DRP-4-04
August 1991

Dredging Research
Technical Notes

Field Evaluation of Endeco Model 1029 Tide Gage

Purpose

The purpose of this work was to evaluate the operation, reliability, and accuracy of the Endeco Model 1029 Tide Gage under typical field conditions.

Background

The US Army Engineer District, Galveston, is presently using Endeco Model 1152 tide gages to monitor tides in harbors and navigation channels, and determine the tide levels for dredging operations. The Galveston District requested the Dredging Research Program to evaluate the adequacy of the gages for their application. Two Model 1029 tide gages were purchased through normal procurement procedures, and the Galveston District supplied one Model 1152. The Model 1152 is similar to the Model 1029 except it includes a transmitter option. The two Model 1029 tide gages (serial numbers 10290434 and 10290426) were delivered to the US Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, on July 30, 1989, and the Galveston District delivered a Model 1152 tide gage (serial number 11500415) to WES on August 12, 1989.

Additional Information

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Discussion of Evaluation

The WES Coastal Engineering Research Center (CERC) Field Research Facility (FRF) at Duck, North Carolina, was chosen as the site for the evaluation. The facility includes a pier that extends 560 m (1,836 ft) into the Atlantic Ocean. The National Oceanic and Atmospheric Administration (NOAA), National Ocean Service operates a primary station which includes a Next Generation Water Level Gage (NGWLG) at the seaward end of the pier. The Endeco tide gages were mounted approximately 12 m (39.4 ft) east of the NOAA tide gage. The manufacturers' specifications for each of the gages are listed in Table 1.

Table 1

Tide Gage Specifications

Endeco Model 1029 Tide Gage	NOAA Next Generation Water Level Gage
Sensor Type	
Strain gage based pressure transducer	Acoustic sensor
Range	
0 to 15.2 m (0 to 49.8 ft)	Up to 10.7 m (35 ft)
Accuracy	
+/-1.5 cm (+/-0.6 in.)	+/-0.3 cm (+/-0.1 in.)
Resolution	
3.72 mm (0.15 in.)	0.3 cm (0.1 in.)
Averaging Interval	
49 sec	3 min
Sample Interval	
1, 2, 5, 10, 15, 20, 30, 60 min	6 min

The Endeco gage sensors were oriented vertically and mounted side by side on a single flat plate. The plate was then installed on the pier support piling (Figure 1) and leveled. Care was taken to ensure that all three sensors were at the same vertical level. Measurements from the top of the pier to the bottom of the sensor housings indicated that the sensors were 3.3 m (10.8 ft) below National Geodetic Vertical Datum (NGVD). Both Endeco and NOAA data were adjusted to NGVD to allow a direct comparison.

The electronics housing and environmental isolator were mounted on the pier hand rail. The environmental isolator compensates for fluctuations in

