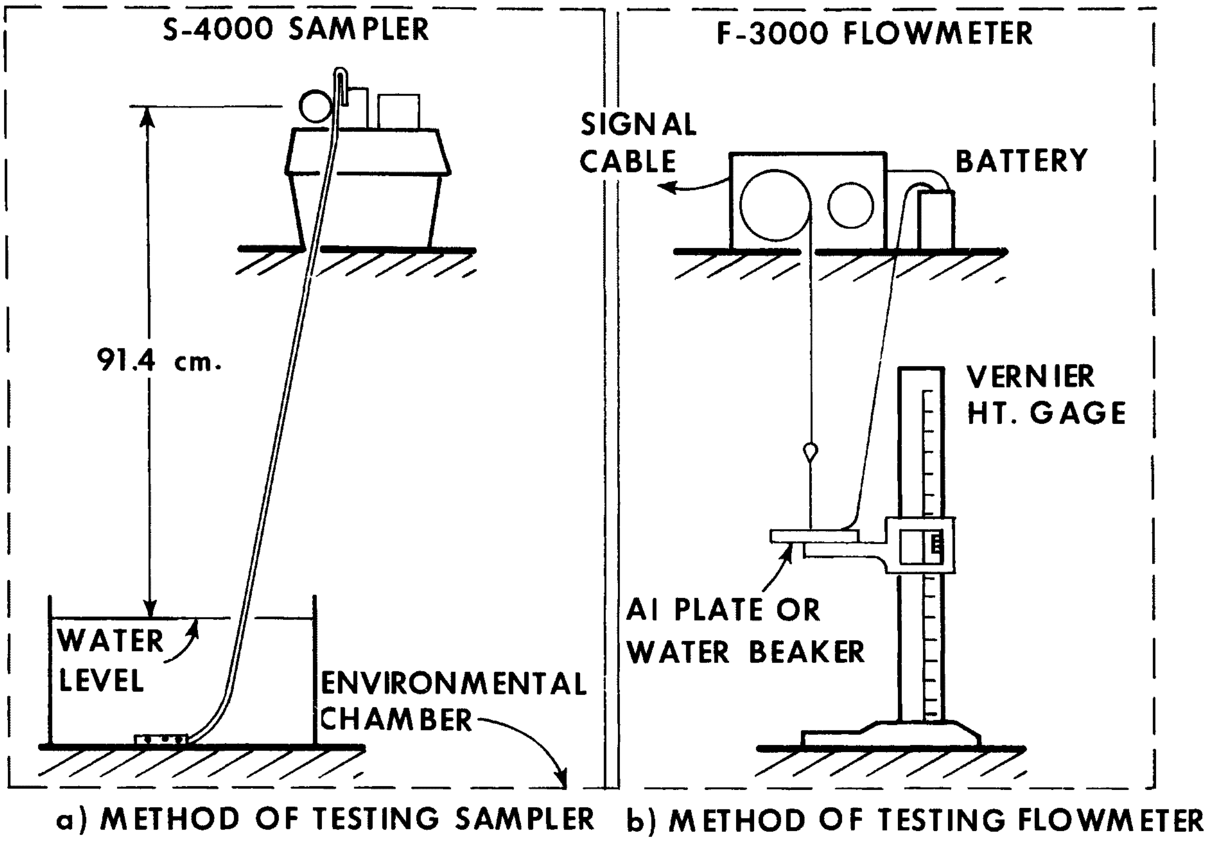


FIGURE 4. Typical "set-up" for testing in the laboratory.

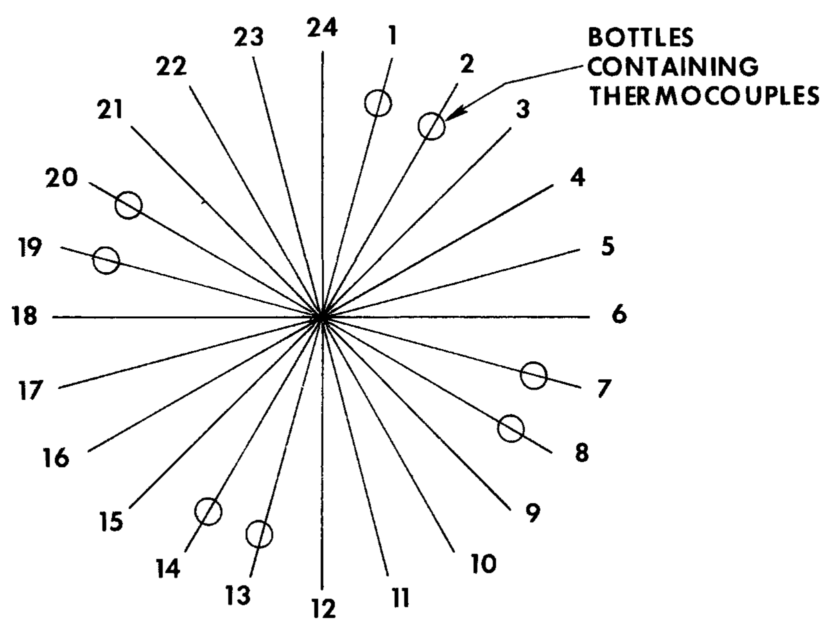


FIGURE 5. Thermocouple locations.

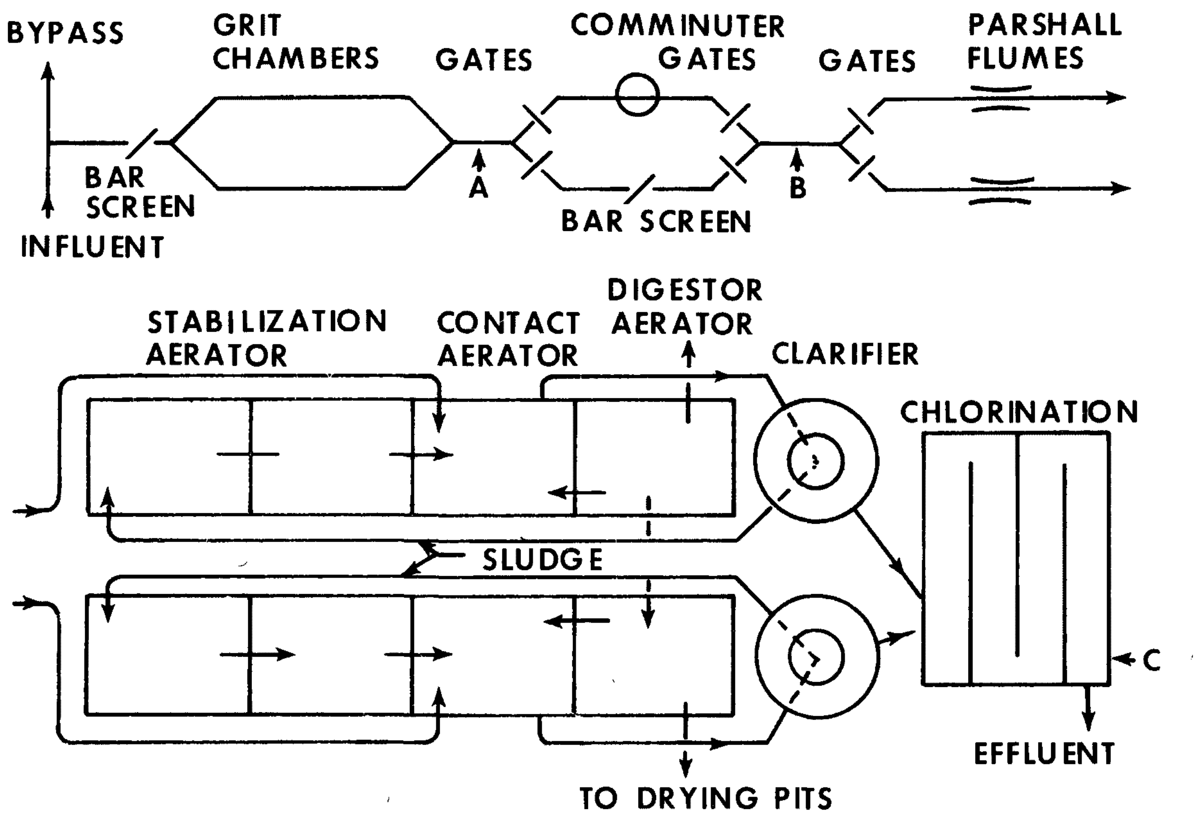


FIGURE 6. Perintown contact stabilization plant. Manning sampler compared to isokinetic (locations B and C), dependability tests (locations A and C).

Tests for dependability were made at locations A and C and tests for sample representativeness were made at locations B and C. Sample representativeness was tested by comparing the S-4000 sampler to isokinetic samples. Isokinetic samples were obtained by the method illustrated in Figure 7. The Manning intake was strapped to the isokinetic intake as shown. Velocity of flow in the waste stream was measured initially with an EPCO electromagnetic current meter. Velocity entering the isokinetic intake was then set equal to that of the waste stream by adjusting the variable speed pump until pressure drop across the venturi gave the correct flow. A graph shown in Figure 1 of the Appendix was used to convert velocity in the 0.620 in. ID isokinetic intake to ΔP. Inlets of both intakes were facing directly into the direction of flow. Sample velocity within the Manning sampler was higher than that of the waste stream for both influent and effluent samples; therefore, to obtain simultaneous samples, it was necessary to wait for the proper residence time within the isokinetic unit before collecting this sample. Waste stream velocities at the influent and effluent were 1.7 and 0.7 feet/sec (fps), respectively. Isokinetic samples were collected 20 and 50 sec for influent and effluent, respectively, after starting the Manning sampler. Comparison samples for representativeness were analyzed for NFS and TOC.

The flowmeter was tested in the laboratory under static conditions, as shown in Figure 4b. Head settings, accurate to .001 in., were made with a vernier height gage. Either an aluminum plate or a small beaker of water was attached to the slide of the height gage and connected to the negative battery terminal of the flowmeter. Test voltages were read with a Keithley electrometer, and an Esterline Angus recorder was used to record battery voltage. Most of the flowmeter tests were made with the sampler connected to the flowmeter, and the Honeywell recorder was connected to the sampler; hence the Honeywell chart gave an accurate record of flowmeter counts versus time.

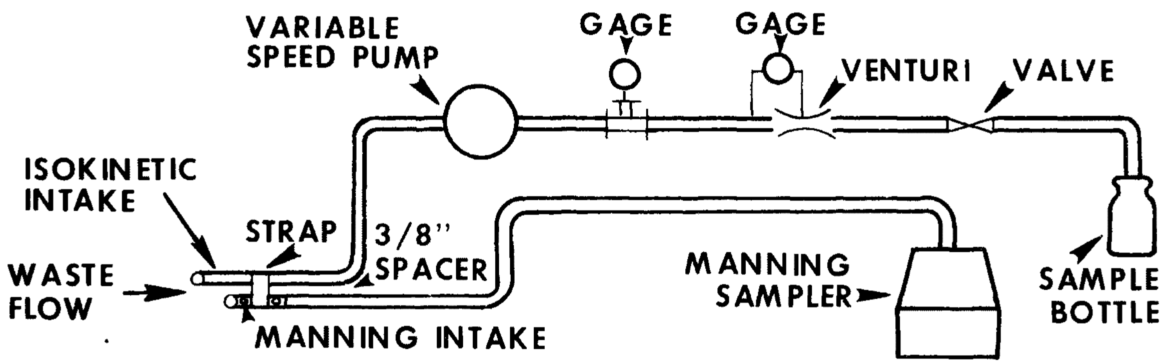


FIGURE 7. Schematic diagram showing method of taking isokinetic and Manning samples simultaneously.

SECTION 5

RESULTS OF PERFORMANCE TESTS OF THE S-4000 SAMPLER

TIMED RUNS

Accuracy of the timing function and volume delivery was tested at approximately 2, 20, and 35C. Table 1 summarizes this part of the original data, which are included elsewhere in the body of the report or in the Appendix. For example, Table 1 shows that run 1 was made with the sampler and water bath at 21.7C. Average volume ($\bar{X}$) of the 24 bottles collected was 277.7 ml (standard deviation S_x = 0.97 ml), and the average time (t) between bottles was 30.00 min. Sampler settings were 300 ml and 30 min for volume and time, respectively. For this run, the average volume collected was satisfactory, and volume variation was not excessive. Average time between samples (30.00) was essentially perfect, hence the sampler has an accurate timing device. Standard deviation for time between discrete samples was not calculated because the variation was so small that it could not be determined on the strip chart. The accumulated error for the entire 720-min run was only 0.025 min and hence insignificant.

