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BULOVA WRIST WATCH, SUBMERSIBLE

C. Prickett, et al

Navy Experimental Diving Unit
Washington, D.C.

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3. ABSTRACT

Three preproduction samples of a BULOVA submersible wrist watch manufactured under BuShips contract in accordance with MIL-SHIPS-W-2181 are evaluated. Watertightness, readability-in-darkness and various subjective tests are reported. The specified test depth is 392 feet (175 psi), held for one hour. The watch face includes a moisture color-indicator and also a control color patch and change in color has been used as an acceptance criteria for watertightness. Two of the three watches indicated moisture, one during testing and the other several days after testing. No water or moisture was noted in the case. Readability of the watch in darkness, underwater, was satisfactory with the exception of the second hand which was too thin to be seen. Several physical improvements are recommended as a consequence of subjective evaluation. The watches are not recommended for acceptance in that the specified watertightness test has not been met.

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EVALUATION REPORT 5-58

BULOVA WRIST WATCH, SUBMERSIBLE

PROJECT NS186-200 SUBTASK 4 TEST 43

10 MARCH 1958

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ABSTRACT

Three preproduction samples of a BULOVA submersible wrist watch manufactured under BuShips contract in accordance with MIL SHIPS-W-2181 are evaluated. Watertightness, readability-in-darkness and various subjective tests are reported. The specified test depth is 392 feet (175 psi), held for one hour. The watch face includes a moisture color-indicator and also a control color patch and change in color has been used as an acceptance criteria for watertightness. Two of the three watches indicated moisture, one during testing and the other several days after testing. No water or moisture was noted in the case. Readability of the watch in darkness, underwater, was satisfactory with the exception of the second hand which was too thin to be seen. Several physical improvements are recommended as a consequence of subjective evaluation. The watches are not recommended for acceptance in that the specified watertightness test has not been met.

SUMMARY

PROBLEM

Do the preproduction samples of the Bulova submersible wrist watch meet the watertightness and luminosity tests specified in SHIPS-W-2181?

Perform additional subjective tests to fully evaluate the watch as a practical swimmer's time-piece.

FINDINGS

Two of the three watches indicated entrance of moisture into the case as evidenced by the color indicator.

The readability-in-darkness of the watch's face, bezel ring and minute and hour hands is satisfactory. The second hand's readability is inadequate.

The watch strap supplied is too long and provision for adjustment is inadequate.

The watch stem appears to be vulnerable to damage.

RECOMMENDATIONS

It is recommended that the watch, as exhibited by the preproduction samples, not be accepted for production in view of the unsatisfactory watertightness.

It is recommended that:

- (a) The two watches which leaked be opened to determine how much moisture entered and its affect.
- (b) The second hand be made wider.
- (c) An improved strap be furnished.
- (d) Protection be provided the stem.

A. ADMINISTRATIVE INFORMATION

On 5 February 1958, representatives of BuShips, Code 565, delivered by hand, three Bulova submersible wrist watches (pre-production samples) for test in accordance with contract NObs 73016. These watches had been designed and developed under the above contract to conform to "Bureau of Ships Contract Specification; Wrist Watch, Submersible," SHIPS-W-2181 of 5 December 1955.

Work at the Experimental Diving Unit was performed under the continuing project NS186-200, Subtask 4, Test 43 entitled "Miscellaneous Swimmer's Auxiliary Equipment." Charges incurred were lodged against allotment 16102/58.

Magnetic signature testing, shock testing, and accuracy checks called for in the specification are being carried on under the direction of the Bureau of Ships at other activities and are not covered in this report.

C. M. PRICKETT, GM1(DV), USN and J. L. WHEAT, MEC(DV), USN were designated as Project Engineers and LCDR W. F. SEARLE, Jr., USN as Project Officer. Preliminary runs were conducted and witnessed by BuShips representatives on 6 February 1958. Detailed testing was commenced on 7 February and completed on 19 February. In May 1957 three similar watches had been submitted for preproduction test and found to leak at depth during the preliminary runs in the presence of BuShips representatives and were returned to the manufacturer without formal report.

The following breakdown indicates the manpower expended on this project:

<u>DESCRIPTION</u>	<u>MANHOURS</u>
Preliminary Runs (May 1957)	10
Preliminary Runs (Feb 1958)	6
Depth Runs (chamber)	5
Subjective working dives	8
Luminosity tests	8
River runs	10
Report preparation	10
Clerical services	10
TOTAL	67

The original preproduction samples were returned to Code 565 in May 1957 without formal report and the current preproduction samples were returned on 24 February 1958. This is the first report of the subject watches. A subsequent report will be furnished if and when improved preproduction samples are submitted.

This report is issued in the evaluation report series and is distributed only by the Bureau of Ships.

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1. OBJECT

1.1 Object

1.1.1 The object of this project is to evaluate the preproduction samples of the Bulova Submersible Wrist Watch to determine conformance with BuShips Contract Specification SHIPS-W-2181 of 5 December 1955.

