RESULTS OF QUALIFICATION TESTS ON WATER-LEVEL SENSING INSTRUMENTS

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U.S. GEOLOGICAL SURVEY

Open-File Report 85-199

NSTL, Mississippi 1985

UNITED STATES DEPARTMENT OF THE INTERIOR

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ABSTRACT

This report has been prepared to communicate to the users of hydrological instrumentation and the U.S. Geological Survey procurement personnel a list of instruments that have met or exceeded the Survey's minimum performance requirements. The Hydrologic Instrumentation Facility (HIF) at National Space Technology Laboratories, Mississippi conducted qualification tests on seven instrument systems. The data collected are summarized and a brief description is given for each of the five systems that met the performance requirements. As a result of these test results, these systems have been included on the Survey's "Qualified Products List" (QPL), which will be used for future procurements of water-level sensing systems.

INTRODUCTION

The U. S. Geological Survey conducts a nationwide program of water resources surveys, investigations, and research. Over the years the need for streamflow and ground-water-level information has led the Survey to establish countrywide thousands of gaging stations on rivers, canals, streams, lakes, and reservoirs, and observation well sites. Various methods of automatically measuring water-surface elevation or stage are available, the most common of which features the use of floats and manometers. Stage is sensed, for automatic recording, either by a float in a stilling well, or by a gas-purge system that transmits the pressure head of water in a stream to a manometer. The latter system, which does not require a stilling well, is known as a bubble gage (Rantz, 1982).

A number of hydrologic instrumentation manufacturers have developed a variety of new systems to sense the water level and record its stage. One model each of six new systems and a STACOM manometer were tested at the HIF during the period June 1983 to September 1984. The test purpose was to determine whether each system could meet the Survey's minimum performance requirements for the collection of stage data (Buchanan, 1968; Kennedy, 1983; and Rapp, 1982). This report presents a summary of the data collected during the qualification tests and describes each of the five systems that qualified.

Under the Qualified Products List (QPL) program, all stage-sensing systems will be tested before procurement by the HIF. Systems passing the qualification tests will be placed on the Survey's QPL. The Federal Acquisition Regulations (General Services Administration, 1984) allow Federal Agencies to require prospective bidders to have their products tested and qualified for the QPL before bids are submitted in response to a solicitation for bids. After a QPL is established, only bidders for stage-sensing instrumentation whose products are on the QPL will be invited to bid. The QPL can be used as a guide by the Survey's field offices when purchasing systems are not available from the HIF.

Purpose and Scope

The purpose of this report is to provide the users of stage-sensing instruments a list of instrument features, test-data summaries, and a brief description of performance qualification test procedures followed. Recommendations are not made as to which is the best instrument system for any given application. The report does, however, provide pertinent information and test results. This will assist the reader in selecting one or more systems that meet the requirements of a particular site or the data needed.

Acknowledgments

The authors acknowledge the cooperation of the instrument manufacturers who provided their instruments for the qualification tests.

DESCRIPTION OF INSTRUMENT SYSTEMS TESTED

One model of each instrument system was tested. These instruments are available from the manufacturers listed alphabetically in table 1. Also a comparison of major system features is given in table 1. A brief description of each system and its special installation requirements follows.

Fluid Data Systems Fluidgage[1], Model HY 50 FT H2O

The instrument is an electro-mechanical device that senses pressure. A gas-purge system transmits the pressure head of water over an orifice, which is submerged in the stream. It uses one bellows and a balance beam with a moving weight. Null-balancing is accomplished by a servo-controlled motor. A source of regulated gas pressure, a sight-feed bubbler chamber, a flow regulator, and a bubble or gas transmission tube with an orifice are required.

An analog to digital recorder (ADR), paper punch recorder, or a graphic recorder can be used to record water-level data from the shaft output. The instrument has a mechanical digital display.

The instrument can be modified to cover a number of ranges in change in water-level stage from 0 to 10 to 0 to 225 feet. Only a 0- to 10- and 0- to 50-foot range unit were used for the qualification tests.

Output accuracy can be affected by vibrations transmitted to the instrument. Shelters should be isolated from vibration sources, such as highway and railroad traffic.

[1]The use of brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Table 1.--Comparison of instrument system features.

Instrument Company and Model Name[a] / Features[b]	Fluidgage HY 50FT H20	Golden River Waterman Model 502	ISCO Model 2300	Sarasota Upward Looking	STACOM Manometer
Station Type[c] daily discharge (daily) or special (special)	[d,i] special	daily	daily	special	daily
System error as tested (feet)	-.12 to +.03	+0.02	+0.01	+0.05	+0.01
Sensor Type - Float (F) Manometer (M) or Transducer (T)	M	F	T	T	M
Stilling well (SW) or orifice (OR)	OR	SW	[e] SW	SW	OR
Sensor distance to recorder (feet)	1600	300	100	300	1600
Recommended range in stage (feet)	[f] 0-50	0-215	.08-12	[g] 2-30	0-35 or 0-50
Affected by sediment	Yes	Yes	Yes	Yes	Yes
Power requirement (volts dc, ac)	12, 120	[h] 6	12, 120	12	12
Instrument weight (lbs)	30	11	15.5	22	50
Instrument size[b]	B	A	A	A	C
Shelter required	Yes	Yes	Yes	No	Yes
Operating range in air temperature (^{o}C)	-40 to 65	-20 to 65	-17 to 65	0 to 65	-40 to 65
Internal data memory	No	Yes	Yes	Yes	No
Data output to	ADR	ASCII	ASCII	ASCII	ADR

[a] The use of brand names in this report is for identification purposes only and does not constitute endorsement by the U. S. Geological Survey. (See Appendix D for company names and addresses.)

[b] See glossary for definition of terms.

[c] Recommended use, based on maximum allowable error. (See Appendix C.)

[d] Shelter temperature should be maintained above 0^{o}C to reduce temperature induced errors to +0.03 foot.

[e] Can mount sensor in culvert pipe without stilling well. A vertical or sloping stilling well is recommended for open channel flow sites.

[f] Only the ranges 0 to 10 and 50 feet were tested. Manufacturer claims ranges to 225 feet.

[g] Only the range 2 to 15 feet was tested. Manufacturer claims range to 164 feet, but we recommend range to 30 feet.

[h] Two internal rechargable batteries

[i] May not be acceptable for daily discharge stations that have very sensitive controls.

Golden River Waterman Model 502

The system consists of a solid-state electronic shaft encoder, recorder, and rechargeable batteries housed in one case. The instrument is installed directly over a stilling well.

The instrument recorder outputs to either the manufacturer's Model 557 Retriever Unit or through a 300 baud modem to a computer. The system was tested using the manufacturer's retriever. The output units are in inches or millimeters.

The retriever unit can be used to program the Golden River data recorder. The instrument can record water-level changes from 0 to 215 feet.

It uses a 0.418-foot diameter pulley (1.312-foot circumference) designed for a cable, float, and counterweight sensor system. It is recommended that the standard Survey pulley (float-tape wheel) be used. The unit can be modified by the manufacturer to accept the Survey pulley.

ISCO Open Channel Flow Meter Model 2300

The instrument has solid-state electronic circuitry. It utilizes a submersed differential pressure transducer mounted on the end of a cable to sense the pressure head of the water. A microprocessor computes flow rates from the water-level inputs and a rating equation stored in memory. Testing was limited only to the sensing of water level.

The data output to a computer uses the serial ASCII communications protocol (see glossary). Range in water-level change is from 0.08 to 12 feet. The sensor can be installed in sewer pipes or placed in an open channel with suitable mounting brackets and anchors. The HIF recommends that a stilling well be installed in open-channel applications to dampen waves and to protect the sensor from damage by debris or ice.

Sarasota Automation Ultrasonic Water-Level Sensor

The instrument is a solid-state electronic, ultrasonic, water-level sensing and recording system. The system compares the times of return echoes from a fixed target ring and the water surface to compute water depth above the sensor. The sensor is an upward looking ultrasonic transducer assembly mounted on the bottom end of a 1-1/2-inch rigid PVC pipe two feet long. Additional sections of pipe are required below the maximum water surface to act as a sonic wave guide.

The system output is either binary coded digital (BCD) for a digital input-output recorder or to a computer using serial ASCII communication protocol. The range in water-level sensing is from 2 to 164 feet above the ultrasonic transducer. Only the range from 2 to 15 feet was checked.

The HIF recommends that the 1-1/2-inch pipe be installed in a larger stilling well in open-channel flow locations to dampen waves and to protect the transducer from damage by debris or ice. The stilling well may either be mounted vertically or sloping.

Stabilized and Temperature Compensated Manometer (STACOM)

The instrument is an electrical-mechanical mercury manometer designed by the Survey's Instrument and Development Laboratory (Craig, 1983) and built by contractors to HIF specifications. A gas-purge system transmits the pressure head of water over the orifice, which is submerged in the stream. A source of regulated gas pressure, a sight-feed bubbler chamber, and bubble or gas transmission line with an orifice are required.

The standard instrument is built to monitor 0- to 35- or 0- to 50-foot range in water-level change. Other ranges can be built to special order. The output is to an ADR paper punch recorder or graphic water-level recorder.