Runs 21 and 22 in Table 1 show that the controller malfunctioned, as indicated by failure to cycle at the correct times. The controller was returned to the factory and runs 23 through 43 were made after the repair. When the accumulated error for runs 1 and 2 is compared with that for runs 23 through 43, it is seen that the sampler was a little less accurate after being repaired. For example, runs 1 and 32 were both set to cycle every 30 min, and the accumulated error for run 1 was 0.025 min versus 0.3 min for run 32. The total error of 0.3 min in 12 hr is not too significant, however the accumulated error of 0.025 min for run 1 shows that almost perfect accuracy was possible with the Manning timing function.

Run 33 was made with the recorder moving at a higher chart speed (0.8 in./min), and it was possible to estimate the average time/cycle and the standard deviation of discrete cycles. During this run the average time of a cycle was 60.023 min, and the standard deviation was 0.014 min. The complete 24-hr cycle took 0.56 min (33.6 sec) too long. This is satisfactory for most sampling purposes, however it is possible to do even better, as shown by run 1. Complete data for run 33 are shown in the Appendix.

In Table 1, runs 23 through 43 were made with the equipment operating at temperatures of approximately 2, 21, and 35C. The accumulated error for all of these runs is about the same (0.5 to 0.7 min for 24-hr runs and 0.3 min for 12-hr runs). Therefore, temperature change did not affect timer performance.

Table 1. SAMPLER ACCURACY (TIMED RUNS)*

Run	Temp. (C)	Volume (ml) set	$\bar{X}$	S_X	Time (min.) set	$\bar{t}$	S_t	accumulated error
1	21.7	300	277.7	0.97	30	30.00	†	0.025
2	21.6	400	424.8	0.85	30∇	30.00	†	0.0
21	24.3	400	371.2	1.28	30	18.49	.45	276.24
22	22.3	400	375		15	8.996	.19	144.1
Sent controller back for repair								
23	23.3	400	379.5	0.88	60	60.025	†	0.6
24	22.8	400	380.5	0.83	60	60.026	†	0.62
25	22.8	400	382.9	0.99	60	60.026	†	0.63
32	2	400	387.5	1.10	30	30.013	†	0.3
33‡	2	400	384.6	0.72	60	60.023	.014	0.56
34	21	400	X	X	60	60.02	†	0.5
35	22	400	380	0.69	60	60.03	†	0.7
36	31	400	383.4	0.85	60	60.02	†	0.5
41	35	425	414.6	1.47	60	60.03	†	0.6
42	35	425	413.8	2.25	60	60.03	†	0.7
43	21	425	414.1	1.05	60	60.03	†	0.6

*Averages ($\bar{X}$ and $\bar{t}$) and standard deviations (S_X And S_t) were calculated from 22, 23, or 24 samples.
†Variation was too small to read.
XBottles floated up and hit indexing arm, see run 34 in the Appendix.
∇Multiplexer.
‡Run made at faster chart speed (0.8 in./min); able to detect more precise time between cycles.

Table 2, run 28, shows that the last sample was skipped and that time for the first cycle was inaccurate. Additional data (run 28A) show that this happened when the indexing spout was stepped to the first position by connecting the battery instead of pushing the bottle-advance button. The sampler was turned on 5 min after the battery connection was made, and this is the reason that the first sample was collected after approximately 10 min instead of 15. Hence, the battery connection will index the spout to the first bottle and start the digital timer, but samples are not collected until the switch is turned on. Run 28B was started by stepping the spout to the first bottle with the bottle-advance button, and this run was satisfactory. The sampler should be wired so that nothing starts until the switch is turned on, and all circuits should also reset to zero at this time. It may be necessary to incorporate a button to "reset" before activating the main switch.

Table 2. SYNCHRONIZATION OF SAMPLER

Sample	Run 28*		Run 28A†		Run 28B‡	
	Cycle time (min)	Volume (ml)	Cycle time (min)	Volume (ml)	Cycle time (min)	Volume (ml)
1	13.7	83	9.8	345	15	404
2	15	84	15	347	15	404
3	15	83	15	348	15	404
4	15	83	15.05	347	15	404
5	15	82	15	349	15	405
6	15	83	15	350	15	405
7	15	82	15	350	15	404
8	15	83	15	349	15	404
9	15	83	15.05	349	15	404
10	15	83	15	348	15	405
11	15	83	15	347	15	405
12	15	83	15	347	15	403
13	15	83	15.05	347	15	403
14	15	84	15	348	15	404
15	15	83	15	346	15	404
16	15	83	15	261 ←	15	404
17	15	81	15.05	348	15	388 ←
18	15	83	15	347	15	402
19	15	83	15	247	15	404
20	15	83	15	247	15	403
21	15	82	15	349	15	405
22	15	82	15	349	15	404
23	15	83	15	348	15	405
24		skipped		skipped	15	404

*Stepped to bottle #1 with battery connection.

†Stepped to bottle #1 with battery connection; waited 5 min before turning on switch.

‡Indexed through 24 bottles and to bottle #1 with bottle advance button.

MULTIPLEXER

Tables 3 and 4 give the results of multiplexer runs 2 and 26, which were made up of 2 and 4 aliquots per bottle, respectively. It is seen that in run 2 only one aliquot was taken during the first cycle and that the sampler then went on to the next bottle. For run 26, the second aliquot was taken after 9.9 min and the third after 15.3 min. Only three aliquots were taken into the first bottle instead of four, and after the first cycle the run was 19.8 min ahead of schedule. Other than these discrepancies, the remainder of the multiplexer run was satisfactory.

Table 3. TIMED MULTIPLEXER OPERATION (RUN 2)*

Sample	Time (min)†			Volume (ml)
	Aliquot 1	Aliquot 2	Sample total	
1‡	----	15.0	15.0	215
2	15.0	15.0	30.0	425
3	15.0	15.0	30.0	425
4	15.0	15.0	30.0	423
5	15.0	15.0	30.0	425
6	15.0	15.0	30.0	424
7	14.9	15.1	30.0	427
8	14.9	15.1	30.0	425
9	15.0	15.0	30.0	425
10	15.0	15.0	30.0	425
11	14.9	15.0	29.9	425
12	15.0	15.0	30.0	425
13	15.0	15.0	30.0	425
14	15.0	15.0	30.0	425
15	15.0	15.0	30.0	423
16	15.0	15.0	30.0	423
17	15.1	15.0	30.1	425
18	15.0	15.0	30.0	425
19	15.0	15.0	30.0	425
20	15.0	15.0	30.0	425
21	15.0	15.0	30.0	425
22	15.0	15.0	30.0	425
23	15.0	15.0	30.0	425
24	15.0	15.0	30.0	425
			$\bar{X}$ =	424.8
			S_X =	0.85

*Sampler programmed to collect two 230-ml aliquots/bottle at 15 min intervals. Room temperature, 21.6C; sample water temperature, 18.2C.

†All cycle times were very close to 15 min. Readings of 14.9, 15.1, 29.9, and 30.1 are not exact, but mean slightly low and slightly high.

‡First bottle contained only one aliquot.

Table 4. TIMED MULTIPLEXER OPERATION AND BATTERY ENDURANCE (RUN 26)*

Sample	Time (min) Aliquot 1	Aliquot 2	Aliquot 3	Aliquot 4	Sample total	Volume (ml)
1		9.9	15.3	15	40.2	243†
2	15	15	15	15	60	324
3	15	15	15	15	60	323
4	15	15	15	15	60	323
5	15	15	15	15	60	324
6	15	15	15	15	60	321
7	15	15	15	15	60	323
8	15	15	15	15	60	322
9	15	15	15	15	60	321
10	15	15	15	15	60	320
11	15	15	15	15	60	321
12	15	15	15	15	60	323
13	15	15	15	15	60	322
14	15	15	15	15	60	324
15	15	15	15	15	60	323
16	15	15	15	15	60	322
17	15	15	15	15	60	322
18	15	15	15	15	60	321
19	15	15	15	15	60	325
20	15	15	15	15	60	323
21	15	15	15	15	60	327
22	15	15	15	15	60	324
23	15	15	15	15	60	324
24	15	15	15	15	60	325

*Sample programmed to collect four 100-ml aliquots/bottle at 15-min intervals. Slight variations in the intervals were not detectable because recorder chart speed was too slow (0.1 in./min). Entire run took 39 sec too long. Room temperature, 23.4C; sample water temperature, 21.8C. Initial charge by Simpson meter on 15 V full scale, 85%. Final charge by Simpson meter on 15 V full scale, 79%.

†First bottle contained only three aliquots and time between aliquots for this bottle was in error.

MULTIPLE BOTTLES PER SAMPLE

Runs 9, 17, 19, and 20 (Tables 5 and 6) were set up to take four bottles, one right after the other, and then wait for a timed period before taking the next sample. This function is useful if more than one preservative is required. In runs 9 and 17, the timing was correct, and the average sample size and standard deviation were satisfactory. The time of the first sample was not correct for runs 19 and 20. This is related to the same problem as encountered with the multiplexer. A reset button that would synchronize the start may be required and proper timing would then occur after activating the main switch.

Table 5. MULTIPLE BOTTLES PER SAMPLE*

Run 9†			Run 17		
Sample	Cycle time (min)	Volume (ml)	Sample	Cycle time (min)	Volume (ml)
1		376	1	15	381
2		378	2		382
3		379	3		382
4		379	4		383
5	15	380	5	15	383
6		380	6		382
7		380	7		382
8		380	8		382
9	15	380	9	15	382
10		380	10		382
11		378	11		382
12		379	12		382
13	15	379	13	15	381
14		380	14		381
15		378	15		382
16		378	16		380
17	15	378	17	15	382
18		378	18		382
19		378	19		380
20		379	20		382
21	14.9	379	21	15	382
22		379	22		382
23		379	23		381
24		379	24		380
		$\bar{X}$ = 378.88			$\bar{X}$ = 381.67
		S_X = .992			S_X = .816

*Sampler programmed to put sample into four consecutive bottles every 15 min. Sample volume set at 400 ml.
†Room temperature, 22.4C; sample water temperature, 20.3C.

Table 6. MULTIPLE BOTTLES PER SAMPLE*

Run 19†			Run 20‡		
Sample	Cycle time (min)	Volume (ml)	Sample no.	Cycle time (min)	Volume (ml)
1	127.6	381	1	127.5	379
2		380	2		379
3		380	3		378
4		380	4		378
5	180	380	5	180	379
6		380	6		377
7		380	7		379
8		381	8		380
9	180	380	9	180	380
10		379	10		380
11		380	11		379
12		380	12		380
13	180	380	13	180	379
14		378	14		378
15		379	15		377
16		378	16		379
17	180	378	17	180	378
18		378	18		378
19		377	19		378
20		378	20		377
21	180	379	21	180	377
22		378	22		378
23		378	23		380
24		377	24		378
		$\bar{X}$ = 379.13			$\bar{X}$ = 378.54
		S_X = 1.191			S_X = 1.021

†Room temperature, 24C
Sample water temperature, 19.1C.

‡Room temperature, 22.3C
Sample water temperature, 19.1C.

*Sampler programmed to sample into four consecutive bottles every 180 min. Sample volume set at 400 ml.

BATTERY OPERATION AND ENDURANCE

Tables 4 and 7 show the results of runs 26 and 27, which were made at room temperature (approximately 23.5C). The sampler was programmed to take four aliquots into each bottle at 15-min intervals. The fact that the first aliquot was skipped in runs 26 and 27, as mentioned earlier, was a problem of reset and was not the fault of the battery. These runs were started with a new YUASA model 12N12A-4A, 12-volt battery that was charged for over 20 hr with YUASA's 500 ma charger. Gassing was seen in the battery electrolyte before the charger was removed. Therefore the battery was assumed to be fully charged. Initial charge was read at 85 percent on the 15-volt scale (12.75 volts) of a Simpson Model 379 battery tester.

