RESULTS OF QUALIFICATION TESTS ON WATER-LEVEL SENSING INSTRUMENTS 1984-85

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ABSTRACT

This report presents the results of the second qualification tests on water-level sensing instruments. The Hydrologic Instrumentation Facility at National Space Technology Laboratories, Mississippi conducted qualification tests on five water-level sensing instrument systems. The data collected are summarized and a brief description is given for the one system that met the minimum performance requirements. As a result of these tests, this system has been included in the U.S. Geological Survey's Qualified Products List, which will be used by the Survey for future procurements of water-level sensing systems.

INTRODUCTION

The U.S. Geological Survey, Water Resources Division, 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, 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. For automatic recording, the water-level elevation is sensed either by a float in a stilling well or by a gas-purge system, known as a bubble gage (Rantz, 1982), that transmits the pressure head of water in a stream to a manometer.

A number of hydrologic instrumentation manufacturers have developed a variety of new systems to sense the water level and record its elevation. One model each of five systems was tested at the Hydrologic Instrumentation Facility (HIF) during the period of August 1984 to January 1985. The test purpose was to determine whether each system could meet the Survey's minimum performance requirements for the collection of water-level data, (Buchanan, 1968; Kennedy, 1983; and Rapp, 1982). This report presents a summary of the data collected and describes the system that qualified. The four instruments that failed to meet one or more of the minimum performance requirements will be given a second opportunity to pass the qualification tests. The results of the second tests and the descriptions of each instrument will be published in a future report.

Under the Qualified Products List (QPL) program, all water-level 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 (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 water-level 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 not available from the HIF warehouse.

This test report serves to inform Survey procurement personnel and users of hydrologic instruments of what products have been added to the list of instruments that have met the Survey's minimum requirements for water-level sensing systems for either daily value stations or special case stations (see glossary).

Purpose and Scope

The purpose of this report is to provide the users of water-level sensing instruments a list of instrument features, a brief description of test procedures and test-data summaries. This report does not make recommendations as to which is the best instrument system for any given application. It does however, provide pertinent information and test results that will assist the reader in selecting one or more systems that meet the requirements of a particular study site or of data needed. The system described in this report has met the Survey's minimum performance requirements (Rapp, 1982) during the qualification test period and has been placed on the Survey's QPL (appendix C).

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. The instrument that passed the qualification tests is available from the manufacturer listed in appendix C. A brief description of the system and its special installation requirements follows.

Tavis[1] Pressure Transducer, Model Number SPCL

The instrument is a nonsubmergible pressure transducer (table 1). It uses a dynamic pressure system, which is the standard Survey gas purge system (Craig, 1983) connected to the unit by a polypropylene tube.

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[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 Model name	Tavis Corporation Insulated Transducer Model No. SPCL
Features	
Station Type daily discharge (daily) or special (special)	Special
System difference from standard reference (feet)	-.08 to +.06
Sensor Type - Pressure Transducer (PT) Ultrasonic Transducer (UT)	PT
Stilling well (SW) or orifice (OR)	OR
Maximum sensor distance to recorder (feet)	1600
Recommended range in water-level (feet)	0 to 34.7
Affected by sediment	Yes
Power requirement (volts dc, ac)	10 to 32 vdc
Instrument weight (lbs)	3.5
Instrument size (See Glossary)	A
Shelter required	Yes
Operating range in air temperature (C^{o})	-10 to 65
Internal data memory	No
Data output, analog	0 to 5 vdc

The pressure sensing unit with electronics and a temperature sensitive resistor were placed by the manufacturer in a PVC pipe with styrofoam insulation. A source of regulated gas pressure, a sight-feed, a differential pressure gas regulator and a bubble or gas transmission line with an orifice are required. The pressure transducer senses the pressure of the water column over the orifice.

The unit has a range of 0 to 15 pounds per square inch gage pressure, requires an input of 10 to 50 volts dc unregulated, and has an output of 0 to 5 volts dc. It is temperature compensated from -33°C to 54°C (oral communication with Tavis Corp.).

The instrument packaging appeared to be adequate and contained desiccant and a temperature sensor.

TEST PROCEDURES

The laboratory qualification tests were conducted by the HIF's Test and Evaluation Section, using one model of each candidates system. Upon receipt from the manufacturer, each system was unpacked, inspected for shipping damage, and set up in the laboratory in accordance with the manufacturer's instructions. All tests were run indoors under controlled conditions, which simulated average and extreme field conditions to assure that each instrument system was tested under the same conditions.

The first test on each system was made under prevailing room temperature and humidity conditions for two days. This was a bench test to familiarize personnel with system operation and to test instrument output at a constant input level, 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.