The system must be properly installed and maintained to prevent the loss of liquid mercury. The system has an overflow reservoir to capture the mercury in the event of an overpressure situation caused by operator error or by the plugging of the gas line or orifice.

TEST PROCEDURES

The laboratory qualification tests were conducted by the HIF's Test and Evaluation Section, using one model of each candidate system. All tests were run indoors under controlled conditions, which simulated average and extreme field conditions. This was in part to assure that each instrument system was tested under the same conditions.

Each system, upon receipt from the manufacturer, was unpacked, inspected for shipping damage, and set up in the laboratory, in accordance with the manufacturer's instructions. The first test on each system was made under prevailing room temperature and humidity conditions for two or more days. This was a bench test to familiarize personnel with system operation and to test instrument output at room temperature and humidity conditions. Auxiliary laboratory instruments, printers, and recorders for the tests were connected to each system during this period. The power consumption and stability of each system's output was monitored for several days.

The calibration of each instrument was checked in the second test, using procedures appropriate for that type of system. The sensors and a gas-line orifice were placed in water columns (see appendix A, for procedures followed).

Environmental tests were run to establish the system performance under simulated field conditions. These tests were run in environmental test chambers where temperature and humidity were controlled. Each instrument package was placed in the test chamber on the sensor placed in a water column or connected to a gas-pressure line. The column of water was held at a constant level and kept at room temperature, or at constant pressure in the case of gas pressure line. The purpose of these tests was to measure the performance of each system throughout a selected range in air temperatures and relative humidities.

The last test run was a calibration check following the above procedures. The purpose was to check for drift in each instrument's output after 50 or more days of tests.

TEST RESULTS

The data were collected under the conditions described in the preceding section. The data are summarized in graphical and tabular forms. Only those five instrument systems that passed the qualification tests are reported. The two systems that failed one or more of the following tests were returned to the manufacturer for repair and have not been resubmitted. They may be retested a second time at the manufacturers' option, and the results will then be published in a future report.

A representative sample of the calibration data is presented in figures 1 through 5 and tables 2 through 6. Each instrument calibration was linear above 0.05 foot. Laboratory facility limitations prevented calibration over the full range of some instruments.

Two of the environmental chamber temperature-test cycles are shown in figures 6 and 7. Five out of the seven instruments tested experienced one or more failures to operate during these and other temperature tests. Three of the five instruments discussed in this report were repaired and successfully passed a later test. All tests were run at a constant water level or pressure head as explained above. Instrument outputs changed with temperature as shown in figures 8 through 12.

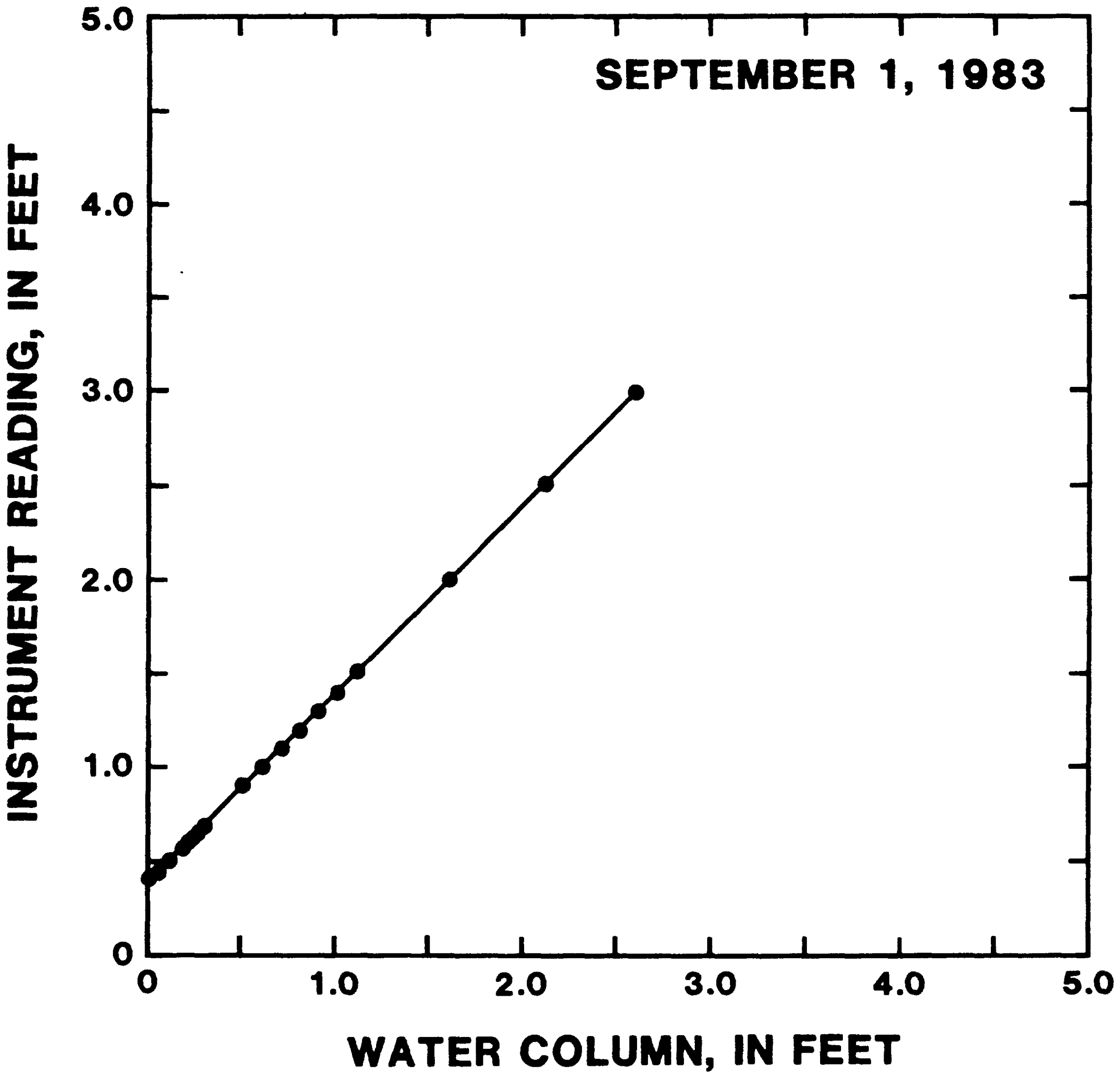

FIGURE 1 -- FLUIDGAGE, HY50FT-H20 SERIAL NUMBER 8300601, CALIBRATION AT ROOM TEMPERATURE.