Table 7. TIMED MULTIPLEXER OPERATION AND BATTERY ENDURANCE (RUN 27)*

Sample	Time (min) Aliquot 1	Aliquot 2	Aliquot 3	Aliquot 4	Sample total	Volume (ml)
1	--	15	15	15	45	245
2	15	15	15	15	60	333
3	15	15	15	15	60	329
4	15	15	15	15	60	330
5	15	15	15	15	60	330
6	15	15	15	15	60	330
7	15	15	15	15	60	330
8	15	15	15	15	60	331
9	15	15	15	15	60	332
10	15	15	15	15	60	333
11	15	15	15	15	60	336
12	15	15	15	15	60	333
13	15	15	15	15	60	339
14	15	15	15	15	60†	500‡
15	15	15	15	15	60	
16	15	15	15	15	60	
17	15	15X				
18						
19						
20						
21						
22						
23						
24						

*Sampler programmed to collect four 100-ml aliquots/bottle at 15-min intervals. Slight variations in the intervals were not detectable because recorder chart speed was too slow (0.1 in./min). Timing error was a little more than 1 sec/bottle. Room temperature, 23.7; sample water temperature, 22.4C. Initial charge by Simpson meter on 15 V full scale, 79%. Final charge by Simpson meter 15 V full scale, 18%.
†Failed to step to next bottle.
‡Overflowing.
XTimer continued to function accurately to this point.

Run 26 was completed and the battery failed while bottle 14 of run 27 was receiving a sample. When battery power is low the unit fails to index, therefore this bottle overflowed, but the timer continued to function for a few more cycles. Final charge, as read by the Simpson meter, was 18 percent of 15 volts or 2.7 volts. The total number of accurate samples collected was 146. Since the maximum setting on the sampler is five samples/bottle for 24 bottles or 120 samples, a freshly charged battery has enough power for one run of the most severe type at normal temperatures.

Manning Corporation noted that its tests averaged 170 samples at room temperature and 140 samples at 0.5C. Run 38 (Table 8) shows that battery power was sufficient to complete a similar type run at 31.5C. Initial and final battery voltage (as read by the Simpson Tester) was 85 percent and 79 percent for 12.75 and 11.85 volts, respectively. Low temperature is usually the most severe condition for batteries, and run 44 (Table 9) was made at 2C. Initial and final charge and specific gravity of battery electrolyte are included in Table 9. The battery's power was satisfactory during this run, but the specific gravity of its electrolyte at the end of this run was only 1.15 to 1.16. It would be undesirable to run the sampler much longer than this because voltage would start to drop off rapidly.[2]

Table 8. BATTERY ENDURANCE (RUN 38)*

Sample	Time (min) Aliquot 1	Aliquot 2	Aliquot 3	Aliquot 4	Sample total	Volume (ml)
1	--	15	15	15	45	315
2	15	15	15	15	60	422
3	15	15	15	15	60	422
4	15	15	15	15	60	421
5	15	15	15	15	60	422
6	15	15	15	15	60	421
7	15	15	15	15	60	422
8	15	15	15	15	60	423
9	15	15	15	15	60	423
10	15	15	15	15	60	425
11	15	15	15	15	60	424
12	15	15	15	15	60	424
13	15	15	15	15	60	424
14	15	15	15	15	60	423
15	15	15	15	15	60	421
16	15	15	15	15	60	422
17	15	15	15	15	60	424
18	15	15	15	15	60	425
19	15	15	15	15	60	424
20	15	15	15	15	60	423
21	15	15	15	15	60	424
22	15	15	15	15	60	428
23	15	15	15	15	60	425
24	15	15	15	15	60	425

*Sampler programmed to collect four 125-ml aliquots/bottle at 15 min intervals. Slight variations in the intervals were not detectable because recorder chart speed was too slow (0.1 in./min). Entire run took 0.5 min too long. Chamber temperature, 31.5C. Started run with new battery. Initial charge by Simpson meter on 15 V full scale, 85%; final charge by Simpson meter on 15 V full scale, 79%.

Table 9. BATTERY ENDURANCE (RUN 44)*

Sample	Aliquot 1	Aliquot 2	Time (min) Aliquot 3	Aliquot 4	Sample total	Volume (ml)
1	15	15	15	15	60	486
2	15	15	15	15	60	485
3	15	15	15	15	60	485
4	15	15	15	15	60	485
5	15	15	15	15	60	485
6	15	15	15	15	60	488
7	15	15	15	15	60	485
8	15	15	15	15	60	486
9	15	15	15	15	60	485
10	15	15	15	15	60	486
11	15	15	15	15	60	487
12	15	15	15	15	60	486
13	15	15	15	15	60	485
14	15	15	15	15	60	487
15	15	15	15	15	60	487
16	15	15	15	15	60	487
17	15	15	15	15	60	484
18	15	15	15	15	60	487
19	15	15	15	15	60	489
20	15	15	15	15	60	488
21	15	15	15	15	60	488
22	15	15	15	15	60	478
23	15	15	15	15	60	489
24	15	15	15	15	60	488

*Sampler programmed to collect four aliquots/bottle at 15-min intervals. Slight variations in the intervals were not detectable because recorder chart speed was too slow (0.1 in./min). Entire run took about 0.5 min too long. Chamber temperature, 2C. Initial charge by Simpson meter on 15 V full scale, 86%; final charge by Simpson meter on 15 V full scale, 78%.
Specific gravity of electrolyte in cells:

Start run	1.29	1.27	1.27	1.27	1.30	1.29
End run	--	1.16	1.16	1.16	1.15	--

Level of electrolyte in first and last cells was too low to draw sample.

The specific gravities taken after runs 41, 42, and 43 (Table 10) show that the battery has more than enough power for the usual type of run when multiplexing is not used.

Table 10. SAMPLES ICED AND BATTERY ENDURANCE*

Sample	Run 41		Run 42		Run 43	
	Cycle time (min)	Volume (ml)	Cycle time (min)	Volume (ml)	Cycle time (min)	Volume (ml)
1	60	410	60	413	60	412
2	60	415	60	413	60	415
3	60	415	60	413	60	415
4	60	416	60	415	60	414
5	60	415	60	414	60	415
6	60	410	60	415	60	415
7	60	415	60	414	60	414
8	60	415	60	415	60	414
9	60	415	60	415	60	415
10	60	415	60	415	60	415
11	60	415	60	415	60	415
12	60	415	60	415	60	415
13	60	415	60	414	60	415
14	60	414	60	404	61	413
15	60	415	60	414	60	414
16	60	415	60	414	60	413
17	60	415	60	415	60	412
18	60	415	60	415	60	414
19	60	415	60	414	60	413
20	60	415	60	412	60	413
21	60	415	60	415	60	413
22	60	415	60	414	60	415
23	60	415	60	414	60	†
24	60	416	60	413	60	†
	$\bar{X}$ = 414.6		$\bar{X}$ = 413		$\bar{X}$ = 414.05	
	S_X = 1.469		S_X = 2.25		S_X = 1.046	

*Slight variation in cycle time was not detectable because recorder chart speed was too slow (0.1 in./min). Each run took approximately 0.6 min too long. Temperatures for runs 41, 42, and 43 were 35, 35, and 20C, respectively.
†Turned off intentionally.

Specific gravity of battery electrolyte:

Start	End	Start	End	Start	End
1.26	1.20	1.27	1.21		1.25
1.26	1.21	1.27	1.21	No	1.25
1.26	1.21	1.27	1.22	data	1.25
1.26	1.15	1.27	1.23		1.21
1.26	1.21	1.27	1.22		1.25
1.26	1.23	1.27	1.21		1.25

In summary, battery power was sufficient for the most severe run that could be made with this sampler. If batteries are charged before each run and checked with a hydrometer, there should be no problem.

SAMPLE PRESERVATION WITH ICE

Manning's sample bottle tub has space for ice in the center, and the outer surface is made of an insulating material. The purpose of these runs was to determine the temperature of the iced samples and the length of time that they remain cold. EPA methods[1] require a preservation temperature of 4C for some parameters. The tests were run as mentioned in Section IV of the report. Thermocouples were located in bottles 1, 2, 7, 8, 13, 14, 19, and 20, as shown in Figure 5. Figures 8 and 9 are plots of sample temperature versus time for 35C environmental chamber runs. Figure 8 shows the results of a run in which the center of the tub was packed with ice and cold water was poured over the ice so that the lower portion of the sample bottles were immersed in ice water. Figure 9 gives the results of a run in which only ice was packed into the center compartment. Figure 8 shows that the temperature of samples 1 and 2 dropped rapidly after the sample was taken and reached a minimum point (10C) after 5 hr. Figure 9 shows that it took 7 hr for samples 1 and 2 to reach a minimum point of only 14.5C. In summary, these graphs show that it is best to have the bottles partially submerged in ice water for better heat transfer. A larger compartment with more ice is also required if the sample is to reach 4C and remain there for 24 hr. Better insulation may also be needed.

Figure 10 depicts the results of an environmental chamber run at 21.5C. This run was made with the center compartment filled with ice and cold water covered the lower portion of the sample bottles. The temperature of samples 1 and 2 dropped to 9.2C and then rose as the ice melted. The first dip in the curve (i.e., sample 1 going from 14.2 to 14.5) show that the temperature of the sample rose slightly as the bottle next to it was filled. Bottles within the sampler are shaped to fit tightly together as shown in Figure 1a. Better heat transfer would be obtained if a little space were left between the bottles to accommodate ice water.

FIELD TESTS

Dependability

The sampler was taken to a small wastewater treatment plant at Perintown, Ohio, and tested for ability to collect a representative sample and ability to run dependably and without clogging for a 24-hr period. Figure 6, a flow diagram of the plant, shows sampler locations.

Dependability investigations were made by running the sampler for 24-hr periods at locations A and C. Controls were set to collect samples at 1-hr intervals, and the center compartment was packed with ice. Freshly charged batteries were used during both tests, the results of which are shown in Tables 11 and 12. The sampler ran throughout the 24-hr period, samples were collected at 60-min intervals, and no samples were missed. Table 12 shows that the volume variation for effluent samples was not

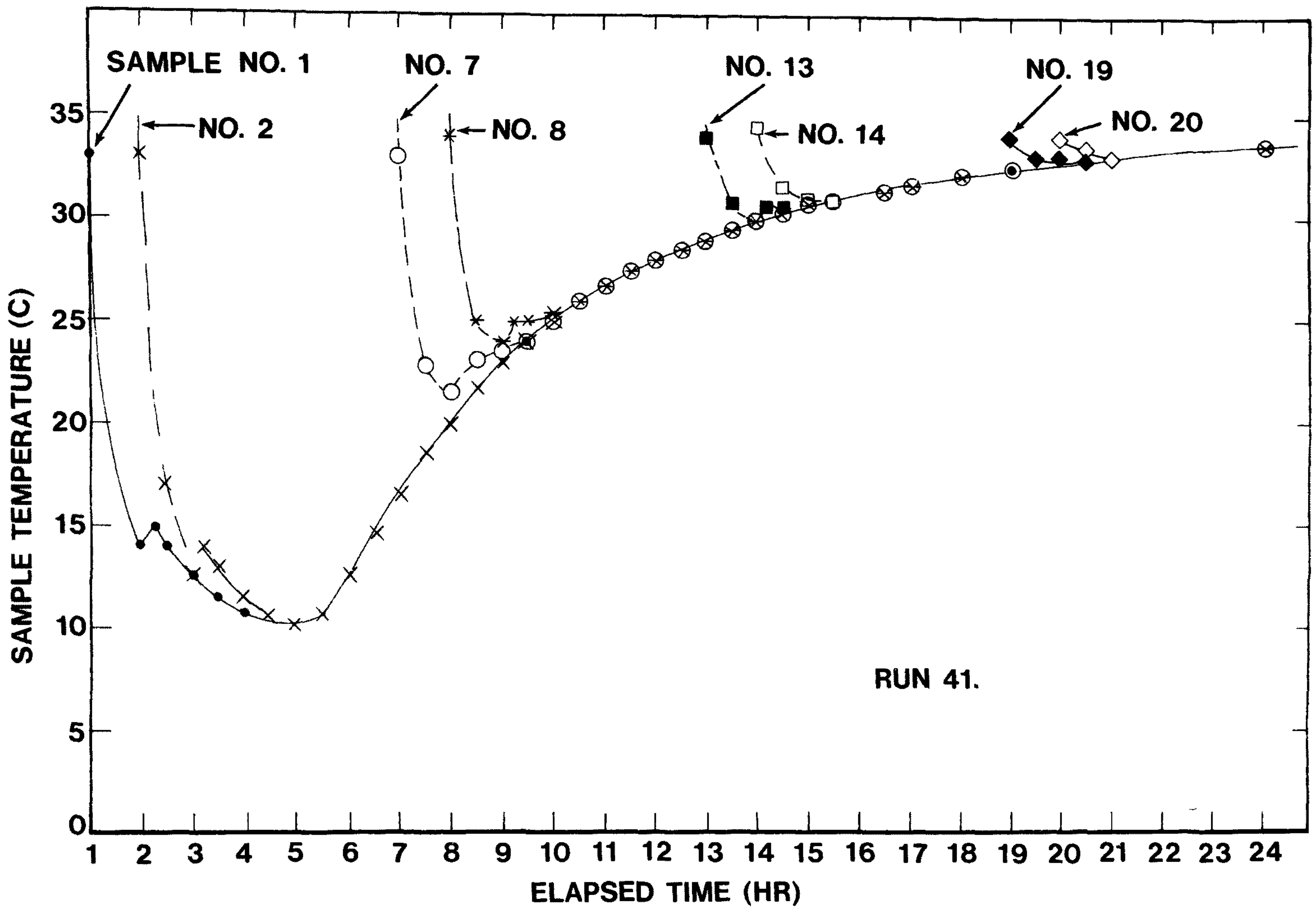


FIGURE 8. Discrete sample temperature versus time (chamber temperature at 35C) additional water poured over ice so that lower part of sample bottles were in ice water.