The calibration of each instrument was checked in the second test, using procedures appropriate for that type of system. (See appendix A for a description of the test procedures.)

Environmental tests were run to establish the system performance under simulated field conditions. The instrument packages were placed in the environmental test chamber, and the tests were run under controlled temperature and humidity conditions.

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 30 days of tests.

TEST RESULTS

The data were collected under the conditions described in the preceding section. Test results are summarized in graphs (figs. 1-3) and table 2. Only the instrument system that passed the qualification tests is reported. The four systems that failed one or more of the following tests were returned to the manufacturers 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 figure 1 and table 2 showing the instrument output over the range of head of water (pressure). The instrument calibration curve is nearly linear.

The environmental chamber temperature-test cycles and instrument outputs changes are shown in figures 2 and 3. Four of the five instruments tested experienced one or more failures to operate during these and other temperature tests. All tests were run at a constant water level or pressure head, as explained in the previous section.

CONCLUSIONS

One of the five instrument systems tested met the Survey's minimum performance requirements for special case discharge stations over the range of stated test conditions. This system, shown in appendix C, has been 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.

Table 2.--Tavis Model SPCL, Serial Number 13965
calibration data September 12, 1984

Head of water (feet)	Instrument reading (volts)
0.00	0.006
.33	.055
1.00	.151
2.00	.296
4.33	.632
21.17	3.066
29.50	4.267
34.72	5.022
29.50	4.269
21.17	3.068
4.33	.632
2.00	.294
1.00	.150
.33	.053
.00	.004

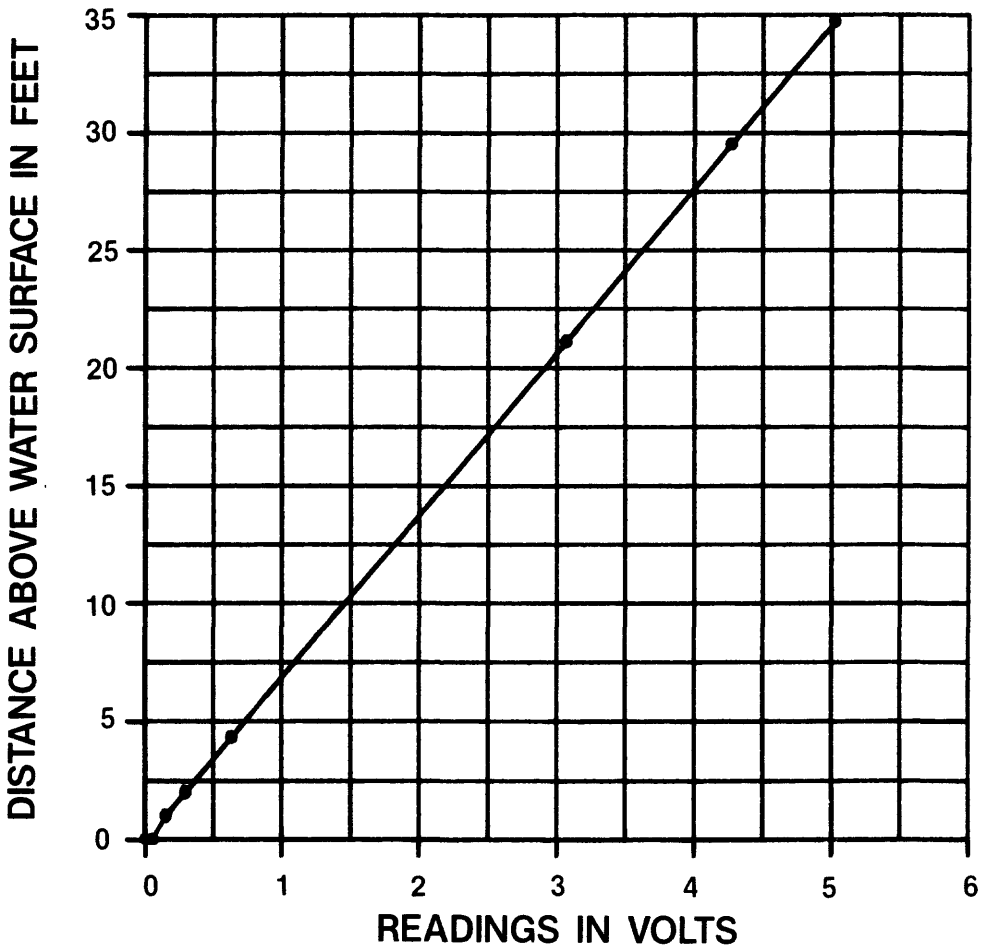

Figure 1. Tavis Calibration Test, September 12, 1984.