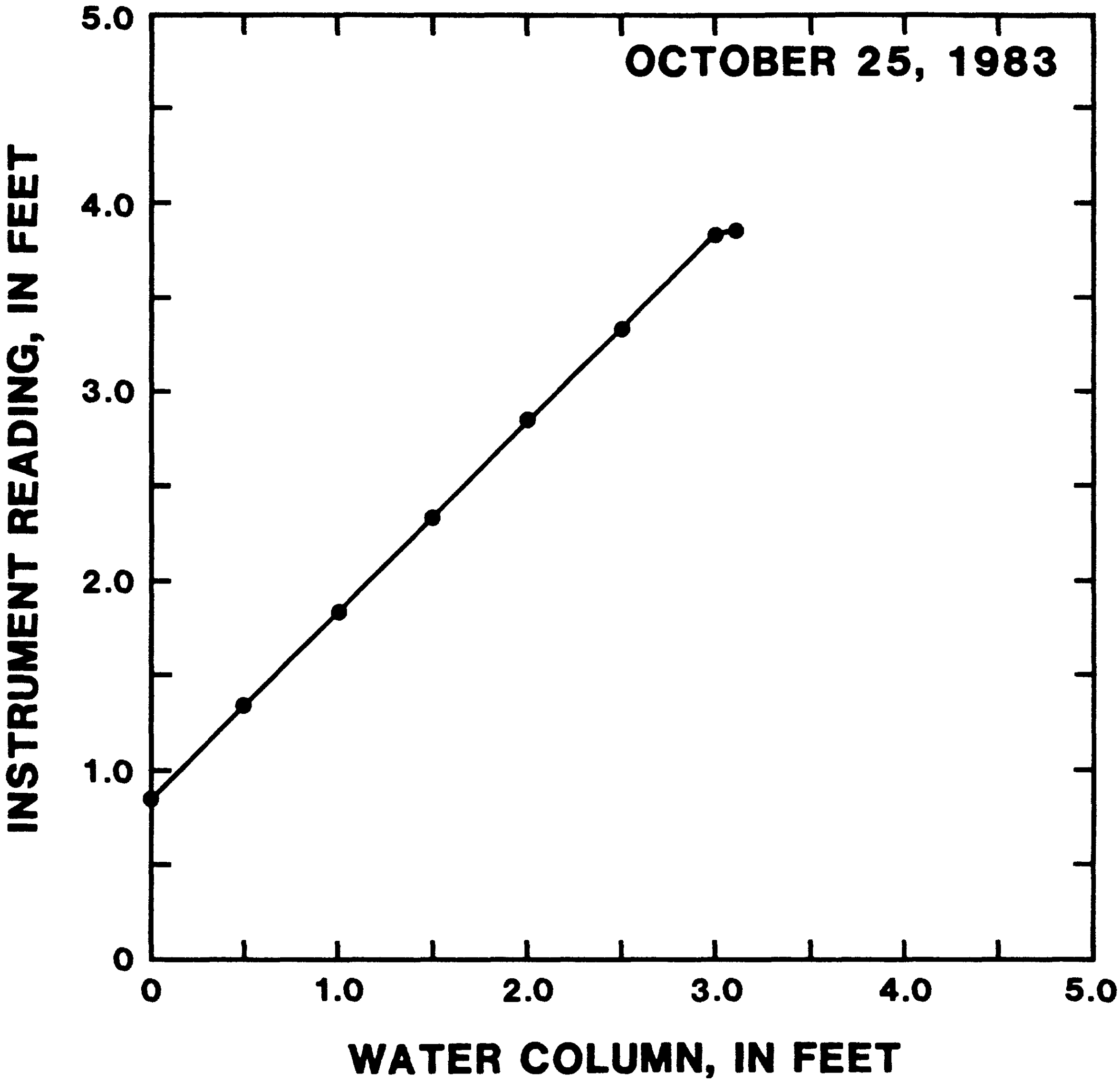

FIGURE 2 -- GOLDEN RIVER, WATERMAN, MODEL 502 SERIAL NUMBER 10, CALIBRATION AT ROOM TEMPERATURE.

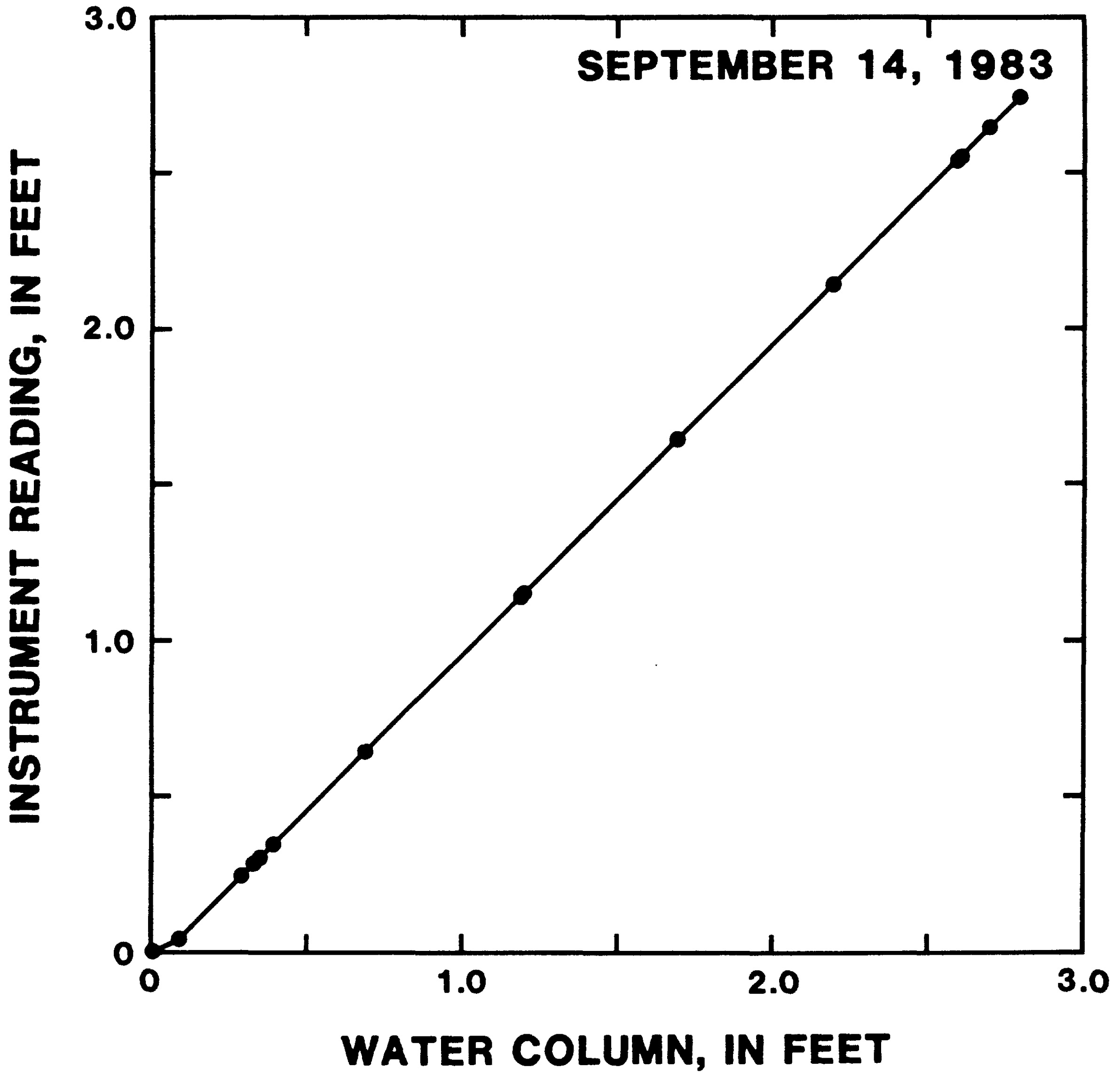

FIGURE 3 -- ISCO, OPEN CHANNEL FLOW METER , MODEL 2300 SERIAL NUMBER 190, CALIBRATION AT ROOM TEMPERATURE.

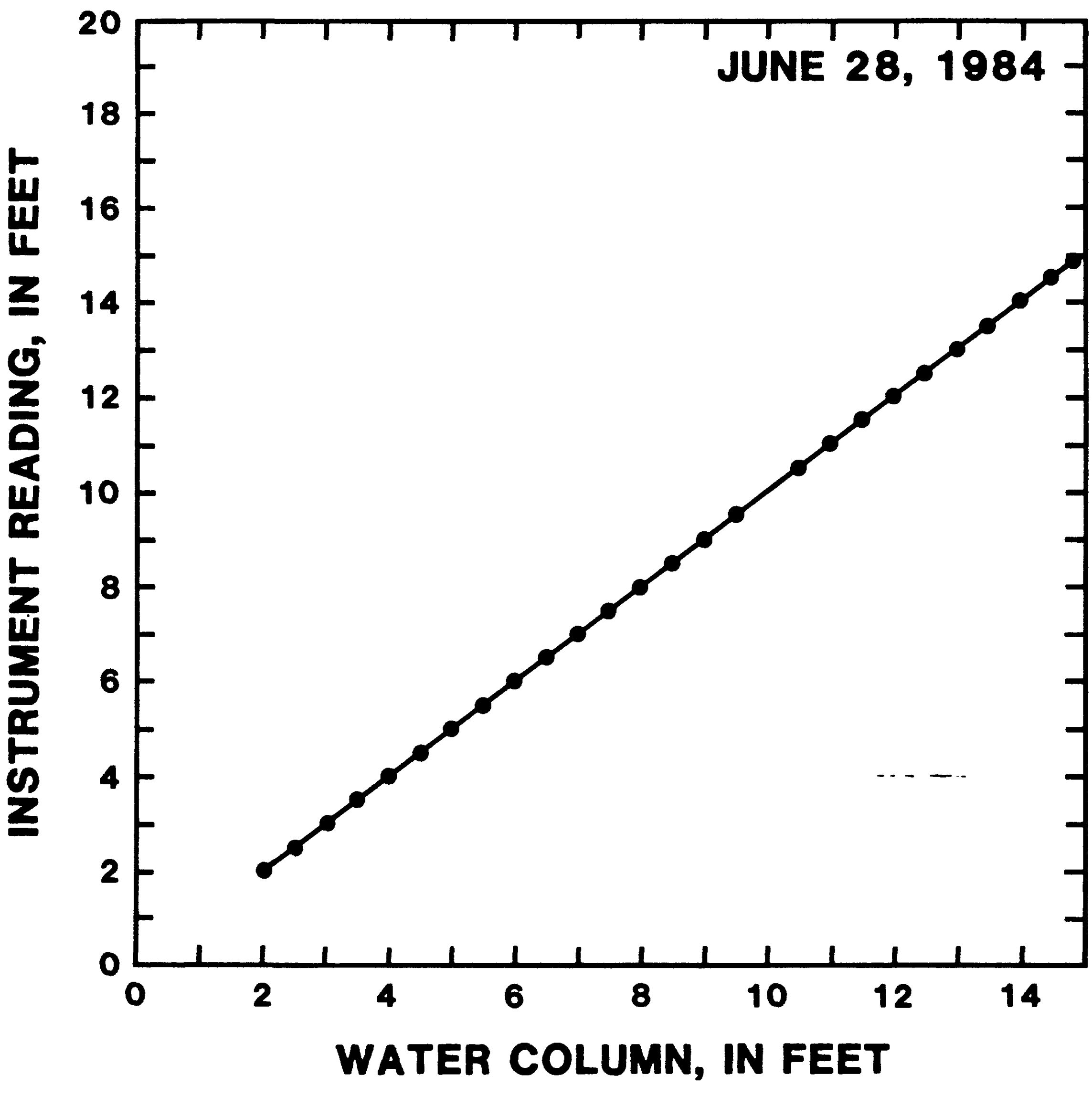

FIGURE 4 -- SARASOTA AUTOMATION, ULTRASONIC WATER-LEVEL SENSOR MODEL NO SERIAL NUMBER, CALIBRATION AT ROOM TEMPERATURE.