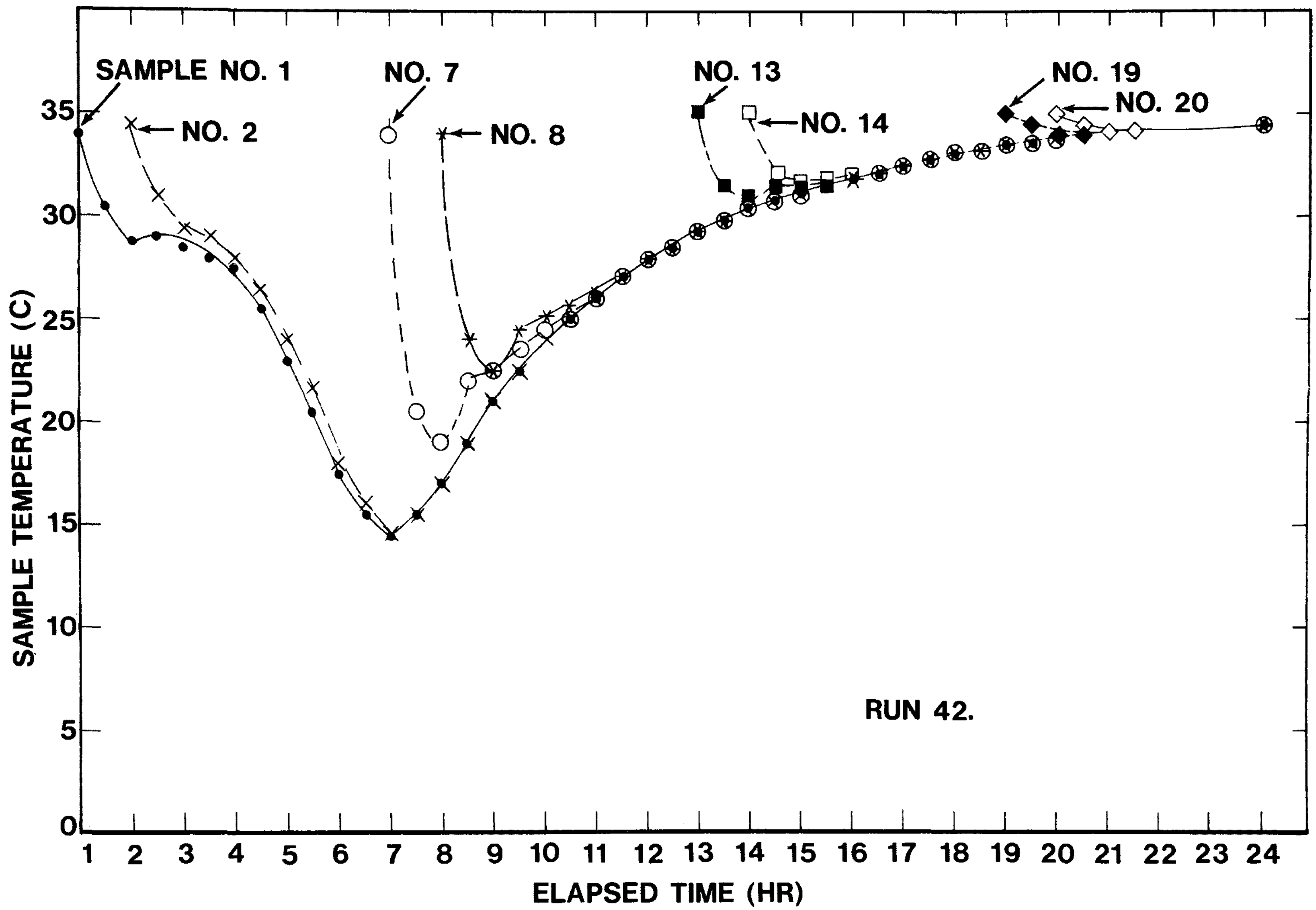


FIGURE 9. Discrete sample temperature versus time (chamber temperature at 35C) no additional water poured over ice or around bottles.

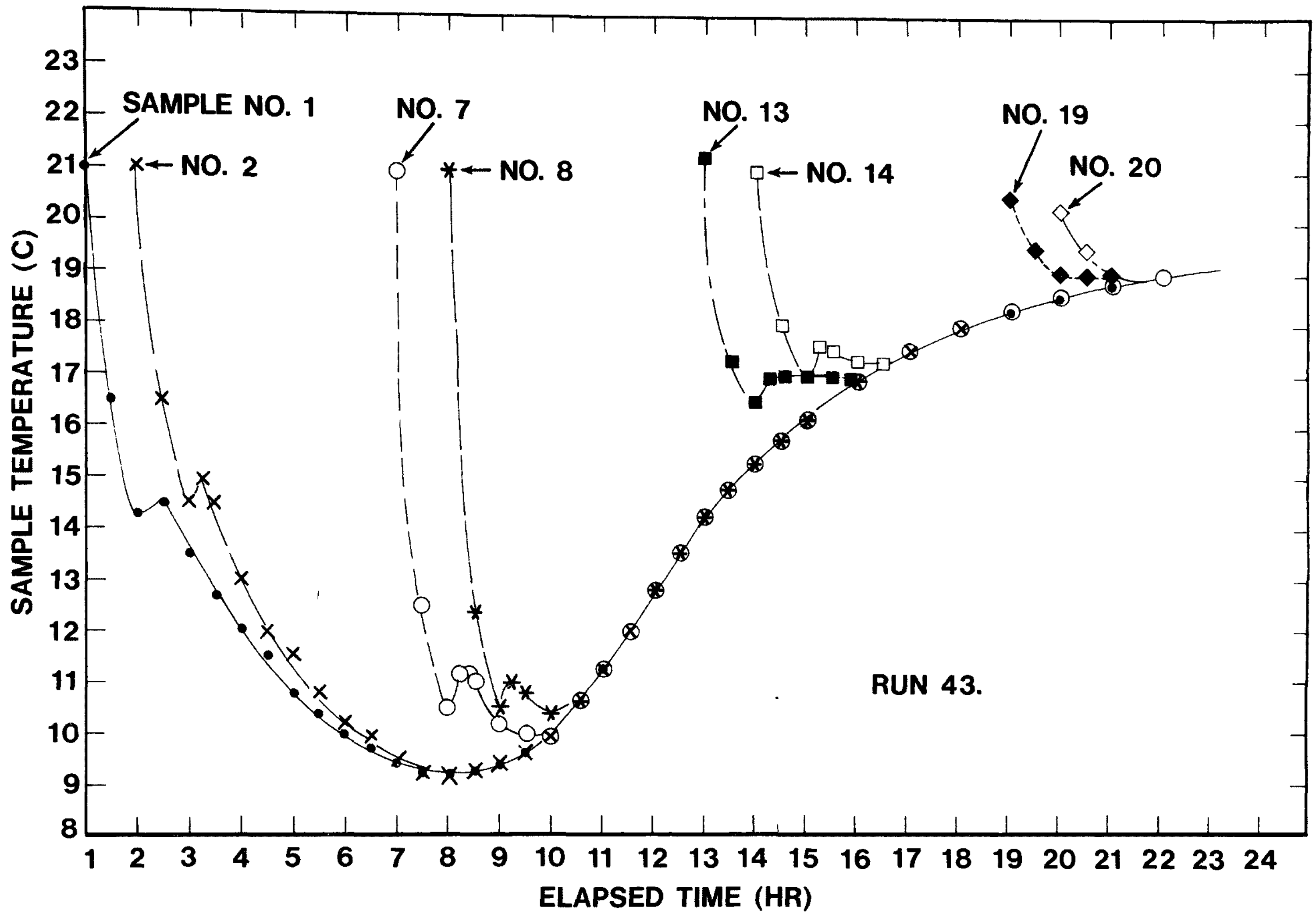


FIGURE 10. Discrete sample temperature versus time (chamber temperature at 21.5C) additional water poured over ice so that lower part of sample bottles were in ice water

significant (S_X = 1.76 ml, range 405 to 410 ml). Volume variation for the influent samples (Table 11) was more significant (S_X = 7.79, range = 361 to 408 ml). The most variation occurred on the first two samples, and the volumes of the third through 24th bottles were more precise. The quantity of sample collected in all bottles was satisfactory for analysis. Precise volumes are important for composite and flow-proportional samples.

All ice was melted in the center of the sampler before the runs were completed, and the final temperature in both runs was about 12.5C. Maximum ambient temperature for both runs was only 27.5C, therefore better cooling of samples is required.

Sample Representativeness

These tests were made as described in Section IV. Figure 7 shows the method of collecting simultaneous samples for comparison of Manning to isokinetic. Comparison samples were analyzed for NFS and TOC. Influent and effluent results are given in Tables 13 and 14. A statistical T-test[3] was used to determine if there was a difference between isokinetic and Manning samples. Influent samples for NFS and TOC showed no significant difference at the 95 percent confidence level. Effluent samples did show a difference for TOC at the 95 percent confidence level. Observing these data in a rational manner and considering variations for NFS that have been detected during other studies[4] leads to the conclusion that there was no serious difference between isokinetic and Manning for these tests.

Table 11. DEPENDABILITY TESTS AT PERINTOWN INFLUENT

Date 1975	Approx. time	Sample	Volume (ml)	Temperature (C) air	Temperature (C) influent sewage	Remarks
11/3	10:00A	1	361	16	18	←Manual cycle. Initially, ice was placed inside sampler with about one cup of water. Lift at the influent was about 1 ft.
	11:00A	2	408	22	20	
	12:00N	3	397	25	20	
	1:00P	4	397	23.5	19.5	
	2:00P	5	398	23	19.5	
	3:00P	6	400	22.5	20	
	4:00P	7	395	20.5	20	
	5:00P	8	397			
	6:00P	9	398			
	7:00P	10	397			
	8:00P	11	393			
	9:00P	12	395			
	10:00P	13	395			
	11:00P	14	395			
	12:00M	15	395			
11/4	1:00A	16	395			
	2:00A	17	393			
	3:00A	18	396			
	4:00A	19	395			
	5:00A	20	395			
	6:00A	21	395			
	7:00A	22	395			
	8:00A	23	393			
	9:00A	24	394	15.5	17	
		$\bar{X}$ =	394.7			
		S_X =	7.79			
		$\bar{X}$ =	396.1			First sample omitted from calculation.
		S_X =	3.11			
		$\bar{X}$ =	395.6			First and second samples omitted from calculation.
		S_X =	1.69			

The following temperatures were taken when the sample was collected at 9:00A on 11/4/75.