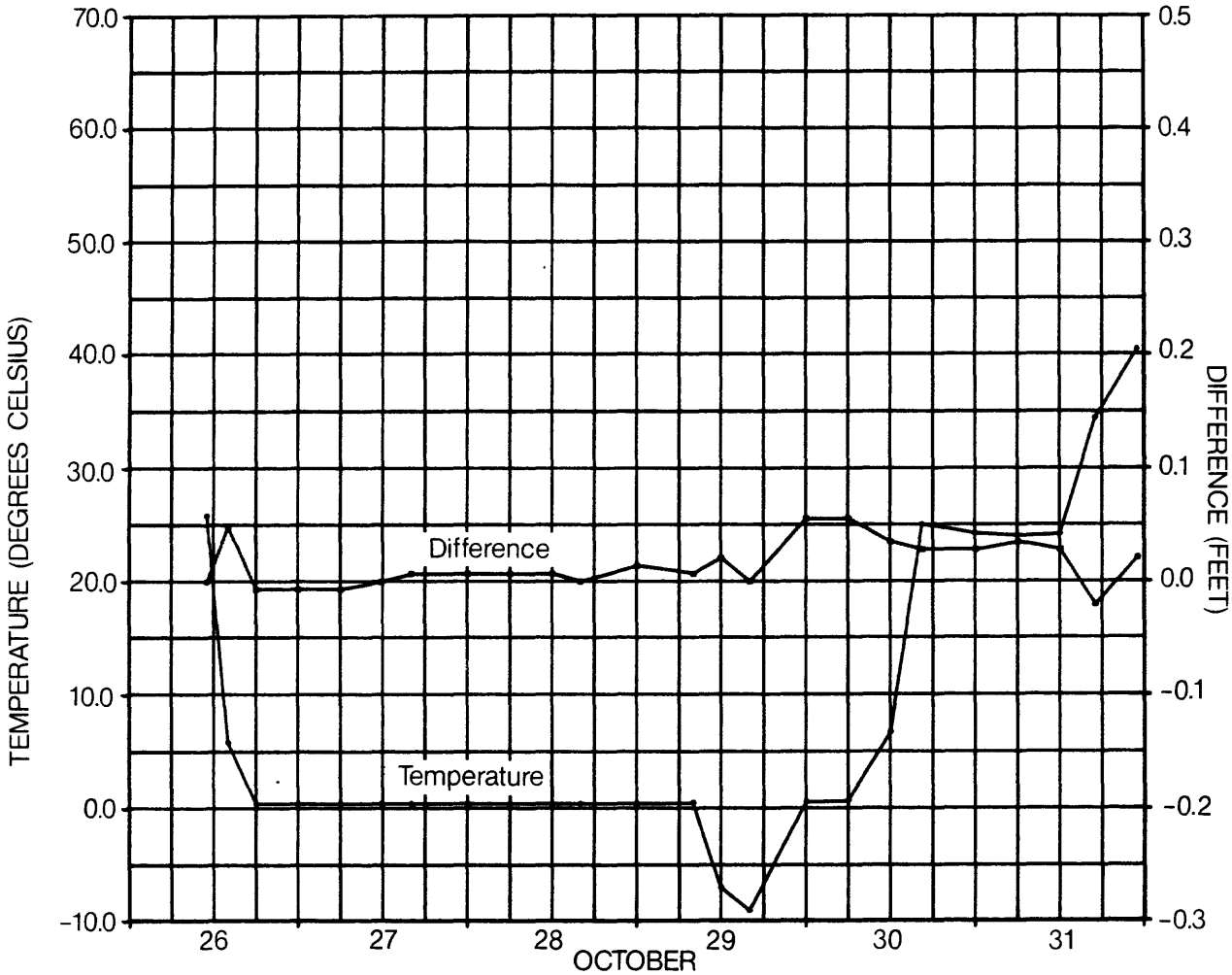

Figure 2. Tavis environmental test showing output difference due to changes in temperature, October 26-31, 1984.