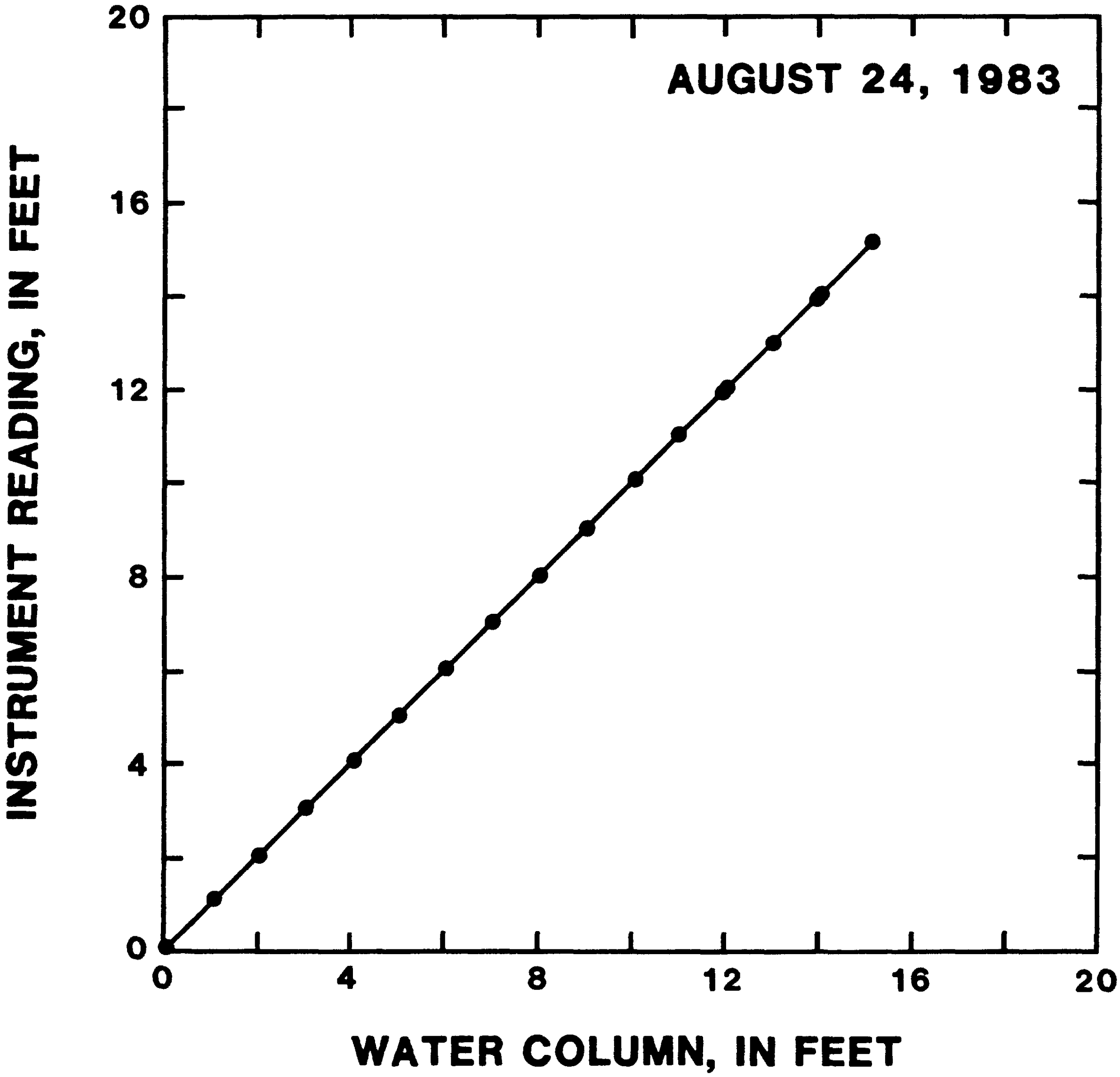

FIGURE 5 -- STACOM MANOMETER SERIAL NUMBER 1601,
CALIBRATION AT ROOM TEMPERATURE.

Table 2.--Fluidgage HY50FT-H20, Serial Number 8300601 calibration data September 1, 1983

Electrical Tape Gage Reading (ft)	Instrument Reading (ft)
0.409	0.008
0.444	0.057
0.494	0.016
0.504	0.120
0.514	0.129
0.595	0.129
0.697	0.311
0.898	0.512
0.998	0.611
1.099	0.712
1.199	0.812
1.299	0.910
1.399	1.011
1.500	1.110
1.500	1.110
1.520	1.130
2.000	1.609
2.501	2.108
2.982	2.580
2.992	2.599
3.002	2.609
2.992	2.599
2.982	2.589
2.501	2.108
2.000	1.608
1.520	1.128
1.510	1.118
1.500	1.110
0.998	0.618
0.697	0.311
0.677	0.290
0.657	0.269
0.635	0.250
0.615	0.229
0.595	0.208
0.575	0.189
0.494	0.170
0.412	0.020

Table 3.--Golden River Model 502, Serial Number 10 calibration data October 31-November 1, 1983

Electrical Tape (ft)	Instrument Reading Observed (mm)	Instrument Reading Computed (ft)
11.000	3355	11.008
9.998	3050	10.007
9.000	2745	9.006
8.990	2742	8.996
8.980	2739	9.987
8.003	2440	8.006
7.000	2135	7.005
6.002	1830	6.004
5.004	1525	5.004
4.993	1522	4.994
4.985	1519	4.984
4.005	1220	4.003
3.005	915	3.002
2.003	610	2.001
1.005	305	1.001
0.995	302	0.991
0.985	299	0.981
0.993	302	0.991
1.006	305	1.001
2.006	610	2.001
3.007	915	3.002
4.004	1220	4.003
4.980	1519	4.984
4.991	1522	4.994
5.004	1525	5.004
6.002	1830	6.004
6.999	2135	7.005
8.000	2440	8.006
8.980	2739	8.987
8.989	2742	8.996
9.000	2745	9.006
10.000	3050	10.007
11.001	3355	11.008

Table 4.--ISCO Model 2300, Serial Number 190 calibration data September 14, 1983

Electrical Tape Gage Reading (ft)	Instrument Reading (ft)
0.000	0.000
0.088	0.044
0.290	0.244
0.331	0.284
0.351	0.305
0.391	0.345
0.691	0.642
1.192	1.142
1.202	1.152
1.692	1.640
2.193	2.137
2.594	2.538
2.604	2.548
2.694	2.640
2.794	2.738
2.694	2.637
2.604	2.550
2.594	2.539
2.193	2.143
1.693	1.645
1.201	1.155
1.191	1.142
0.691	0.645
0.390	0.345
0.350	0.305
0.330	0.284
0.290	0.244
0.087	0.044
-0.002	0.001

Table 5.--Sarasota Upward Looking Ultrasonic Sensor calibration data June 24, 1983

Electrical Tape Gage Reading (ft)	Instrument Reading (ft)
2.000	2.005
2.008	2.014
2.500	2.500
2.999	2.997
3.499	3.497
4.500	4.493
4.999	4.990
6.000	5.987
6.999	6.979
7.497	7.475
8.000	7.973
8.498	8.470
9.000	8.971
9.501	9.466
10.501	10.463
10.999	10.959
11.496	11.454
12.001	11.954
12.500	12.450
13.002	12.950
13.500	13.444
14.003	13.944
14.500	14.438
14.998	14.939
14.498	14.445
13.999	13.945
13.502	13.451
13.000	12.953
12.500	12.456
11.996	11.950
10.996	10.956
9.000	8.967
8.000	7.969
6.999	6.973
5.998	5.978
5.001	4.985
3.998	3.993
2.999	2.997
2.498	2.500
2.001	2.005

Table 6.--STACOM Serial Number 1601 calibration data August 24, 1983

Electrical Tape Gage Reading (ft)	Instrument Reading (ft)
0.068	0.079
1.069	1.110
2.053	2.061
3.055	3.064
4.080	4.091
5.039	5.048
6.032	6.036
7.035	7.035
8.032	8.033
9.039	9.043
10.048	10.051
11.041	11.039
12.058	12.050
13.034	13.035
14.050	14.041
15.167	15.160
15.135	15.118
13.978	13.971
13.011	13.011
11.973	11.961
11.009	11.002
10.077	10.076
9.067	9.064
8.062	8.064
7.043	7.043
6.050	6.051
5.053	5.071
4.058	4.071
3.062	3.073
2.059	2.065
1.059	1.064
0.065	0.074