Sample no.	Temperature C	
1	12.5	
16	12.5	
24	15.5	
Cold water in center of sampler	13	No ice was remaining.

Table 12. DEPENDABILITY TESTS AT PERINTOWN EFFLUENT

Date 1975	Approx. time	Sample	Volume (ml)	Temperature (C) air	Temperature (C) effluent sewage	Remarks
11/5	8:48A	1	405	14.5	17	← Manual cycle. Initially, ice was placed inside sampler with about one cup of water. Lift at the effluent was about 6 ft.
	9:48A	2	408	20	18	
	10:48A	3	408	23	19	
	11:48A	4	410	25.5	19	
	12:48P	5	408	27.5	19	
	1:48P	6	410	27.5	19	
	2:48P	7	410	25	19	
	3:48P	8	408	23	19	
	4:48P	9	407			
	5:48P	10	406			
	6:48P	11	407			
	7:48P	12	405			
	8:48P	13	408			
	9:48P	14	407			
	10:48P	15	405			
	11:48P	16	405			
11/6	12:48A	17	405			
	1:48A	18	405			
	2:48A	19	405			
	3:48A	20	405			
	4:48A	21	405			
	5:48A	22	405			
	6:48A	23	407			
	7:48A	24	406	10	11.5	

$\bar{X} = 406.7$
$S_X = 1.76$

The following temperatures were taken when the sample was collected at 9:00A on 11/6/75.

Sample no.	Temperature C
1	12
6	12
12	12
18	12
24	12.5

Cold water in center of sampler 12.5 No ice was remaining

Table 13. SAMPLE REPRESENTATIVENESS AT PERINTOWN INFLUENT

Sample	Total nonfilterable solids (mg/l)			Total organic carbon (mg/l)		
	Isokinetic	Manning	Diff(d)	Isokinetic	Manning	Diff(d)
1	89.4	96.3	-6.9	165.4	160.9	4.5
2	147.0	138.0	9.0	167.5	173.7	-6.2
3	162.2	143.0	19.2	190.1	189.7	0.4
4	170.9	151.7	19.2	196.0	186.6	9.4
5	174.7	152.5	22.2	200.2	216.3	-16.1
6	154.1	158.8	-4.7	195.5	234.3	-38.8
7	203.4	199.9	3.5	204.2	220.2	-16.0
8	195.6	202.3	-6.7	223.7	215.7	8.0
9	185.9	191.0	-5.1	251.3	237.6	13.7
10	151.9	153.5	-1.6	204.2	195.8	8.4
11	141.1	142.5	-1.4	206.8	178.3	28.5
12	147.4	150.0	-2.6	203.9	184.9	19.0
			$\bar{d}$ = 3.675			$\bar{d}$ = 1.23
			S_d = 10.926			S_d = 18.2

Total nonfilterable solids

H_0: $\mu_d = 0$

H_1: $\mu_d \neq 0$

$\alpha = 0.05$

Critical region: T<-2.201, T>2.201 where $T = (d - 0)/S_d/\sqrt{12}$ and ν = 11 degrees of freedom

Computations: $T = \frac{3.675\sqrt{12}}{10.926}$

$T = 1.165$

Conclusion: Accept H_0 and conclude that the Manning method of sample collection for NFS at the influent is not significantly different from isokinetic.

Total organic carbon

H_0: $\mu_d = 0$

H_1: $\mu_d \neq 0$

$\alpha = 0.05$

Critical region: T<-2.201, T>2.201 where $T = (\bar{d} - 0)/S_d/\sqrt{12}$

ν = 11 degrees of freedom

Computation: $T = \frac{1.23\sqrt{12}}{18.2}$

$T = 0.234$

Conclusion: Accept H_0 and conclude that the Manning method of sample collection for TOC at the influent is not significantly different from isokinetic.

Table 14. SAMPLE REPRESENTATIVENESS AT PERINTOWN EFFLUENT

Sample no.	Total nonfilterable solids (mg/l)			Total organic carbon (mg/l)		
	Isokinetic	Manning	Diff(d)	Isokinetic	Manning	Diff(d)
13	4.9	4.2	0.7	81.7	75.6	6.1
14	4.7	4.3	0.4	83.8	81.4	2.4
15	5.0	4.6	0.4	84.7	82.3	2.4
16	4.5	4.8	-0.3	83.8	85.9	-2.1
17	6.3	6.0	0.3	85.6	81.4	4.2
18	6.6	---	---	84.4	----	---
19	5.3	5.9	-0.4	85.3	82.0	3.3
20	5.3	5.3	0.0	85.0	83.8	1.2
21	5.4	5.0	0.4	81.2	79.1	2.1
22	4.6	5.7	-1.1	85.0	82.9	2.1
23	6.1	5.5	0.6	83.2	84.7	-1.5
24	5.1	5.6	-0.5	85.0	84.4	0.6
			$\bar{d} = 0.045$			$\bar{d} = 1.89$
			$S_d = 0.557$			$S_d = 2.35$

Total nonfilterable solids:

H_0: $\mu_d = 0$

H_1: $\mu_d \neq 0$

$\alpha = 0.05$

Critical region: T<-2.228, T>2.228 where $T = (\bar{d} - 0)/S_d/\sqrt{11}$ and $\nu = 10$ degrees of freedom

Computations: $T = \frac{0.45\sqrt{11}}{.557}$

$T = 0.268$

Conclusion: Accept H_0 and conclude that the Manning method of sample collection for NFS at the effluent is not significantly different from isokinetic.

Total organic carbon:

H_0: $\mu_d = 0$

H_1: $\mu_d \neq 0$

$\alpha = 0.05$

Critical region: T<-2.228, T>2.228 where $T = (\bar{d} - 0)/S_d/\sqrt{11}$ and $\nu = 10$ degrees of freedom

Computations: $T = \frac{1.89\sqrt{11}}{2.35}$

$T = 2.667$

Conclusion: Reject H_0 and conclude that the Manning method of sample collection for TOC at the effluent is different from isokinetic.

SECTION 6

RESULTS OF PERFORMANCE TESTS OF THE F-3000 FLOWMETER

TRACKING

The ability of the liquid level dial to track head accurately and precisely is important because this dial is used in calibration. Tracking tests were made with the aid of a vernier height gage and either a small beaker of water or an aluminum plate attached to the slide of the height gage (Figure 4b). The liquid level dial was read as accurately as possible but, since graduations were marked only every 1/4 in. and 1/2 cm, it was impossible to read the dial as precisely as the vernier (0.001 in.). Table 15 gives the results of static tests made within an environmental chamber at 2 and 35C. The liquid level dial followed changes in the vernier height gage satisfactorily, and no significant difference due to temperature change was detected. Readings shown in Table 15, such as 17.95 for the level dial versus 18 for the height gage during run 72, mean that the level dial was just a little low, since the 1/4 in. graduations made it impossible to read as close as 17.95. Graduations on the level dial of 0.1 in. and 0.2 cm would be more acceptable. Table 15 also shows that the percent flow dial was always a little higher than the chart, and better agreement is required. Also some backlash or deadband is indicated in Table 15 for the percent flow dial and this will be explained later.

Table 16 shows a test in which the dipper was made to follow an ascending and decending height gage, and satisfactory agreement was obtained.

Table 17 illustrates another tracking test and no serious difference was detected.

In summary, tracking is satisfactory, but graduations on the "level dial" should be at least 0.1 in. and 0.2 cm. Also the percent flow dial has numbers every 5 percent but no graduations. Graduations should be included for every 1 percent of flow. Graduations on the percent flow chart should be at least every 5 percent instead of every 10 percent. Also the time markings on the chart paper are not properly synchronized with the pen arm (error is about 15 min for an instantaneous full scale swing on the chart). There is an adjustment for length of the pen arm, but this is not adequate; the pivot point needs to be relocated slightly.

Table 15. HEAD-TRACKING ABILITY OF THE F-3000 FLOWMETER* AT 2 AND 35C

Run	Temperature (C)	Vernier height gage (in.)	Liquid level dial (in.)	Flow dial (%)	Chart (%)
72	2	5	5	2	0
		9	9	7.5	6
		12	12	15	13
		15	15	27	24
		18	17.95	44	41
		21	21	67	63
		23	23.05	82	80
		5	5	2	1
73	35	5	5	2	0
		9	9	7.5	6
		12	12.05	13	12
		15	15.03	25	23
		18	18	42	41
		21	21.05	66.5	65
		23	23.05	--	--
		5	5.05	2.5	1
		23	23.08	86	82.5
		5	5.05	2.5	1
74	2	5	5.05	2.5	1
		9	9.05	5.5	5
		12	12.05	13	12
		15	15.05	27.5	25
		18	18	41	39
		21	21.05	67.5	64
		23	23.08	83	82
		5	5.05	2.5	1

*Calibrated with flow dial at 100% and liquid level dial at 24 in. (V-notch weir).
Vernier height gage with dipper striking metal plate.
Liquid level dial initially set at 5 on run 72 and not reset throughout runs 72, 73, and 74.

Table 16. TRACKING (PROBE DESCENDING AND ASCENDING)*

Probe ascending		Probe descending		Probe ascending	
Vernier (in.)	Level dial (in.)	Vernier (in.)	Level dial (in.)	Vernier (in.)	Level dial (in.)
4	4	4	4	4	4
7	7	7	6.95	7	6.95
13	13	13	13	13	13.03
19	19			19	19

*Calibrated with flow dial at 100% and liquid level dial at 9 in. (flume). Vernier height gage with dipper striking water beaker. Liquid level dial initially set at 4 in. and not reset throughout run.

Table 17. TRACKING (ROOM TEMPERATURE)*

Vernier height gage (in.)	Liquid level dial (in.)
4	4
7	7
13	13.05
19	19.05

*Calibrated with flow dial at 100% and liquid level dial at 9 in. (round pipe). Vernier height gage with dipper striking water beaker. Liquid level dial initially set at 4 in. and not reset throughout run.

ANALOG TO DIGITAL CONVERSION

The analog signal from the flow rate pot (Figure 3) is integrated and fed to a digital pulse circuit that controls the totalizing counter. The object of this test was to determine if the output frequency at the counter was linearly proportional to the voltage signal from the wiper of the flow rate pot. Results are given in Table 18 and plotted in Figure 11; the latter shows that analog to digital conversion was linear. These tests were made with the flowmeter connected to the water sampler, and the sampler was connected to a recorder so that the chart gave a record of sampler cycles versus time (hence flowmeter counts versus time).

Table 18. LINEARITY OF ANALOG TO DIGITAL SIGNAL CONVERSION (RUN 97)

Date	Time	Test	Battery voltage	R101 Center tap (volts)	Cycles (min)	Probe
10/6/75	3:55	A	12.565	.291	.086	up
		B		.341	.091	↑
		C		.454	.143	
		D	12.58	.656	.197	
		E		.812	.25	
		F		1.093	.339	
		G		1.365	.435	
		H		1.733	.552	
		I	12.565	2.15	.696	
		J		2.63	.860	↓
10/6/75	5:35	K	12.565	3.10	1.013	up
10/7/75	10:30A	L		3.09	1.013	down
		M	12.56	1.76	.567	↑
		N	12.56	.841	.260	↓
		O		.342	.093	down

DRIFT

Drift Caused by Temperature Change

Tests for electronic drift caused by temperature change were made in groups of three within an environmental chamber whose temperature was set at 2, 35, and 2C. During the runs the flowmeter was connected to the sampler, which was connected to a recorder; the strip chart from this recorder gave cycles/min. All runs were made with the flowmeter on calibrate at 100 percent or in the operate position with the dipper set to 100 percent. Table 19 shows that the average variation in output due to changing temperature from 2 to 35C was 0.011 cycle/min or 1.1 percent; hence flow readings would be slightly higher at the cold temperature. Manning states that the output should be 1 cycle/min at the 100 percent setting, but the table shows that the output is slightly higher.