1.2 Scope

1.2.1 This report covers those tests in the specification concerning water-tightness at depth and liminosity. Tests of the time-keeping accuracy, the magnetic signature and shock resistance are to be performed elsewhere.

1.2.2 Though not covered by the specification, a test is also included of the tendency of the watch's outer, rotatable ring to clog and become inoperable when working in sand or silt.

1.3 Background

1.3.1 The watch has been developed under the cognizance of the Bureau of Ships to meet an operational need of UDT and EOD swimmers. The previous standard USN submersible watch and available commercial underwater watches have not proved satisfactory.

2. DESCRIPTION

2.1 General

2.1.1 The watch has been manufactured to meet BuShips specification SHIPS-W-2181 of 5 December 1955. Contract NObs-73016 requires the submission of a complete set of manufacturing drawings and therefore a detailed description will not be included in this report.

2.1.2 The watch is approximately 1 5/8 inches in diameter, 1/2 inch thick and weighs 3 ounces dry (excluding strap). Submerged weight (excluding strap) is 2.3 ounces.

2.2 Specifications

2.2.1 The primary requirement of the watch is that it be water-tight to specified test depth. Pertinent paragraphs from the contract specification are quoted as follows:

"3.6.1 Requirements, Case, General.

--The case and crystal assembly shall be sealed and sufficiently rigid to withstand a hydrostatic pressure of 175 pounds per square inch (gage) with no leakage and no deformation which might interfere with the proper functioning of the movement. A moisture vapor sensitive test will be used to detect leakage.--

"3.9 Requirements, Moisture Indicator.

A moisture indicator shall be securely fastened to the dial in a visible location. The free rotation of the hands shall not be affected when the indicator is in place. - - .

"4.3.6 Inspection Tests, Watertightness Test.

Each watch shall be thoroughly dried and sealed at atmospheric pressure with its moisture indicator distinctly showing a deep blue portion and a pink portion. The ambient temperature during this test shall be 75°F +10°F. Each watch shall then be placed in the pressure vessel in any position and surrounded with water at a pressure of 175 pounds per square inch (gage) +5 minutes. The watch shall then be removed from the pressure vessel and allowed to sit in the open air for 2 hours +10 minutes. It shall then be visually examined for any evidence of water penetration. Any watch whose moisture indicator is no longer clearly divided into a blue portion and a pink portion shall be rejected.

"6.1 Notes, General Material.

- - A watch which is impervious to the entrance of water vapor for periods of many months is highly desirable."

2.2.2 The hands and face of the watch are intended to be visible in the dark. Paragraph 3.7.1 and 3.7.4 of the contract are quoted as follows:

"3.7.1 Requirements, Dials and Hands, General

Readability of this watch is of primary importance. It shall be able to be read in total darkness. Care shall be taken to ensure that all markings are sharp edged, clean and readily distinguishable from other remove and adjacent marks.

"3.7.4 Requirements, Dials and Hands.

- - The three hands shall be distinctly different from each other and shall clearly stand out from the dial

background when viewed in either natural daylight conditions or in total darkness."

2.2.3 The watch case is fitted with an outer, rotatable ring, spring loaded, for indicating elapsed time. Paragraph 3.6.6 of the contract specification is quoted as follows:

"3.6.6 Requirements, Case, Rotatable Ring.

The watch shall be equipped with a rotatable ring in the location normally occupied by the bezel. - - In use, the ring will be rotated to line up the index mark with one of the hands. - - The ring shall be designed to be rotated and set by hand without tools and shall be protected against unintentional movement caused by abrasion, shock and vibration."

3. PROCEDURE AND RESULTS

3.1 Depth Runs

3.1.1 Watertightness or depth runs on the watches were conducted as follows:

(a) The watch was suspended in a beaker of fresh water inside a recompression chamber and located directly in front of a port hole so as to be clearly visible for observation from outside. The watch was running. Chamber pressure (depth was increased at a rate of approximately 30 feet per minute. For the preliminary runs and the first test run, in both of which the watch face was vertical, the descent was stopped for two minutes at each 50 foot level to observe color of the indicators and any possible leakage. In the second test run with the watch face horizontal, no 50 foot stops were made since the face could not be observed.

(b) Final depth was 392 feet for all runs. This depth was held for 15 minutes in the preliminary runs and for one hour in each of the two test runs. The ascent was regulated slowly so as to return the chamber to the surface in 15 minutes, keeping a close watch for bubbles which might emanate from the watch case.

(c) Before and after each run the color indicators were closely observed by three different divers. Colors were closely observed during the runs (except for the second test run wherein the watch face was horizontal and not visible through the port) and immediately after removal from the chamber. Colors were also observed one hour after the run, and, thereafter, at random times (at least once daily) over the succeeding two weeks.