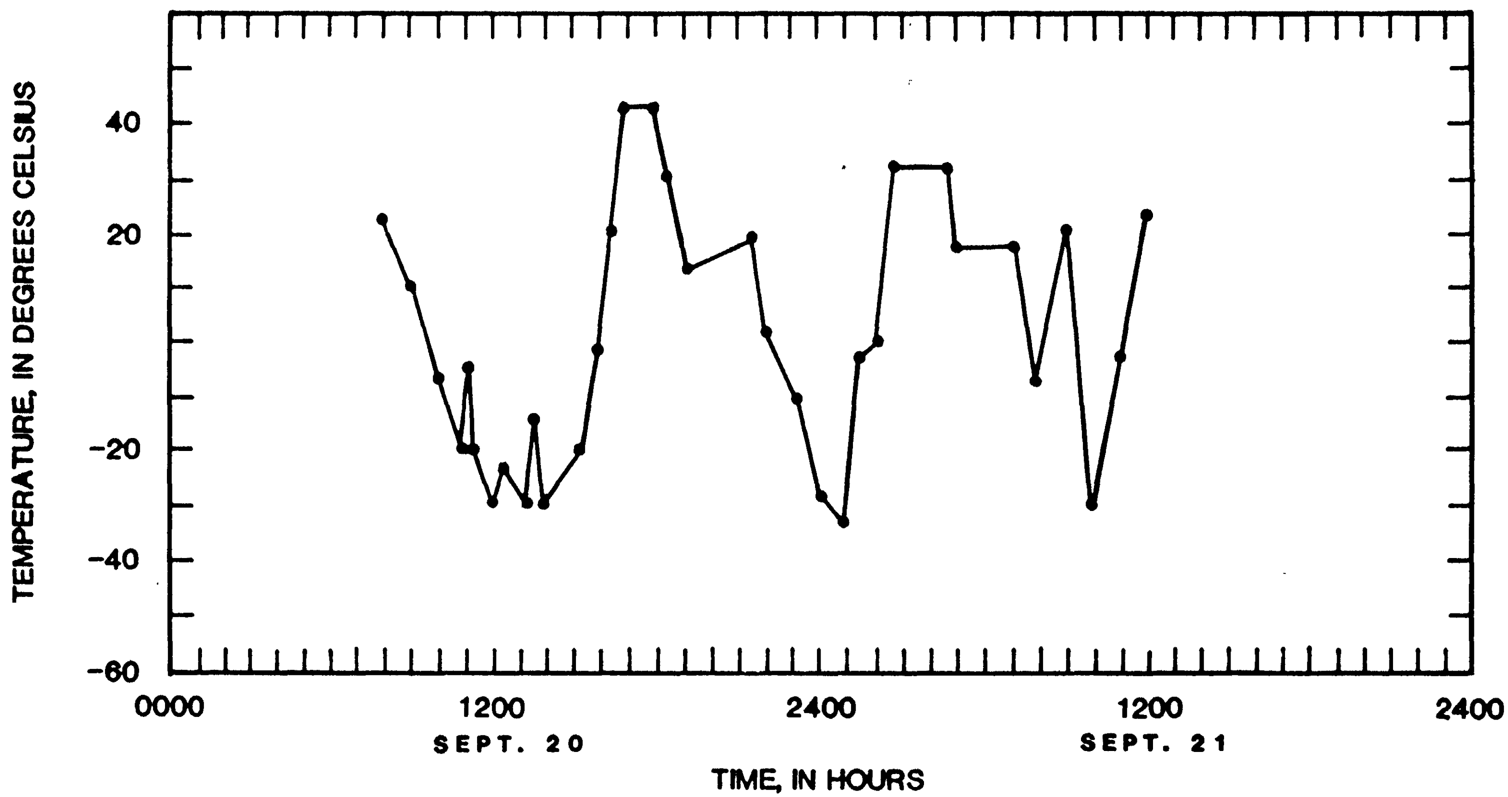

FIGURE 6 -- TEMPERATURE CYCLING TEST OF SEPTEMBER 20 AND 21, 1983.

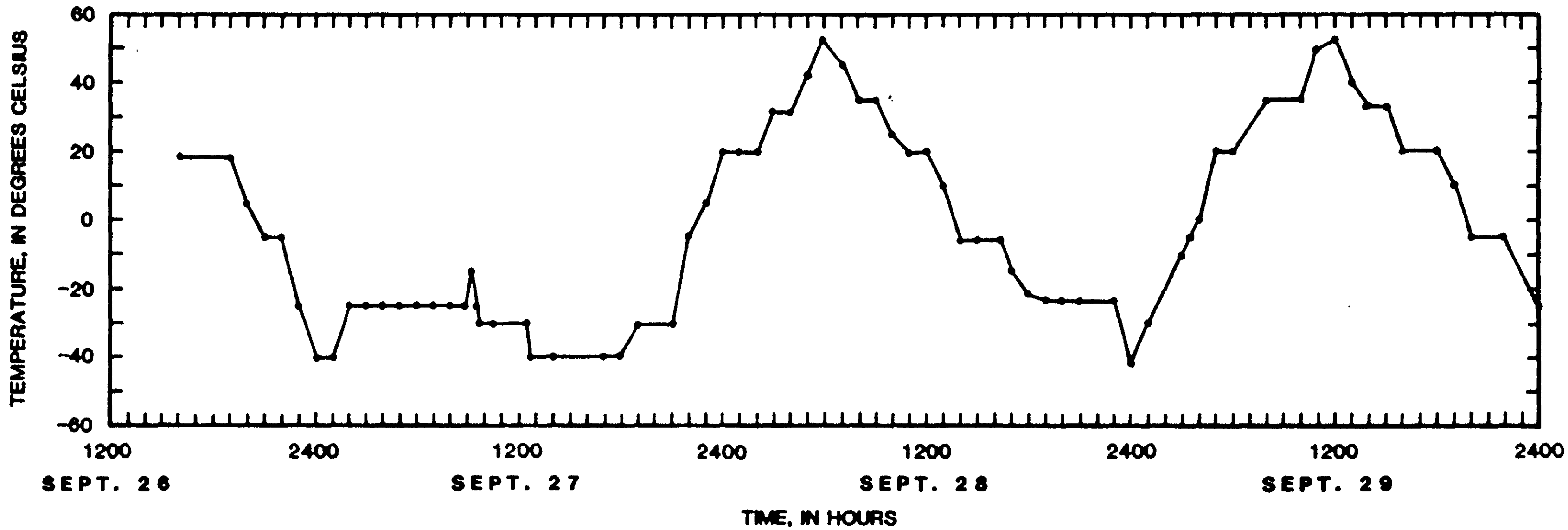

FIGURE 7-- TEMPERATURE CYCLING TEST OF SEPTEMBER 26-29, 1983.

