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Selected Article

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Abstract

Our new Twin Waterproof compact pH meters, models B-211 and B-212, feature improved performance and resistance to immersion. These pH meters will continue to operate reliably even after they have been dropped into water. These innovative products use conventional technology, such as sheet-type composite electrodes, but have been improved to allow convenient use in many new applications and under very demanding field conditions.

In this paper the products' construction, functions, and performance are outlined with particular focus on the benefits of the waterproof case, the sensor guard, and the scoop-up measurement feature.

1. Introduction

The incorporation of microprocessors into pH meters has led to increasingly sophisticated meter systems, yet at the same time there is a demand for compact, inexpensive meters that allow easy measurements to be made outdoors. To meet this demand, we developed the B-211 and B-212 Twin Waterproof series of stick-shaped pH meters. No longer limited to university and industrial laboratories, these compact and affordable pH meters are successfully used by a wide variety of users including citizen groups who monitor acid rain, environmental educators in elementary, middle and high schools, and aquarium hobbyists. As the range of applications expands, the demand is increasing for a pH meter that inexperienced users find easy to use-an easy-to-operate meter with simple and convenient functions tailored to the application.

In response to this need, we have recently developed the Twin Waterproof compact pH meters (B-211 & B-212), a pair of compact, waterproof pH meters. The features and components of these meters are described in this article.

2. Components and Features of the Meter

2.1 Components and Specifications of the Meter

The B-211/B212 is shown in **Figure 1**.

Fig. 1 Compact Waterproof pH Meter, Twin Waterproof (B-211 and B-212)

The meter consists of the main body that contains the display and operation keys and a sensor unit that contains a flat sensor. The design is compact and the sensor unit can be replaced. A sensor guard is attached to the sensor unit that both protects the sensor and makes it possible to directly scoop up and measure the sample in the sensor unit. The specifications of the B-211 and B-212 are shown in **Table 1**.

The B-211 is capable of automatic 1-point calibration using pH 7 standard liquid, and the B-212 is capable of automatic 2-point calibration using pH 7 and pH 4 standard liquids.

Table 1 Specifications for the B-211 and B-212

Model name	B-211	B-212
Measurement method	Glass electrode method	
Display method	Digital LCD display	
Measurement range	pH 2~12	
Reproducibility:	±0.1 pH	
Operating temperature	5 ~ 40 ℃	
Functions	Automatic 1-point calibration (Calibration value backup)	Automatic 2-point calibration
Dimensions/Weight	165mm × 29mm × 19 mm Approx. 53 g	
Power supply	3 V × 2 (CR-2032 lithium battery 2)	
Main material	ABS resin	
Accessories	Standard solution pH 7 (14 ml) 1 CR-2032 lithium battery 2 Syringe 1 Instruction manual 1 Storage case 1 Waterproof packing 1	Standard solution pH 7 (14 ml) 1 Standard solution pH 4 (14 ml) 1 CR-2032 lithium battery 2 Syringe 1 Instruction manual 1 Storage case 1 Waterproof packing 1

*The level of waterproofing of this device conforms to grade 7 protection, (immersion-proof type) defined in Testing Rules for Waterproofing of Electrical Appliances and Wiring Materials.

2.2 Features

(1) Waterproof structure

The entire unit is waterproof. There is no fear of damaging the unit by accidentally dropping it in water or splashing water on it.

(2) Flat dipping/scooping measurement

In addition to conventional dipping measurement, the sample can be directly scooped up and measured in the sensor unit. This eliminates the need to gather samples with a syringe or beaker.

(3) Sensor guard

A sensor guard has been attached to the flat sensor unit to protect the sensor and prevent damage in case the meter accidentally strikes an object.

3. Waterproof Structure and Performance

3.1 Case Structure

Figure 2 shows the structure of the meter.