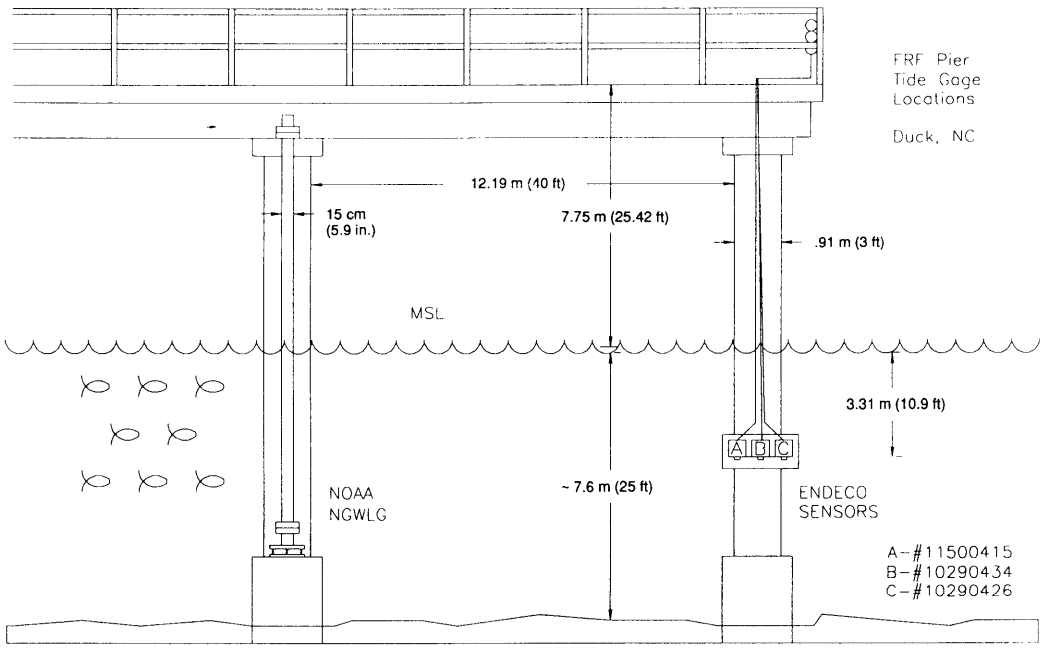

Figure 1. Diagram showing sensor location on pier

atmospheric pressure while maintaining a closed system. It prevents water vapor from entering the sensor housing and degrading electronic components. The isolator consists of a dip-molded neoprene rubber bladder inside a polyvinyl chloride (PVC) canister. The bladder is sufficiently compliant that the pressures inside and outside are equal over a wide range.

The Endeco Model 1029 gages were set to collect a 49-sec averaged sample every 5 min. The NOAA gage collects a 180-sec averaged sample every 6 min.

Gage Performance

Tide gages serial number (SN) 10290434 and SN 11500415 were installed at the FRF on August 13, 1989. Gage SN 10290426 was installed on August 31, 1989. Tide gage SN 10290425 failed when it was bench tested at the FRF before installation. It was returned to Endeco for evaluation. Endeco found electronic components had failed in the electronics package due to improper assembly. Endeco replaced SN 10290425 with SN 10290426. The environmental isolator used to maintain the dryness of the system leaked on all three systems.

Gage SN 10290434 had several shut-downs. The problem was found to be a break in the cable which connects the surface and subsurface units. It is believed the break was caused by stress from high wave action.

Nine data cartridges failed. The failures were caused by the installation of C-MOS circuits instead of N-MOS circuits at the factory. Normal handling of the data cartridges can cause the C-MOS memory circuits to fail.

All the gages were removed on March 23, 1990, and shipped to WES to check the calibrations of the sensors. The calibrations were completed on March 29, 1990, and all tide gages were returned to Endeco for failure analysis and modifications. Endeco found the following problems with the systems: sensor drift, software problems, and leaks in the environmental isolator.

The tube in the cable from the underwater sensor to the electronics package allowed moisture into the system. Endeco reported these errors accounted for an overall error of 2-10 cm (0.8 - 3.9 in.). Endeco modified the tide gages to monitor water temperature and altered the software to use water density computed from the measured temperature to make more accurate estimates of the height of water above the sensor. To correct some of the sensor drift problems, efforts were made to minimize moisture infiltration during the manufacturing process.

After modifying the tide gages, Endeco returned them to the FRF on July 13, 1990. They were mounted in the same configuration as in the prior deployment. However, the depth was adjusted to 3.4 m (11.2 ft) below NGVD. The tide gages would take only one sample when operated in the 5-min sample interval mode. All three instruments had this problem, which was due to a missing jumper on the control card. This defect could be fixed only at the factory, so it was decided to continue the test using the 1- or 2-min sample intervals.

On July 19, 1990, the environmental isolators were checked. The environmental isolator on tide gage SN 10290434 was partially deflated, and the environmental isolator on tide gage SN 10290426 was completely deflated. Both environmental isolators were reinflated.

On August 31, 1990, the environmental isolators were checked again. The isolator on tide gage SN 10290426 was again found to be completely deflated and was reinflated.

On October 5, 1990, the isolators were again checked. The isolator on tide gage SN 10290434 was partially deflated, and the isolators on tide gages SN 10290426 and SN 11500415 were found to be completely deflated and were reinflated.