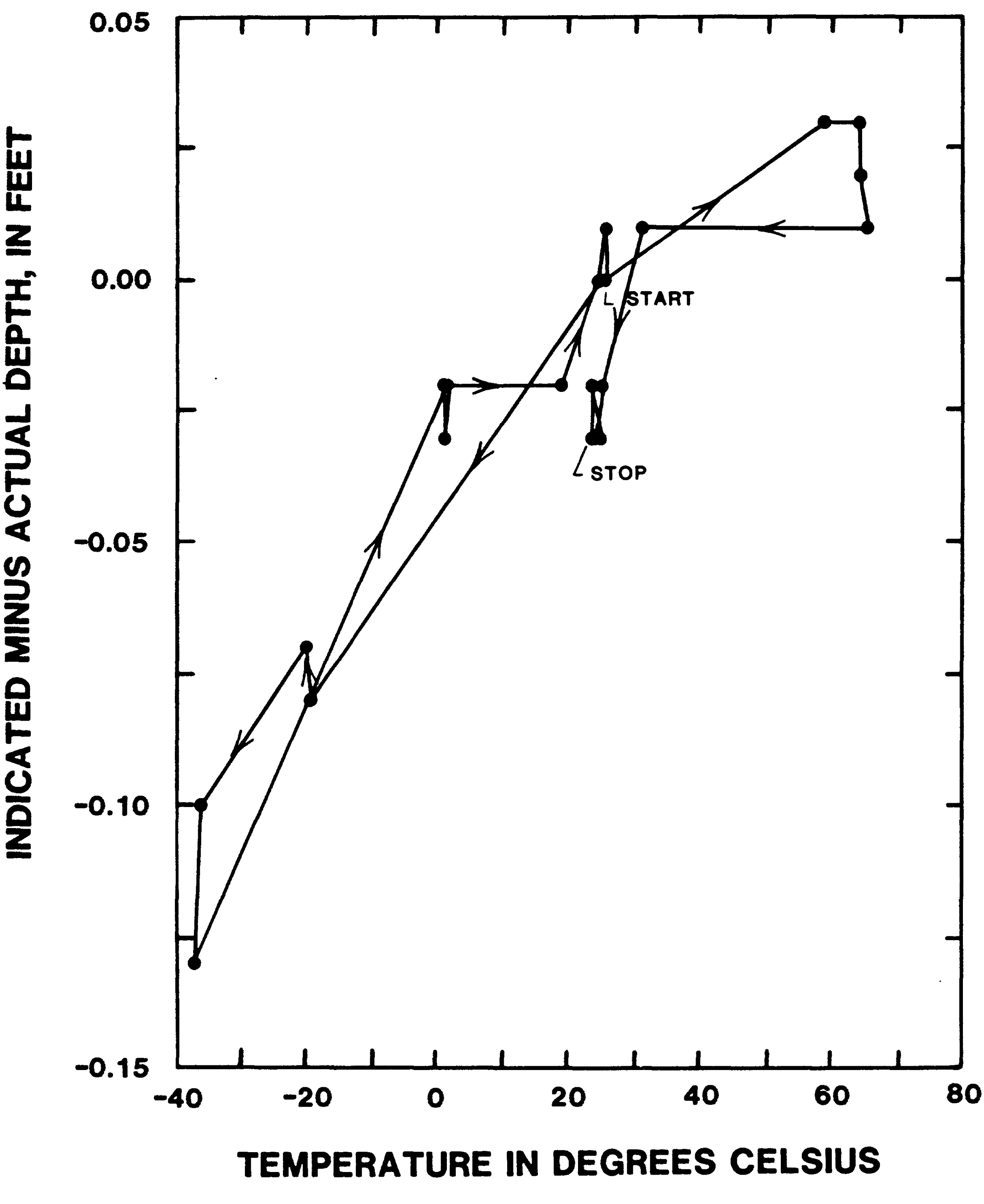

FIGURE 8 -- FLUIDGAGE , MODEL HY 50 FT-H20 SERIAL NUMBER 830601, OUTPUT RESPONSE TO CHANGE IN TEMPERATURE.

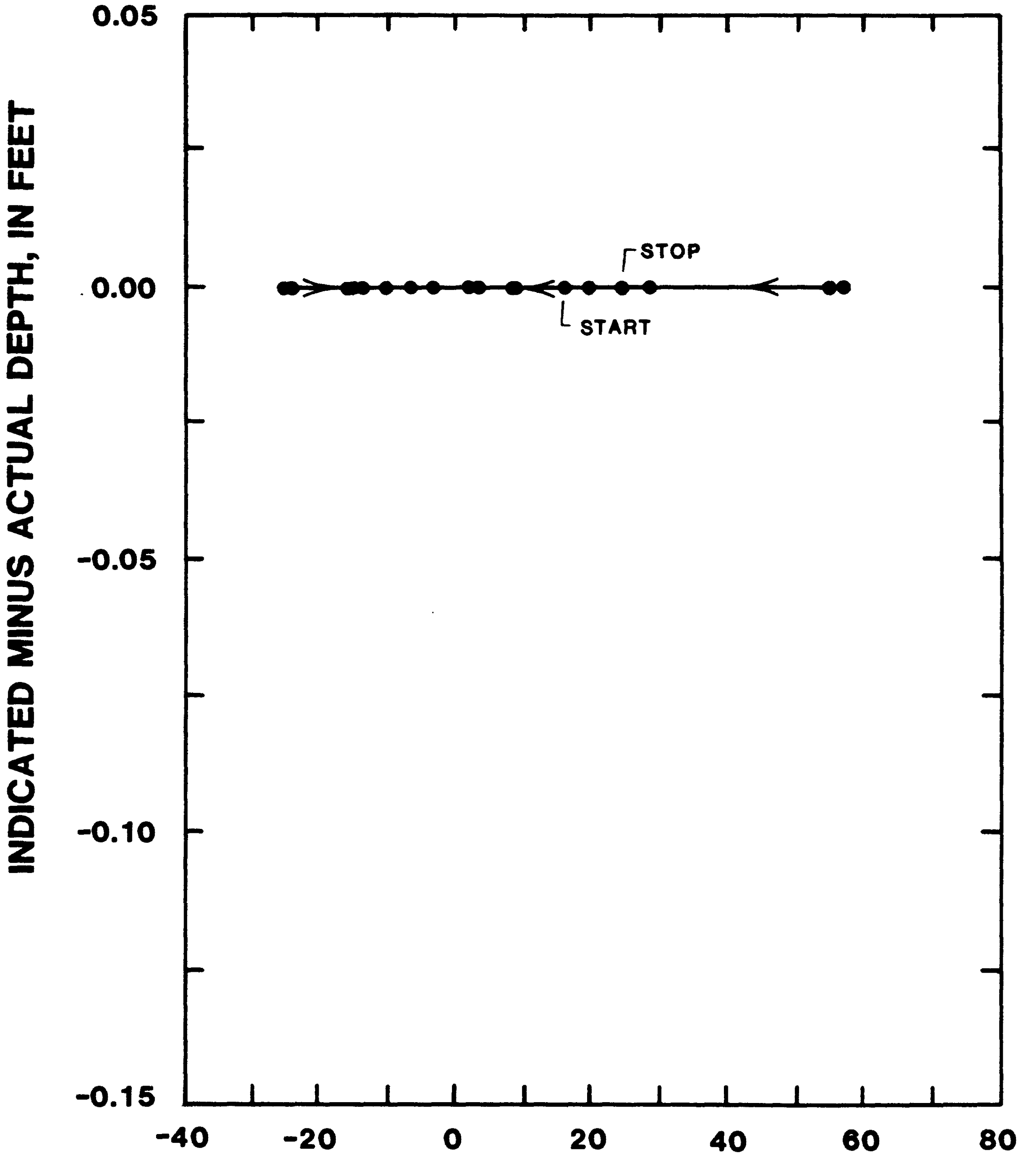

FIGURE 9 -- GOLDEN RIVER WATERMAN, MODEL NUMBER 502 SERIAL NUMBER 10, OUTPUT RESPONSE TO CHANGE IN TEMPERATURE.

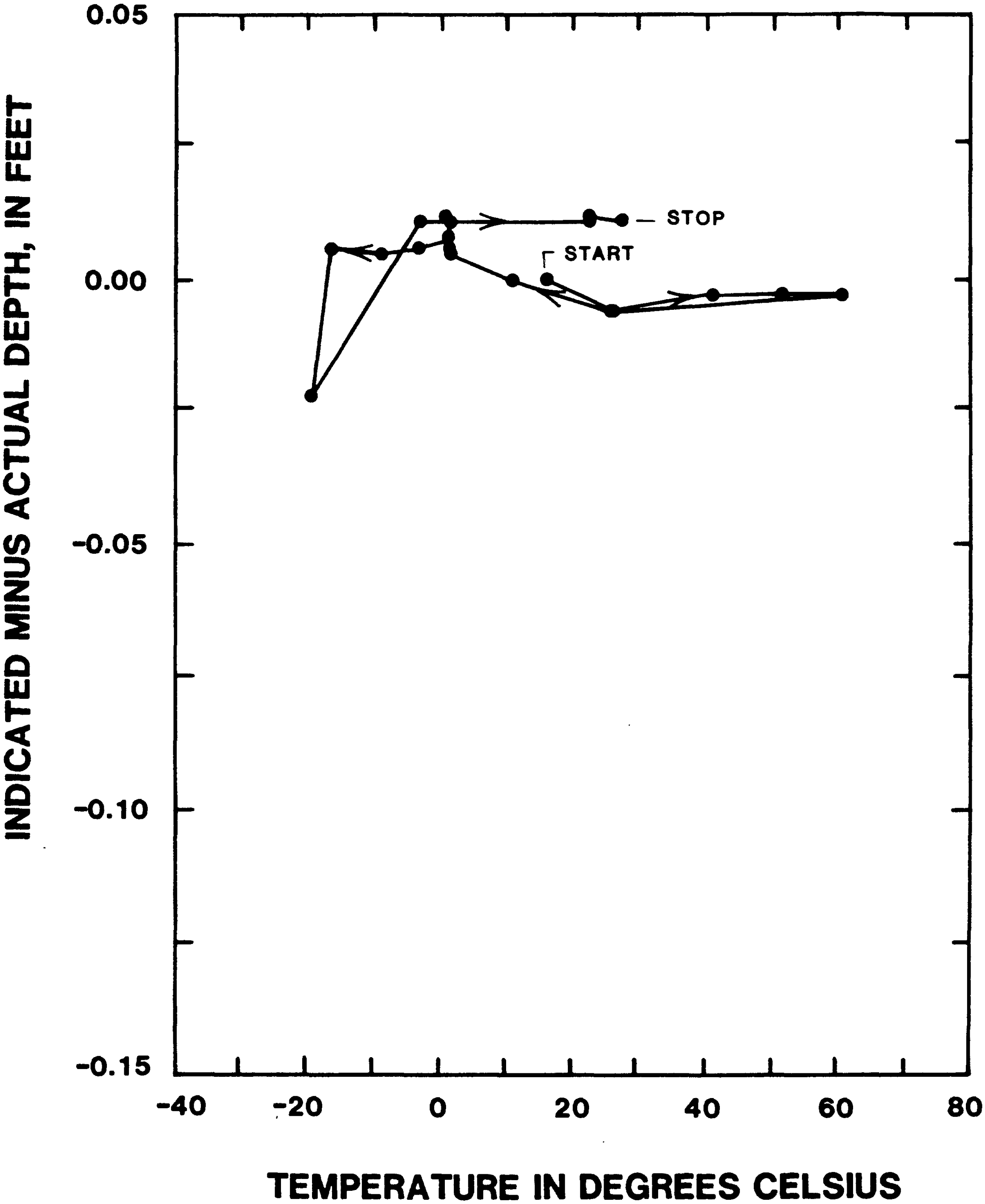

FIGURE 10 -- ISCO OPEN CHANNEL FLOW METER, MODEL NUMBER 2300 SERIAL NUMBER 190, OUTPUT RESPONSE TO CHANGE IN TEMPERATURE.