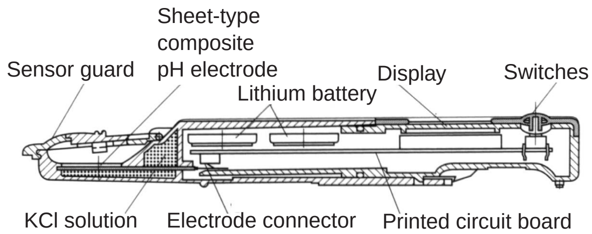


Fig. 2 Sketches of structures of B-211 and B-212

To achieve reliable waterproofing, we designed the main body and sensor unit cases to be a tube shape with a pouch structure. Sealed parts were minimized. A transparent display window and switches are provided on the main body. We used a double molding of elastomer and transparent resin for the window and switches, which gave us a waterproof structure and switches with a soft feel. We enclosed the sheet-type composite pH electrode in the sensor case, filled the sensor case with a gel consisting primarily of KCl solution, and sealed the case.

3.2 Types of Waterproofing and Properties

Table 2 shows the levels of waterproofing that are defined in standard JIS C0920-1982, "Testing Rules for Waterproofing of Electrical Appliances and Wiring Materials." This meter satisfies the requirements of grade 7 protection (immersion-proof type) of the standard, because water does not enter the instrument even if it is dropped in water. The properties of the immersion-proof type and testing methods are shown in **Table 3**.

To determine the limit of the meter's waterproofing ability, the meter was placed in a pressure container filled with water, pressurized, and then checked for damage and water penetration. The results of this test are shown in **Table 4.** No

Table 2 Types of waterproofing and definition of terms

Protection grade	Type	Definition
0	–	Not protected
1	Type I drip-proof	Water drops falling vertically onto the unit do not cause damage.
2	Type II drip-proof	Water drops falling down over a range of 15 do not cause damage.
3	Rain-proof	Rain falling down over a range of 60 does not cause damage.
4	Splash-proof	Spray from any direction does not cause damage.
5	Jet stream protection type	A direct jet stream from any direction does not cause damage.
6	Water-resistant	A direct stream of water from any direction does not cause water entry.
7	Immersion-proof	Water does not enter the unit when immersed in water under specified conditions.
8	Underwater	Can be normally used under water at a specified water pressure.
–	Humidity-proof	Can be used at a relative humidity of 90% or higher

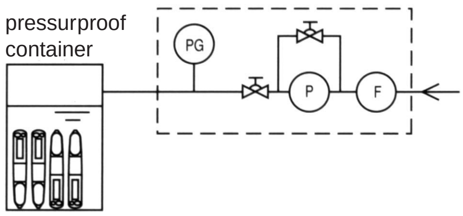
Table 3 Performance of protection grade 7 (immersion-proof type) and its test method

Protection grade	Type	Definition
7	Immersion-proof	When tested according to the method indicated in 1 of 4.9, there is no evidence of water having entered the device. When tested according to the method indicated in (2), bubbles do not form.

Test for grade 7 of protective level 4.9 (immersion protection type).
Either of following two methods:

(1) The device is held under water for 30 minutes with the uppermost part of the device at least 150 mm below the surface of the water and the bottommost part at least 1 mm below the surface of the water.

(2) The outer surface of the device is coated with liquid soap or the device is held under water so that the top surface is immersed, and air pressure of 0.05 kgf/cm2 (4.90 kPa) is applied to the inside of the device for one minute.



Test method:

The meter was successively pressurized from 10 to 50 kPa for 30 minutes, and then a visual inspection was conducted and the presence or absence of water verified.

Table 4 Waterproof test results for B-211 and B-212

Vertuality water depth(m)	1	2	3	5	6	7	8
Pressure(KPa)	9.8	19.6	29.4	49.0	58.8	68.6	78.4
Results (Existence of the water)	Non abnormality (Not recognized)	Non abnormality (Not recognized)	Non abnormality (Not recognized)	Non abnormality (Not recognized)	Non abnormality (Not recognized)	Non abnormality (Not recognized)	Non abnormality (Not recognized)

problem was seen even at a simulated water depth of about 8 meters. The meter is designed to float if dropped in water, and thus is sufficiently waterproof for practical use.