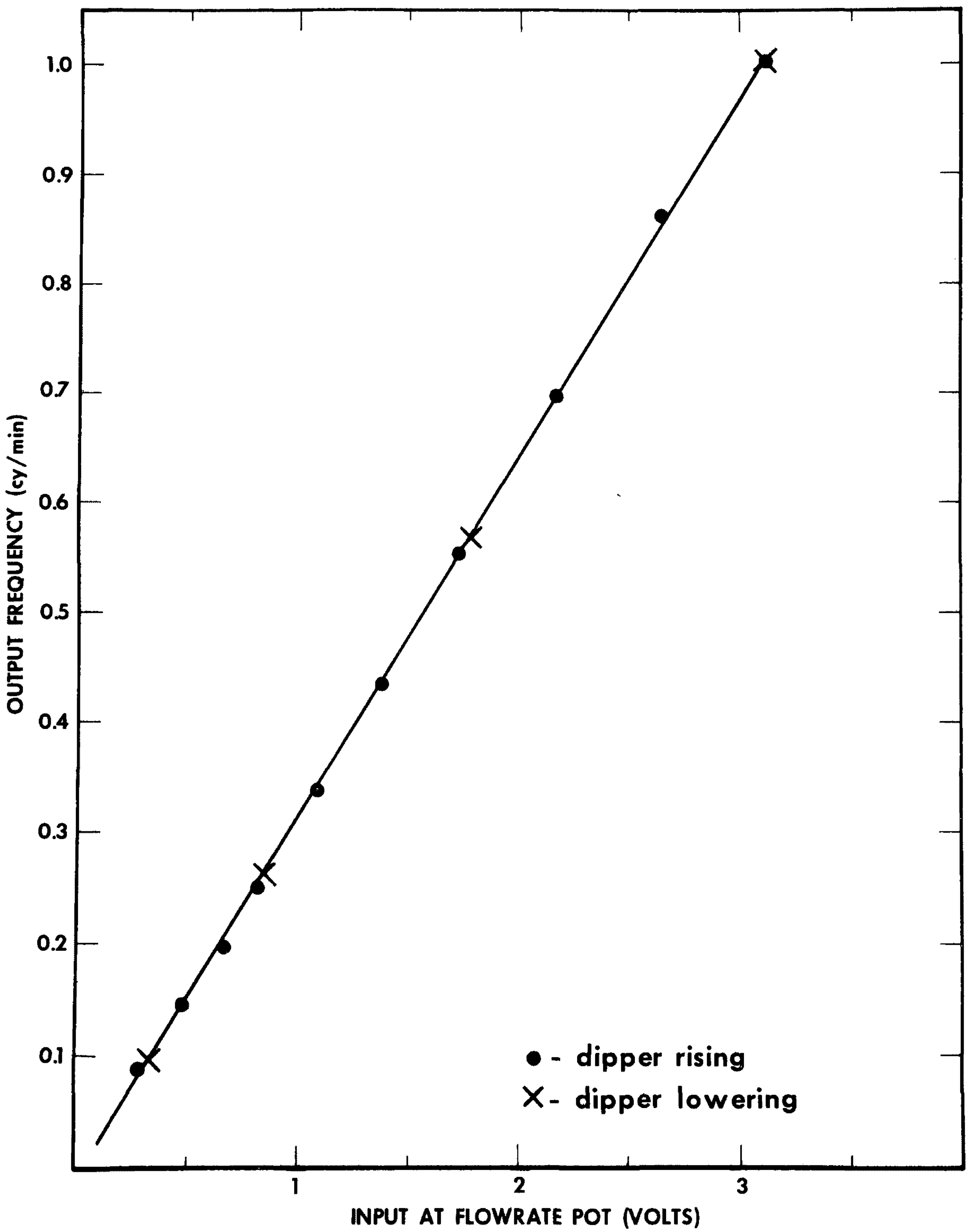


FIGURE 11. Linearity of analog to digital signal conversion

Table 19. ELECTRONIC DRIFT WITH TEMPERATURE CHANGE

Run	Temperature (C)	Cycles (min)	Range (cy/min)	Type of Operation
57	2	1.016		Circular pipe
58	35	1.01	.008	dipper at
59	2	1.018		maximum flow
60	2	1.018		Circular pipe
61	35	1.01	.012	flowmeter on
62	2	1.022		calibration
63	2	1.022		V-notch
64	35	1.009	.013	flowmeter on
65	2	1.017		calibration
66	2	1.019		Parshall flume
67	35	1.007	.013	flowmeter on
68	2	1.020		calibration
69	2	1.032		Parshall flume
70	35	1.023	.009	dipper at
71	2	1.031		maximum flow
		Average	.011	

Drift Caused by Battery Voltage Decay

A variable DC power supply was used to simulate battery decay from 12.9 to 11.5 volts. Results of these tests are plotted in Figures 12 and 13. Battery decay is represented as source voltage on the abscissa. Pin 10 to ground is the wiper of the flow rate pot (input to operational amplifier), and test point 5 to ground is the output of the operational amplifier. As mentioned earlier, this signal is integrated converted to a digital signal and displayed on a counter as total flow (represented on the ordinate as output cycles/min). Figures 12 and 13 show that the analog input at the flow rate pot (pin 10 and Test Point 5) drifted linearly downward as the source voltage decayed, however the output signal did not drift although some variability is shown in the graph. Figure 12 shows that variability of the output signal was greater at 100 percent of flow than at 50 percent flow (Figure 13). Although the output did not drift with source voltage, the output variation of 1.02 to 1.053 cycles/min (Figure 12) at the 100 percent point should be improved.

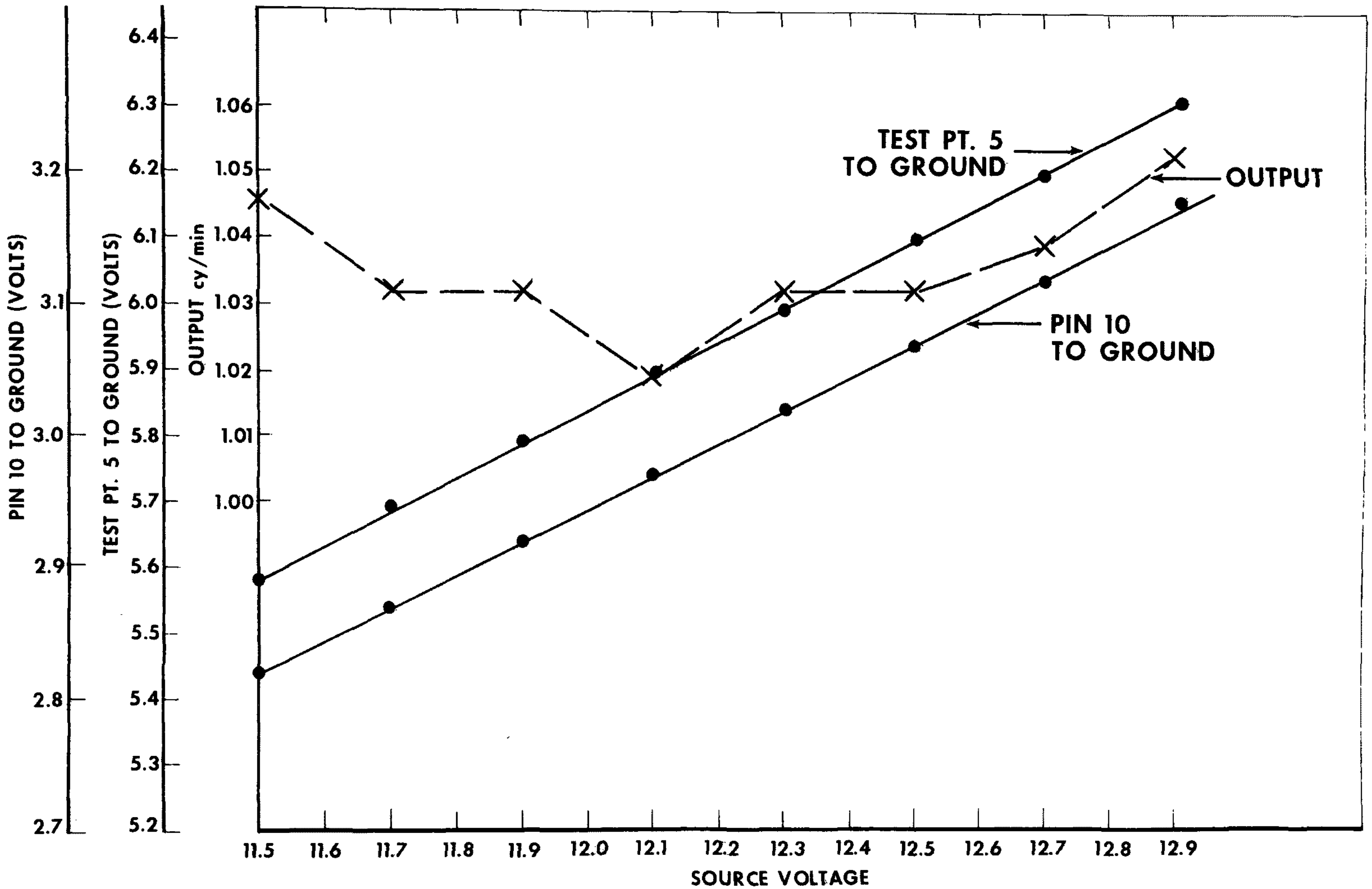


FIGURE 12. Results of source voltage change (flowmeter on calibrate at 100%)

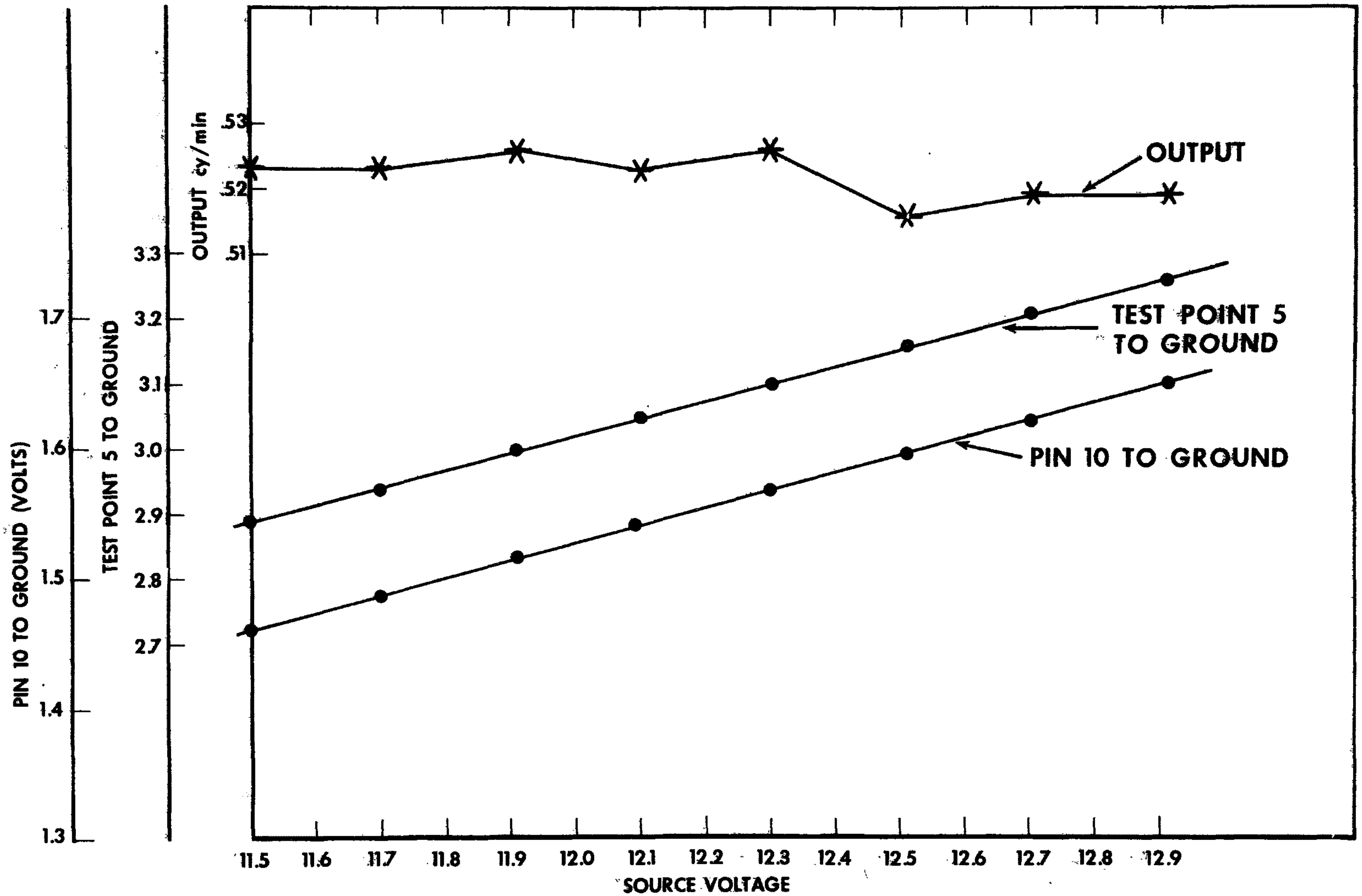


FIGURE 13. Results of source voltage change (flowmeter on calibrate at 50%)