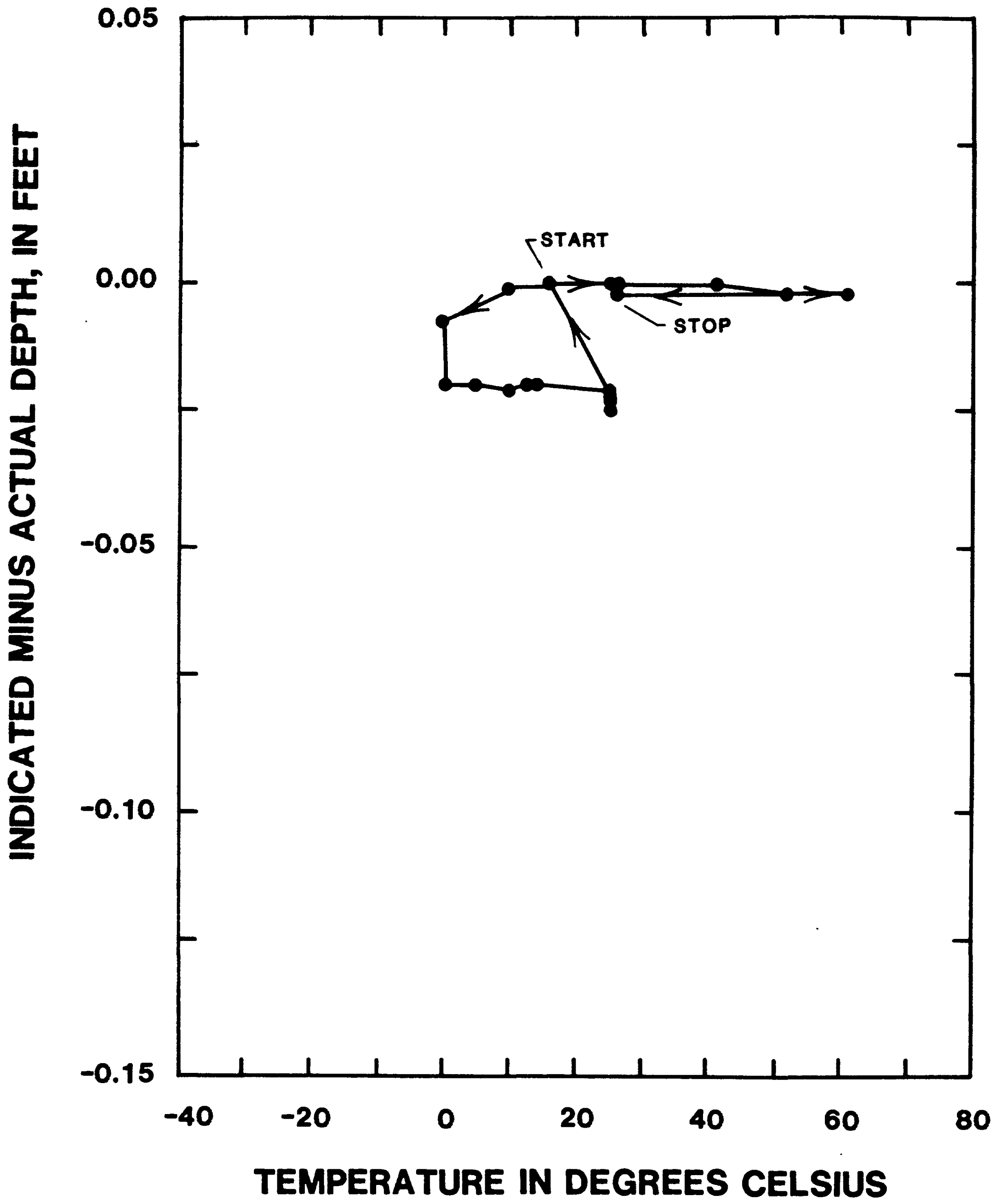

FIGURE 11 -- SARASOTA ULTRASONIC WATER-LEVEL SENSOR MODEL NO SERIAL NUMBER, OUTPUT RESPONSE TO CHANGE IN TEMPERATURE.

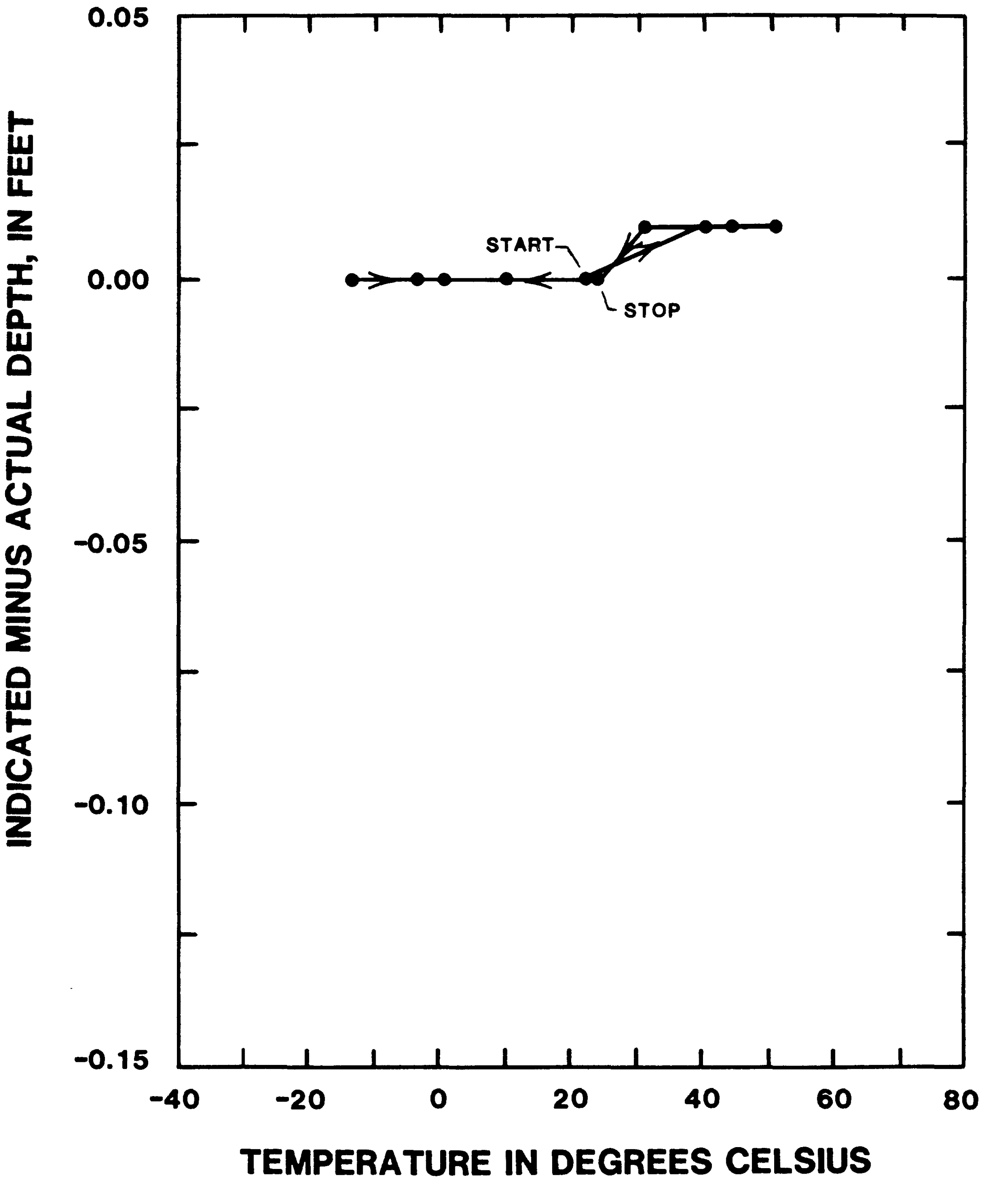

FIGURE 12 -- STACOM SERIAL NUMBER 1601, OUTPUT RESPONSE TO CHANGE IN TEMPERATURE.

CONCLUSIONS

Five of the seven instrument systems tested met the Survey's minimum performance requirements. Four qualified for the daily-discharge stations over the range of stated test conditions. One of the five met the requirements for special case stations, where lower accuracy is acceptable. These five systems, shown in table 1, will be placed on the Survey's Qualified Products List (QPL) for water-level sensing instrumentation systems.