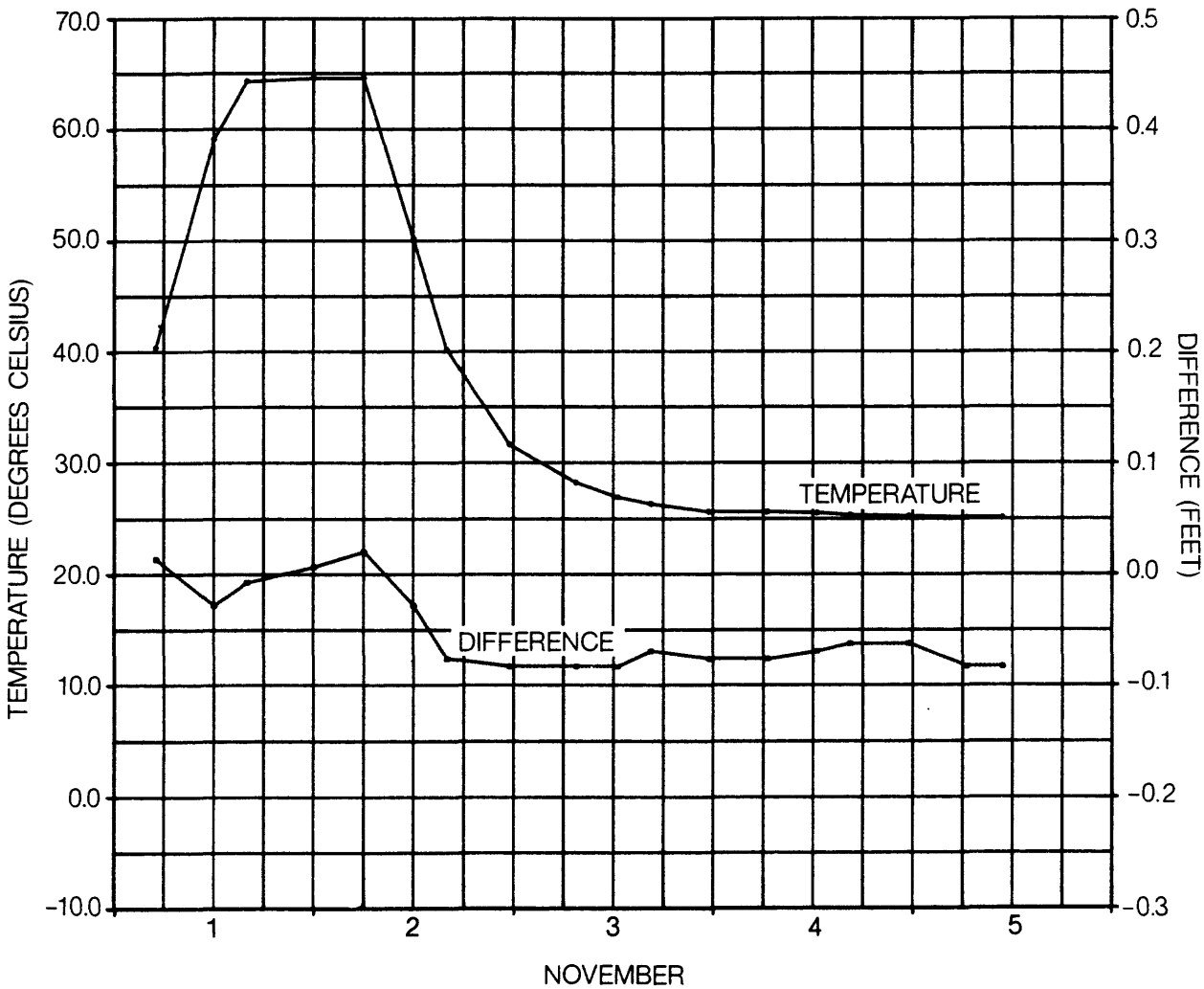

Figure 3. Tavis environmental test showing output difference due to changes in temperature, November 1-5, 1984.

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APPENDIX A

Procedure for running tests on pressure transducers using compressed gas

MAY 18, 1984

EQUIPMENT: Instrulab 2000 Data Logger
Ametek Deadweight 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 transducers 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.

USING THE 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" 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 B

System accuracy for daily discharge and special case stations

Systems accuracy for daily discharge stations to meet minimum performance requirements[1]

Range in stage (feet)	Maximum allowable error[2] (feet)
0-10	± 0.005
0-20	± 0.010
0-35	± 0.018
0-50	± 0.025
0-100	± 0.050
0-200	± 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 (feet)	Maximum allowable error[4] (feet)
0-10	± 0.050
0-20	± 0.100
0-35	± 0.180
0-50	± 0.250
0-100	± 0.500
0-200	± 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 C

Qualified Products List

Water-Level Sensing Instrumentation
APRIL 1985

Daily Value Stations

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

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

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

Special Case Stations

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

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

*Type: Transducer, Pressure (Non submersible)
Tavis Insulated Transducer, Model Number SPCL
Tavis Corporation, 3636 Highway 49, Mariposa, CA 95338

*New addition to QPL, April 1985

GLOSSARY

Terms	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 protocal, an eight-bit character code for communication to computers.
DWT	Deadweight tester, used as a standard for calibrating pressure transducers in which known pneumatic pressures are generated by means of freely balanced (dead) weights loaded on a calibrated ball.
Error	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 water-level 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.