DEADBAND (BACKLASH)

These tests were made with the flowmeter calibrated at 15 in. full scale on the $h^{5/2}$ cam. An aluminum plate was set on a stand below the dipper and connected to the negative battery terminal. When the dipper was touching the plate, the liquid level dial was set to 6 in. Readings were taken after the dipper was lowered to touch the plate, raised to touch the plate, and finally lowered to touch the plate. Results of these tests are given in Table 20. Run 94, for example, was made after the dipper descended to the 6-in. level. The center tap of the flow rate pot gave 0.391 volts. Percent flow was 9 percent on the flowmeter dial and 7.5 percent on the chart. Flow at 6-in head for a 90° V-notch weir, according to Manning's manual, is 200 gal/min (gpm). Total flow after operation for 155.6 min is 31.125 gal and 10.29 percent of maximum flow. The instrument's integrator, as read from the counter after multiplying by maximum flow (1943.3 gpm), gave 33,036.1 gal; therefore, the resulting error was 6.14 percent of reading or 0.6 percent of full scale. This same procedure was followed with the dipper ascending and gave an error of -11.63 percent of reading. Readings were taken again after the electrode had descended, and the error was 5.5 percent of reading. This error was due to deadband or backlash in the mechanical gearing of the instrument (gearing is illustrated in Figure 3). The error is most obvious from voltage readings of the flow rate pot (0.391, 0.337, 0.389). Voltage should be the same at 6 in. head, regardless of whether the dipper descends or ascends to reach its destination. Error of this type was most significant at lower flows, as shown in Table 20 by comparing percent of reading to percent of full scale. The least error was at maximum flow where percent of reading equals percent full scale (-1.2 percent to 0.6 percent). Error as percent of reading becomes progressively more significant as flow decreases (-11.63 to 6.14 at 6 in. head). Backlash in this instrument was too great and improvement is warranted. Some of this error would be eliminated if anti-backlash gears were used; the use of forms of electronic devices such as a functional amplifier or microprocessor instead of gears and cams would completely eliminate error of this type.

Table 20. DEADBAND (BACKLASH)*

Run	Battery (volts)	Flow rate pot (volts)	Liquid level dial (in)	Percent flow dial	Percent flow chart	ΔT (min)	Flow from tables (gal/min)	Total flow (gal)	Percent of max. flow	Integrator Total flow (gal)	Integrator Error % Reading	Integrator Error % Full scale
94	12.62	0.391	6↓	9	7.5	155.6	200	31,125	10.29	33036.1	6.14	0.6
95	12.59	0.337	6↑	7.5	6.5	153.9	200	30,785	10.29	27206.2	-11.63	-1.2
96	12.59	0.389	6↓	9	7	18.4	200	3,684	10.29	3886.6	5.5	0.6

*Instrument calibrated at 15 inches maximum flow for 90°V notch weir.
↓Descending electrode.
↑Ascending electrode.

OVERALL ACCURACY AND PRECISION

Overall accuracy and precision are illustrated in Tables 21, 22, and 23. These runs were made with the equipment at 2, 22, and 35C. In Table 21, for example, run 85 shows that the vernier height gage was set at 6 in. and the dipper stopped slightly above 6 in. The length of this run times the flow rate from Manning's tables gave total flow as 37,925 gal, whereas the counter read 39,331 for an error of 3.7 percent. Error as percent of full scale was 1.72 percent. The instrument dial and chart read 46 percent and 45 percent, respectively, compared to the reading from the tables of 46.5 percent. It is seen from the tables that error, as a percent of reading, was greatest at low heads and became less significant as maximum flow was approached. Most of this error, as mentioned earlier, was caused by deadband or backlash. Tables 21, 22, and 23 also show that the percent of maximum flow on the dial was usually a little lower than the reading from the tables, and the chart reading was lower than the dial. The dial and chart need to be adjusted for better accuracy. The elimination of backlash is required for better precision.

POSSIBLE THEORETICAL INACCURACY

The F-3000 flowmeter converts head into flow rate by using three cams that are machined as a function of $(h)^{3/2}$, $(h)^{5/2}$, and the Manning equation for circular pipe. Some error will exist if the equation for the specific primary device has a slightly different exponent. For example, the equation for small Parshall flumes are:

3" Parshall flume $$Q = .992H^{1.547} \quad (1)$$

6" Parshall flume $$Q = 2.06H^{1.58} \quad (2)$$

9" Parshall flume $$Q = 3.07H^{1.53} \quad (3)$$

Q = flow rate (ft^3/sec)

H = head(ft)

When Manning's $(h)^{1.5}$ cam is used for small Parshall flumes, slight error will exist. Equations for many primary devices, such as suppressed rectangular, Cipolletti and V-notch weirs, have exponents of 3/2 and 5/2. The F-3000 flowmeter is convenient for portable applications, but permanently installed instrumentation for flow measurement should follow the exact equation of the primary device.

Table 21. OVERALL ACCURACY AND PRECISION FOR CIRCULAR PIPE†

Run	Temperature (C)	Level (in)		Total flow				Percent of maximum flow		
		Vernier	Dial	Table (gal)	Counter (gal)	Error, % of Reading	Error, % of Full scale	From tables	Dial	Chart
84	2	4	4*	35,314	37,621	6.5	1.45	22.3	22	19.5
47	22	4	4	41,007	39,331	-4.1	-0.91	22.3	20	19
81	35	4	4*	35,795	37,621	5.1	1.14	22.3	22	18
85	2	6	6.05	37,925	39,331	3.7	1.72	46.5	46	45
45	22	6	6*	39,505	39,331	-0.4	-0.19	46.5	45	42
82	35	6	6	36,874	37,621	2.6	1.21	46.5	46.5	45
86	2	11.25	11.3	147,512	150,483	2	2.0	100	100	100
46	22	11.25	11.25	302,966	306,095	1	1.0	100	100	100
83	35	11.25	11.25	150,376	150,483	0.07	0.07	100	100	99

†Static tests, dipper touching beaker of water or Al plate attached to slide of vernier height gage.
*Set point.

Table 22. OVERALL ACCURACY AND PRECISION FOR 90°V-NOTCH WEIR†

Run	Temperature (C)	Level (in)		Total flow				Percent of maximum flow		
		Vernier	Dial	Table (gal)	Counter (gal)	Error, % of Reading	Error, % of Full scale	From tables	Dial	Chart
78	2	6	6*	38,535	42,753	10.9	1.12	10.3	9.5	7.5
50	22	6	6	48,402	44,696	-7.7	-0.79	10.3	7.5	7.5
75	35	6	6*	38,320	42,753	11.6	1.19	10.3	10	7.5
79	2	10	10	45,149	42,753	-5.3	-1.94	36.6	33	31.5
48	22	10	10*	92,585	87,449	-5.5	-2.01	36.6	33.5	32
76	35	10	10	43,654	40,809	-6.5	-2.38	36.6	35	31.5
80	2	15	15	86,525	89,392	3.3	3.3	100	101	100
49	22	15	15	173,129	176,840	2.1	2.1	100	102	100
77	35	15	15	83,416	85,505	2.5	2.5	100	104	101

†Static tests, dipper touching beaker of water or Al plate attached to slide of vernier height gage.
*Set point.

Table 23. OVERALL ACCURACY AND PRECISION FOR SIX-INCH PARSHALL FLUME†

Run	Temperature (C)	Level (in)		Total flow				Percent of maximum flow		
		Vernier	Dial	Table (gal)	Counter (gal)	Error, % of Reading	Error, % of Full scale	From tables	Dial	Chart
51	22	3	3*	12,825.6	13,409	4.5	0.86	19.2	18	16
52	22	6	6.1	26,797	26,235	-2.1	-1.14	54.5	52.5	50
53	22	9.01	9.05	105,266	106,689	1.4	1.14	100	101	100

†Static tests, dipper touching beaker of water or Al plate attached to slide of vernier height gage.
*Set point.

SECTION 7

DISCUSSION

The S-4000 sampler and F-3000 flowmeter are well engineered and designed. They incorporate most features that are desired in portable equipment. They are light in weight, fairly rugged and easy to handle. The sampler's design is good in that it incorporates solid state electronics. Flowmeter electronics are also solid state and include digital output circuitry. The use of some form of microelectronics within the flowmeter such as a microprocessor to eliminate cams and other mechanical components should be considered. Greater use of "plug in" components and circuits should be incorporated. A small event recorder to mark the time that the sample was taken on both time- and flow-proportional runs would be helpful. Improvements are indicated in the conclusions, and it is hoped that they will be effected.

In general, the overall design and performance of the S-4000 sampler and F-3000 flowmeter was above average when compared to other equipment of this type.

SECTION 8

REFERENCES

1. Methods Development and Quality Assurance Research Laboratory, National Environmental Research Center, Cincinnati, Ohio, "Methods for Chemical Analysis of Water and Wastes," U.S. Environmental Protection Agency, Technology Transfer, Washington, D.C., 1974.

2. Livingston, J., "Battery Application Note" 5-475, Manning Environmental Corp., Santa Cruz, Calif.

3. Walpole, R. E., and Myers, R. H., "Probability and Statistics for Engineers and Scientists," The Macmillan Company, 1972, p 244, ex 7.4.

4. Harris, D. J., and Keffer, W. J., "Wastewater Sampling Methodologies and Flow Measurement Techniques," U.S. Environmental Protection Agency, Region VII, June 1974.