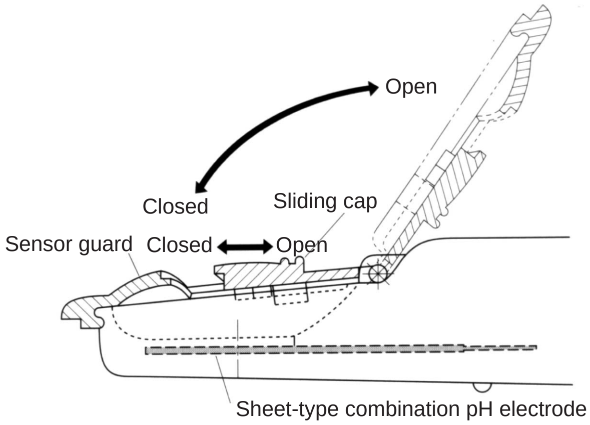
4. Scooping Measurement and Sensor Guard

The structure of the sensor guard is shown in **Figure 3**.

The periphery of the flat sensor is in the shape of a spoon and the sensor guard is attached over it to form a cover. The end of the sensor has a bucket-like structure, and in situations where the collection opening is narrow, the meter can be inserted vertically through the opening to directly scoop up and measure the sample. Naturally the user can take advantage of the shape of the sensor end and use it to scoop up a sample like a spoon. The sensor guard has a sliding cap that opens and closes, and the entire sensor guard can also be opened.

The procedure for scoop-up measurement is shown in **Figure 4**. The sampling amounts for scoop-up measurement are shown in **Table 5**. We investigated these amounts because of the likelihood that they differ for different sample types, in particular differences may occur due to different surface tensions. The meter is capable of reliable measurement if at least 0.1 ml of sample is gathered on the responder of the flat sensor. Thus, measurement is more than possible if the sensor guard is immersed in the sample, swished lightly two or three times, and then used to scoop up the sample. The sensor guard is attached so that it covers the flat sensor, and therefore we verified the correct response of the sensor to changes in sample pH. **Table 6** shows the change of response when pH 4 and pH 10 buffer solutions are changed, and **Table 7** shows the change response when a pH 4 buffer solution is changed to a pH 10 buffer solution.

As **Table 6** shows, there is practically no contamination due to lingering traces of the prior solution when the sample is a low-pH buffer solution. As **Table 7** shows, washing the sensor by scooping up ion exchange water twice after measurement of a high-pH buffer solution, such as a standard solution used for calibration, eliminates



For immersion and scooping measurement: Open the slide cap on the sensor guard.

For flat measurement: Open the entire sensor guard.