This report does not give recommendations for the best instrument system for any given application. It does, however, provide individual characteristics and test results to assist a user in selecting a particular system or systems that best fits a user's set of field conditions.

REFERENCES

Buchanan, T. J. and Somers, W. P., 1968, Stage Measurement at Gaging Stations: U.S. Geological Survey, Techniques of Water Resources Investigations, Book 3, Chapter A7, 28 p.

Craig, J. D., 1983, Installation and Service Manual for U.S. Geological Survey Manometers: U.S. Geological Survey, Techniques of Water Resources Investigations, Book 8, Chapter A2, 57 p.

General Services Administration, 1984, Federal Acquisition Regulations, Volume 1, Part 9.2, Qualified Products, p. 9.4-9.6.

Kennedy, E. J., 1983, Computation of Continuous Records of Streamflow: U.S. Geological Survey, Techniques of Water Resources Investigations, Book 3, Chapter A13, 53 p.

Rantz, S. E., 1982, Measurement and Computation of Streamflow: Volume 1: Measurement of Stage and Discharge, U.S. Geological Survey Water-Supply Paper 2175, p. 32-34.

Rapp, D. H., 1982, Specification for Procurement of Water-Level Sensing Instrumentation, Specification Number HIF-I-1: U.S. Geological Survey, Open File Report 82-89, 24 p.

 (p. 31 follows)

APPENDIX A

Calibration Procedure Using Water Columns

Appendix A

Calibration Procedure Using Water Columns

1. Base gage is a standard Survey Electric-Tape Gage (ETG) with a Vernier scale. Read the Vernier to 0.001 foot. Check ETG against the reference elevation blocks. Record readings and adjust ETG if more than 0.001 foot difference.

2. Read the instruments being calibrated from their output dials or displays and record, if possible, on a data logger or a computer printer.

3. Calibrate each instrument per manufacturer's instructions; for example, setting zero points and span adjustments.

4. Manually record the water-level reading from each instrument, plus time and date. Record at the start, midpoint, and end of the test the following items: air and water temperatures, barometric pressure, and relative humidity.

5. Control room temperature. It should not change more than + 2° C throughout the test. The water should be at room temperature and removed from the reservoir tank that had been filled at least 16 hours prior to start of the test to allow escape of trapped gases and allow water to reach room temperature. The specific gravity should be measured and recorded.

6. Calibration Points: (Record all data in a bound laboratory book.)

Step 1. Using water from the reservoir tank, start at 0.00 or lower, then raise level to 0.00-, 0.01-, 0.02-, 0.03-, 0.10-, and 0.50-foot levels. Next, raise the water level in the column in approximate 0.50-foot steps. At approximately 2.00-foot, 5.00-foot, and 10.00-foot levels raise the water level in four 0.01 steps (5.00, 5.01, 5.02, 5.03). Do this to test resolution (response of the instruments to small changes). Raise the water level in steps to the top of the column. Read the inside staff gage for 0.00 to 5.00 feet for comparison with the ETG. All readings are to be taken after the water level has stabilized. When the STACOM manometer is used as a secondary standard, allow it to reach a stable reading.

Step 2. Lower the column in approximately 0.50-foot steps. Repeat resolution checks at same levels, as in Step 1.

Step 3. Repeat Step 1 at approximately 1.00-foot steps, but omit the 0.01-foot resolution checks, and proceed to Step 4.

Step 4. Repeat Step 2 at approximately 1.00-foot steps, but omit the 0.01-foot resolution checks.

7. Record data as required in paragraph 4.

8. Enter all data into computer memory. Check for entry errors. Then compute a linear regression for each data set.

APPENDIX B

Procedure for Running Tests on Pressure Transducers Using Compressed gas

 (p. 37 follows)

APPENDIX B

Procedure for Running Tests on Pressure Transducers Using Compressed Gas

EQUIPMENT: Instrulab 2000 Data Logger
Ametek Dead Weight Tester (DWT)
Pressurized Nitrogen Gas
Keithley 195 System DMM S/N 185199 CCN 202665
Pressure Transducer being tested
Precision Power Supply HP-6114A

RECOMMENDED WARM-UP TIMES: Follow manufacturer's instructions

PHYSICAL SET UP:

The nitrogen tank regulator is to have a line feed minimum pressure of 400 PSI, not to exceed 450 PSI. The pressure tube leaving the DWT goes to the environmental chamber where it is connected to the pressure line manifold to the transducers. The transducers are hooked up electrically to the power supply at the transducer manufacturer's recommended voltage. The transducer output is connected to the terminals of the data logger.

Set the time, date, and temperature to produce a printout from the data logger. To record the reading select the "Manual" button of the scan mode.

Procedure for Using the AMETEK DWT to Calibrate Transducers

1. Test the accuracy of the data logger. (This should be be done just before and at the close of the calibration of the transducer to check the data logger.)

   a. Set a precision power supply for 0.000, 2.5000, and 5.000 volts verified by the calibrated Keithley DVM connected to each data logger channel to be used one at a time.

   b. Remember to connect the precision power supply to one channel throughout the calibration tests.

   c. A voltage should be recorded with the rest of the data. The value of the voltage should be 0.8 of the full scale.

2. Set the 4-inch holder on DWT with both switches turned off.

3. Turn right switch to "low range" and left switch to "on" in that order.

4. Wait 5 minutes for system to equalize.

5. Take a reading by selecting the "manual" button on data logger.

6. Take a zero reading by closing the left switch to "off" and opening the right switch to "vent" in that order.

7. Repeat steps 4 and 5.

8. Repeat steps 2 and 3.

9. Record all data in the lab book.

APPENDIX C

System Accuracy for Daily Discharge and Special Case Stations

 (p. 41 follows)

APPENDIX C

Systems Accuracy for Daily Discharge Stations to Meet Minimum Performance Requirements.[1]

Range in Stage (ft)	Maximum Allowable Error[2] (ft)
0 to 10	± 0.005
0 to 20	± 0.010
0 to 35	± 0.018
0 to 50	± 0.025
0 to 100	± 0.050
0 to 200	± 0.100
+ 200	± 0.100

[1]Taken from Specification Report (Rapp, 1982)

[2]Full-scale error is 0.050 percent for all ranges less than 200 feet.

Systems Accuracy for Special Case Stations to Meet Minimum Performance Requirements.[3]

Range in Stage (ft)	Maximum Allowable Error[4] (ft)
0 to 10	± 0.050
0 to 20	± 0.100
0 to 35	± 0.180
0 to 50	± 0.250
0 to 100	± 0.500
0 to 200	± 1.000
+ 200	± 1.000

[3]Taken from Specification Report (Rapp, 1982).

[4]Full-scale error is 0.50 percent for all ranges less than 200 feet.

APPENDIX D

Qualified Products List Water-Level Sensing Instrumentation

 (p. 45 follows)

APPENDIX D

Qualified Products List

Water-Level Sensing Instrumentation

Daily Value Stations

Type: Shaft Encoder (Electronic)
Golden River Encoder, Model Number 502
Golden River Coporation, 7315 Redfield Court, Falls Church, VA 22043

Type: Pressure Transducer (Submersible)
ISCO, Model Number 2500
ISCO, Inc., Environmental Division, 531 Westgage Blvd., Lincoln, NB 68501

Type: Manometer (Mercury)
STACOM Manometer
Built by an instrument company for HIF Warehouse.

Special Case Stations

Type: Manometer (Mechanical)
Fluidgage, Model Number HY50FT H20
Fluid Data Systems, 7370 Opportunity Road, San Diego, CA 92111

Type: Acoustic (Contact)
Sarasota Upward Looking
Sarasota Automation, Inc., 1500 N. Washington Blvd., Sarasota, FL 33577

 (p. 47 follows)

GLOSSARY

Term	Description
ADR	Analog to digital recorder, which records water-level data on paper punch tape from the rotating float pulley shaft.
ASCII	American Standard Code for Information Interchange, uses serial communications protocol, an eight-bit character code for communication to computer.
Error	In stage output is defined as the difference between the true water-surface height above a given datum and that measured simultaneously by the stage-sensing system.
Instrument Package Size and Weight	The requirements to house the instrument system including any of the required interface hardware, nitrogen gas tanks, pressure system, power supply, and batteries are classified as follows: A. Smaller than 18 inches long, by 12 inches wide by 18 inches high, and weighs less than 25 pounds. B. Larger than size A, but smaller than 36 inches long by 18 inches wide by 36 inches high, and weighs less than 50 pounds. C. Larger than size B, but smaller than 4.0 feet long by 3.0 feet wide by 8.0 feet high, and weighs less than 75 pounds. D. Larger than size C, and/or weighs more than 75 pounds. Note the weight excludes the weight of a nitrogen gas tank for all four classes, in cases where a tank is required.
Sensor Distance to Recorder	The maximum recommended length of the signal cable or orifice line between the sensor and the recorder.
Special Case Station	A site that does not require the data accuracy of 0.05 percent error of full scale of a Daily Discharge Station, but a 0.5 percent error of full scale is acceptable.