SECTION 9

APPENDIX

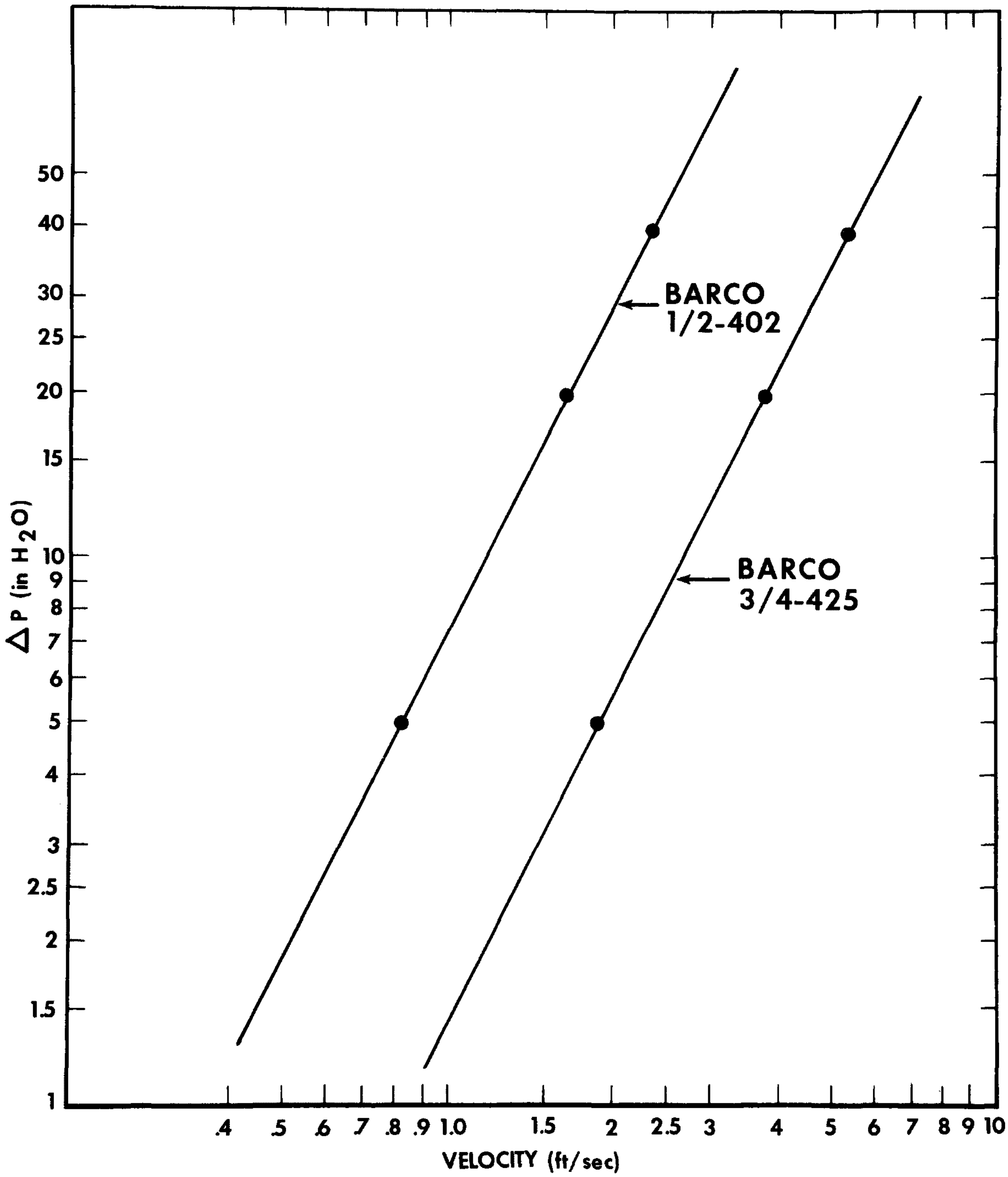


FIGURE 1. Velocity versus ΔP for 0.620 in. I.D. pipe (isokinetic sampling unit).

Table 1. ORIGINAL DATA

RUN 1, TIMED TEST*			RUN 21, TIMED TEST*		
Sample	Cycle time (min)	Volume X (ml)	Sample	Cycle time (min)	Volume X (ml)
1	manual	---	1	20.4	369
2	29.73	279	2	18.8	373
3	30	278	3	18.7	372
4	30	277	4	18.7	370
5	30	277	5	18.6	372
6	30	276	6	18.7	373
7	30	279	7	18.6	372
8	30	279	8	18.5	373
9	30	277	9	18.5	373
10	30	277	10	18.4	372
11	30	277	11	18.4	371
12	30	278	12	18.3	373
13	30	277	13	18.3	372
14	30	278	14	18.3	370
15	30	279	15	18.3	370
16	30	279	16	18.3	370
17	30	279	17	18.3	370
18	30	277	18	18.3	370
19	30	278	19	18.3	370
20	30	278	20	18.2	370
21	30	277	21	18.2	370
22	30	277	22	18.2	371
23	30	276	23	18.2	371
24	30	278	24	18.2	372
		$\bar{X} = 277.7$		$\bar{t} = 18.49$	$\bar{X} = 371.21$
		$S_X = .974$		$S_X = .448$	$S_{\bar{X}} = 1.28$

*Room temperature: 21.7C
Water temperature: 19.8C
Volume set at approximately 300 ml.

*Room temperature: 24.3C
Water Temperature: 19C
Volume set at approximately 400 ml.
Cycle time set at 30 min.
Battery start†: 86%
Battery end†: 82%
†Simpson meter 15V scale.

Table 2. ORIGINAL DATA

RUN 22, TIMED TEST*			RUN 23, TIMED TEST*		
Sample	Cycle time (min)	Volume X (ml)	Sample	Cycle time (min)	Volume X (ml)
1	9.7	376	1	60	379
2	9.2	Only first and last measured, rest approximately equal by visual inspection.	2	60.1	379
3	9.2		3	59.9	380
4	9.2		4	60.2	380
5	9.0		5	59.9	379
6	9.0		6	60.1	380
7	9.0		7	59.9	380
8	9.0		8	60.1	379
9	8.9		9	59.9	380
10	8.9		10	Approximate 60.2	380
11	8.8		11	59.9	380
12	9.0		12	60.2	380
13	8.9		13	59.8	378
14	9.0		14	60.2	379
15	9.0		15	59.9	378
16	8.9		16	60.1	377
17	9.0		17	59.9	379
18	9.0		18	60.1	380
19	9.0		19	59.9	380
20	8.9		20	60.1	381
21	8.8		21	60.0	380
22	8.8		22	60.1	380
23	8.8		23	59.9	379
24	8.9	375	24	60.2	380
	$\bar{t}$ = 8.996			$\bar{t}$ = 60.025	$\bar{X}$ = 379.46
	S_t = 0.190			S_t = 0.129	S_X = .884

*Room temperature: 22.3C
Water temperature: 19.9C
Volume set at approximately 400 ml.
Cycle time set at 15 min.
Battery start†: 90%
Battery end†: 82%
†Simpson meter 15V scale.
Controller returned for repair.

Entire run took 0.6 min too long.
*Room temperature: 23.3C
Water temperature: 23.2C
Volume set at approximately 400 ml.
Used battery and 500 ma charger.

Table 3. ORIGINAL DATA

RUN 24, TIMED TEST*			RUN 25, TIMED TEST*		
Sample	Cycle time (min)	Volume X (ml)	Sample	Cycle time (min)	Volume X (ml)
1	60	380	1	60	382
2	60	381	2	60	383
3	60	381	3	60	383
4	60	381	4	60	384
5	60	380	5	60	383
6	60	381	6	60	384
7	60	380	7	60	383
8	60	383	8	60	383
9	60	381	9	60	384
10	Approximate 60	379	10	Approximate 60	384
11	60	380	11	60	384
12	60	380	12	60	385
13	60	380	13	60	382
14	60	381	14	60	382
15	60	380	15	60	383
16	60	380	16	60	382
17	60	382	17	60	383
18	60	380	18	60	382
19	60	380	19	60	383
20	60	380	20	60	383
21	60	380	21	60	381
22	60	381	22	60	381
23	60	380	23	60	382
24	60	381	24	60	383
		$\bar{X}$ = 380.5			$\bar{X}$ = 382.9
		S_X = 0.843			S_X = 0.992

Run 24:

Entire run took 0.6 min too long.
*Room temperature: 22.8C
Water temperature: 21.6C
Volume set at approximately 400 ml.
Used battery and 500 ma charger.

Run 25:

Entire run took 0.6 min too long.
*Room temperature: 21.3C
Water temperature: 22.8C
Volume set at approximately 400 ml.

Table 4. ORIGINAL DATA

RUN 32, TIMED TEST*			RUN 33, TIMED TEST*		
Sample	Cycle time (min) Approximate	Volume X (ml)	Sample	Cycle time (min)	Volume X (ml)
1	30	387	1	60.000	384
2	30	390	2	60.013	384
3	30	390	3	60.025	386
4	30	388	4	60.013	386
5	30	388	5	60.063	386
6	30	388	6	60.038	384
7	30	387	7	60.013	384
8	30	388	8	60.025	384
9	30	388	9	60.038	385
10	30	388	10	60.025	384
11	30	387	11	60.025	384
12	30	386	12	60.025	385
13	30	387	13	60.025	384
14	30	388	14	60.025	385
15	30	385	15	60.025	384
16	30	388	16	60.038	384
17	30	386	17	60.025	385
18	30	387	18	60.025	384
19	30	387	19	60.000	385
20	30	387	20	60.025	385
21	30	387	21	60.013	385
22	30	388	22	60.013	384
23	30	387	23	60.038	385
24	30	387	24	60.000	384
		$\bar{X}$ = 387.5		$\bar{t}$ = 60.023	X = 384.6
		S_X = 1.103		S_t = 0.014	S_X = 0.717

Entire run took 0.3 min too long.
*Chamber temperature: 2C
Water temperature: 13C
Volume set at approximately 400 ml.
Battery start†: 84%
Battery end†: 80%
†Simpson meter 15V scale.

Entire run took 0.55 min too long.
*Chamber temperature: 2C
Water temperature: 3C
Volume set at approximately 400 ml.
Used Honeywell recorder.
Chart speed: 0.8 in./min.

Table 5. ORIGINAL DATA

RUN 34, TIMED TEST*			RUN 35, TIMED TEST*		
Sample	Iced cycle time (min)	Volume X (ml)	Sample	Iced cycle time (min)	Volume X (ml)
1	60	383	1	60	380
2	60	386	2	60	378
3	60	384	3	60	380
4	60	386	4	60	380
5	60	510†	5	60	380
6	60	Bottles floated up and kept spout from stepping to next bottle.	6	60	381
7	60		7	60	380
8	60		8	60	380
9	60		9	60	380
10	Approximate 60		10	Approximate 60	379
11	60		11	60	381
12	60		12	60	380
13	60		13	60	380
14	60		14	60	380
15	60		15	60	380
16	60		16	60	380
17	60		17	60	379
18	60		18	60	379
19	60		19	60	380
20	60		20	60	380
21	60		21	60	380
22	60		22	60	381
23	60		23	60	380
24	60		24	60	381

$\bar{X} = 380$

$S_X = 0.69$

Entire run took 0.5 min too long.
*Chamber temperature: 21C
Water Temperature: 20C
†Overflowing
Battery start‡: 85%
Battery end‡: 82%
‡Simpson meter 15V scale.

Entire run took 0.7 min too long.
*Chamber temperature: 21.9C
Water temperature: 20C
Volume set at approximately 400 ml.

Table 6. ORIGINAL DATA

RUN 36, TIMED TEST*

Sample	Iced cycle time (min)	Volume X (ml)
1	60	382
2	60	383
3	60	384
4	60	383
5	60	384
6	60	383
7	60	383
8	60	384
9	60	384
10	60	385
11	60	385
12	60	384
13	60	384
14	60	384
15	60	384
16	60	384
17	60	383
18	60	383
19	60	383
20	60	383
21	60	383
22	60	385
23	60	385
24	60	385
		$\bar{X}$ = 383.8
		S_X = 0.85

Entire run took approximately 0.5 min too long.

*Chamber temperature: 31C

Water temperature: 32C

Volume set at approximately 400 ml.

Battery start†: 84%

Battery end†: 83%

†Simpson meter 15V scale.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/4-76-059	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE PERFORMANCE INVESTIGATION OF THE MANNING MODEL S-4000 PORTABLE WASTEWATER SAMPLER AND THE MODEL F-3000 DIPPER FLOWMETER		5. REPORT DATE December 1976 (Issuing Date)
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Richard P. Lauch		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Environmental Monitoring and Support Lab. - Cin., OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268		10. PROGRAM ELEMENT NO. 1HD621
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Same as above		13. TYPE OF REPORT AND PERIOD COVERED In-House
		14. SPONSORING AGENCY CODE EPA/600/06
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

Performance of the Manning model S-4000 wastewater sampler and the model F-3000 flowmeter was investigated.

The S-4000 wastewater sampler was tested at temperatures of 2, 20, and 35C to determine accuracy and precision of the timer and sample volumes. The multiplexer function of delivering multiple aliquots per bottle was tested. Tests for ability to fill up to four bottles with the same sample were made. Battery endurance was determined. Discrete sample temperatures versus time were recorded under iced conditions to determine preservation capability. Field tests were performed to determine representative collection of suspended solids and ability of the unattended sampler to collect raw sewage samples over a 24-hour period.

The F-3000 flowmeter was tested within the laboratory for accuracy and precision of tracking, analog to digital conversion, deadband, and electronic drift caused by temperature change and battery decay. Accuracy of the flow chart and integrator was determined.

Manufacturer's claims were mostly confirmed, however improvement is warranted for some functions of the sampler and flowmeter.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Samplers, Water Pollution, Acceptance sampling, Continuous sampling, Data sampling, Sequential sampling, Flowmeters.	Sampler evaluation, Evaluation, Sewer sampler evaluation, Effluent sampler evaluation, Water sampler evaluation, Water sampler.	13B

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES 62
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (9-73)

☆U.S. GOVERNMENT PRINTING OFFICE: 1977—757-056/5547