On February 14, 1991, the systems were removed from the FRF pier. Severe wave action had pulled the cables from the sensor housing, which allowed water to flood the sensor and electronics.

The gage evaluation was completed on October 29, 1990.

Test Results

Data from January 1 to March 23, 1990, were analyzed for the first deployment, and from August 1 to October 29, 1990 for the second deployment. Results from these tests are shown in Table 2. As can be seen from the results of the first deployment, the systems did not then meet the published specifications. A maximum mean difference of 22 cm (8.6 in.) and a maximum standard deviation of 9 cm (3.5 in.) occurred before modifications were made to the tide gages by Endeco. After modifications, the gages improved to a maximum mean difference of 1.3 cm (0.5 in.) and a maximum standard deviation of 3.1 cm (1.2 in.). The mean difference of 33 cm (13 in.) and standard deviation of 7.8 cm (3.1 in.) from tide gage SN 10290434 for August are believed to be due to a kink in the cable from the gage to the electronic housing and should be ignored. These cables also failed on all systems during a major storm at the FRF when they pulled out of all three sensor housings, flooding the sensors and their electronics.

Conclusions

The mean differences between Endeco Model 1029 and 1152 tide gages and the NOAA NGWLG for the first deployment are between -22.4 cm (-8.8 in.) and 6.0 cm (2.4 in.) under wave conditions not exceeding 2 m (6.6 ft) significant wave height. The mean differences for the second deployment, after vendor modifications were made, improved to between -1.2 to 1.3 cm (-0.47 to 0.51 in.) for wave conditions not exceeding 2 m (6.6 ft) significant wave height.

Improvements should be made to the environmental isolators. It is the opinion of WES that these isolators will not be installed and maintained properly by most field crews. The gages used in this evaluation were installed by skilled technicians and inspected by a Endeco representative; still there were problems with the isolators. Also it is of concern that several failures were traced to manufacturing and inspection practices by Endeco.

Endeco is presently investigating replacing the present pressure transducer with a more accurate and reliable transducer. A new approach is being tried to secure the bladder and correct leaks in the environmental isolator. The vented cable is being sealed to correct the problem of moisture infiltration. The effectiveness of these modifications has not yet been tested.

Based on the limited number of gages evaluated, Endeco model 1029 tide gages which are properly assembled and carefully quality controlled can meet the vendor's published accuracy specifications. However, it is recommended that prospective Corps users verify the accuracy of individual gages before using them for control of dredging operations. Also, if the gages are to be installed in an unprotected location, such as the open ocean, they should be installed in a well to protect the sensor cable.

Table 2

Test Results on Tide Gages, cm (in.)

Before Modification by Vendor

		January	February	March
SN11500415 NOAA minus Endeco	Mean Difference	-22.4 (-8.8)	-9.1 (-3.6)	-6.7 (-2.6)
	Std. Deviation	8.3 (3.3)	0.8 (0.3)	4.7 (1.8)
SN10290426 NOAA minus Endeco	Mean Difference	-4.0 (-1.6)	5.7 (2.2)	6.0 (2.4)
	Std. Deviation	7.2 (2.8)	0.7 (0.3)	2.7 (1.1)
SN10290434 NOAA minus Endeco	Mean Difference	-14.8 (-5.8)	-1.2 (-0.47)	—
	Std. Deviation	9.0 (3.5)	4.3 (1.7)	—

After Modification by Vendor

		August	September	October
SN11500415 NOAA minus Endeco	Mean Difference	0.5 (0.2)	0.6 (0.2)	-1.2 (-0.47)
	Std. Deviation	1.3 (0.51)	1.8 (0.7)	2.2 (0.86)
SN10290426 NOAA minus Endeco	Mean Difference	0.9 (0.35)	1.3 (0.51)	-0.5 (-0.2)
	Std. Deviation	2.1 (0.8)	2.8 (1.1)	3.1 (1.2)
SN10290434 NOAA minus Endeco	Mean Difference	33.4 (13.1)	0.6 (0.23)	-1.1 (-0.43)
	Std. Deviation	7.8 (3.1)	1.9 (0.74)	2.1 (0.8)