Fig. 3 Structure of the sensor guard

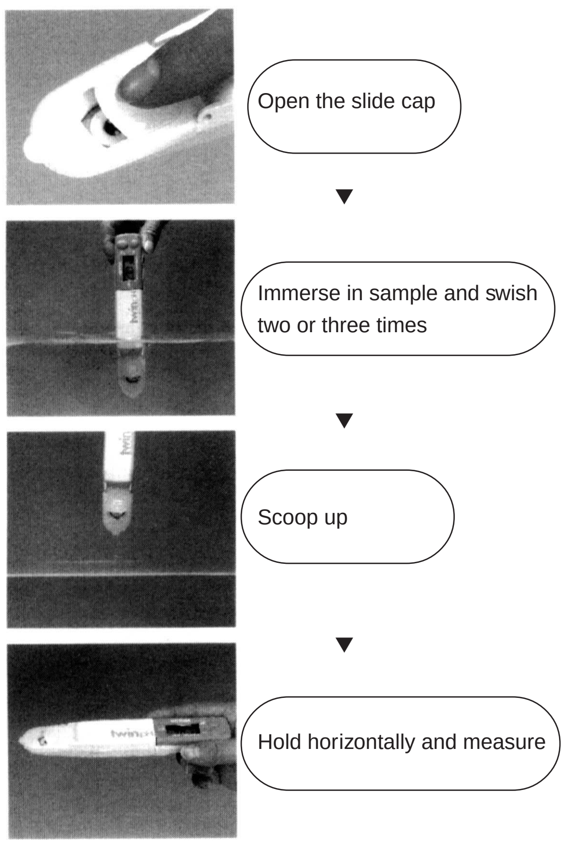


Fig. 4 Scoop-up measurement method

Table 5 Sampling amount by scoop-up measurement

Units:ml

Sample type \ Collection method		(1)	(2)	(3)
Ion exchange	Average sampling amount for 10 samples	0.57	0.71	1.03
	waterMaximum sample amount	0.64	0.76	1.30
	Minimum sample amount	0.52	0.64	0.90
pH 7 standard solution	Average sampling amount for 10 samples	0.61	0.78	1.13
	waterMaximum sample amount	0.70	0.84	1.23
	Minimum sample amount	0.54	0.73	0.99
1% neutral detergent water	Average sampling amount for 10 samples	0.61	0.81	1.05
	waterMaximum sample amount	0.70	0.90	1.21
	Minimum sample amount	0.50	0.70	0.88

(1) The sensor guard is immersed in the sample up to the bottom edge of the outlet window.
(2)The sensor guard is completely immersed in the sample.
(3) The sensor guard is completely immersed in the sample and lightly swished left and right.

Table 6 Substitution response by pH buffer solution

Response time	pH 4 solution → pH 10 solution			pH 10 solution → pH 4 solution		
	(1)	(2)	(3)	(1)	(2)	(3)
After 10 sec.	9.6	9.6	9.4	4.0	4.3	4.4
After 20 sec.	9.6	9.8	9.8	4.1	4.2	4.2
After 30 sec.	10.0	9.9	9.9	4.1	4.1	4.1
After 40 sec.	10.0	9.9	10.0	4.1	4.1	4.1

Solution:
•pH 4 solution: 10^{-4} mol/l HCl solution
•pH 10 solution: 10^{-4} mol/l NaOH solution
Measurement method:
(1) Immersion method (conventional method): The sensor is washed with ion exchange water and wiped dry with a tissue paper before changing to new solution.
(2) Scoop-up measurement: Ion exchange water is scooped up and then drained before changing to new solution.
(3) Scoop-up measurement: No washing with ion exchange water before changing to new solution.

Table 7 Substitution response when high pH buffer solution is replaced by low pH buffer solution

Response time	pH 4 solution → pH 10 solution		
	(1)	(2)	(3)
After 10 sec.	5.4	8.8	9.2
After 20 sec.	5.4	9.3	9.6
After 30 sec.	5.3	9.4	9.8
After 40 sec.	5.1	9.4	9.9
After 50 sec.	5.0	9.4	9.9

Solution:
•pH 4 solution: 0.05 mol/l potassium phthalate
•pH 10 solution: 10^{-4} mol/l NaOH solution
Measurement method:
(1)Scoop-up measurement: No washing with ion exchange water before changing to new solution.
(2)Scoop-up measurement: Ion exchange water is scooped up and then drained before changing to new solution.
(3)The sensor is washed with ion exchange water and wiped dry with a tissue paper before changing to new solution.

contamination when a new sample is measured. In neither case is it necessary to open the sensor guard, wash the sensor, and then wipe off all water. Simply scooping up ion exchange water is sufficient to allow accurate subsequent measurement.

5. Conclusion

This article introduced the Twin Waterproof compact pH meters and described their waterproof structures, scoop-up measurement features, and sensor guards. Maintaining the high performance of our previous pH meters, the Twin Waterproof features enhanced functions for easy and convenient measurement in difficult measurement situations. We hope that many people will use this meter and that pH measurement applications will continue to grow.

References

1) “Compact Ion Meter Using a Flat Electrode: Applications,” Katsuhiko Tomita, Hiromi Okawa, Junji Kojima.
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