(d) The watches were worn by divers during working dives in conjunction with another project. The watches were wound and reset (bare handed) at maximum depth and observed closely.

3.1.2 The three watches tested carried manufacturer's serial numbers 0036, 0063, and 0120. Of the three watches, one passed all the watertightness tests with no leakage as indicated by the color indicator maintaining its original colors; one watch passed all the tests with no indication of moisture, but two days later had changed color; one watch passed the preliminary run with no indication of moisture but by three days later, after two relatively shallow working dives and before further test runs to specified test depth, had changed color. Neither of the two watches in which moisture was indicated appeared to contain water nor did either of them emit bubbles which were discernible during ascent from the specified test depth. All the watches appeared to be running satisfactorily when returned to the Bureau of Ships after all tests.

3.1.3 The water temperature in the beakers in which the watches were suspended was maintained at approximately 75°F throughout all runs.

3.1.4 The results of the test of each watch, presented chronologically, is as follows:

(a) #0036

6 Feb	Preliminary Run - 15 min bottom time at 392 feet	No color change. No bubbles observed on ascent.
11 Feb	Test working dive. 50 min at 130 feet. Total dive 72 min	No color change. Watch wound and reset at 130 feet.
12 Feb	Test working dive. 40 min at 130 feet Total dive 56 min	No color change. Watch wound and reset at 130 feet.
13 Feb	Test run #1. Verti- cle. One hour at 392 feet.	No color change. No bubbles during ascent.
17 Feb	Test run #2. Hori- zontal, face down. One hour at 392 feet.	No color change. No bubbles during ascent.
24 Feb	Returned to BuShips	No color change. Watch running.

(b) #0063

5 Feb	Preliminary run. 15 min bottom time at 392 feet.	No color change. No bubbles observed during ascent. Test witnessed by BuShips representatives.
6 Feb	AM - Test working dive. 40 min at 110 feet. Total dive 46 min	No color change. Watch running nor- mally. Wound and reset at 110 feet.
	PM - Test working dive. 40 min at 110 feet. Total dive 46 min	No color change. Watch running nor- mally. Wound and reset at 110 feet.
7 Feb		Slight color change observed.
8 Feb		Color completely changed. Watch running.
13 Feb	Test run #1. Verti- cle. One hour at 392 feet.	No further change in color. No bubbles during ascent. No fogging or water observed in case. Watch running.
17 Feb	Test run #2. Hori- zontal, face down. One hour at 392 feet.	No further change in color. No bubbles during ascent. No fogging or water observed in case. Watch running.

(c) #0120

6 Feb	Preliminary run.	No color change. No bubbles observed on ascent.
11 Feb	Test working dive. 50 min at 130 feet. Total dive 72 min	No color change. Watch wound and reset at 130 feet.
12 Feb	Test working dive. 40 min at 130 feet. Total dive 56 min	No color change. Watch wound and reset at 130 feet.

13 Feb	Test run #1. Vertical. One hour at 392 feet.	No color change. No bubbles during ascent.
17 Feb	Test run #2. Horizontal, face down. One hour at 392 feet.	No color change. No bubbles during ascent.
18 Feb		Color normal.
19 Feb		Color completely changed. No fogging or water observed in case. Watch running.
24 Feb	Returned to BuShips	No further color change. No indication of fogging or water in case. Watch still running.

3.2 Luminosity Tests

3.2.1 Six experienced divers and swimmers were used as subjects in the evaluation of the ability to read the watches in the dark. The men were placed in a completely darkened recompression chamber (dry) and then underwater in a completely darkened tank and instructed to observe the readability of the watches' hands, face, and bezel ring. The underwater tests were conducted at a depth of six feet.

3.2.2 All subjects reported that, once adapted to the dark, they could read the numerals and intermediate markings on the watch face and bezel ring and that the minute and hour hands could be resolved easily with the watch held approximately six inches from the face. Four of the subjects could not see the second hand no matter how close the watch was held. Two of the subjects were able to see the watches' markings and larger hands at from two to three feet with one reporting ability to see the second hand (with difficulty) with the watch directly in front of his face and the other able to "catch a glimpse of the second hand on the twelve and three mark" with the watch approximately one foot away.

3.3 Bezel Ring Adjustment

3.3.1 It was suspected that some difficulty would be experienced with the adjustable bezel ring jamming as a consequence of sand or grit if the watch were used in sand or silt. Divers working in the Anacostia River were instructed to deliberately work with watch below the silt and mud and to attempt to jam the ring.

3.3.2 After work in the sand and silt, the bezel ring was easily freed of fouling by a few twisting movements of the ring and by "swishing" the arm through the water to wash it out. These tests were conducted in May 1957 on the original watches submitted.

4. DISCUSSION

4.1 Watertightness

4.1.1 The three watches evaluated and reported herein were definitely more watertight than the watches submitted originally in May 1957. But, as indicated by results, they do not as yet strictly conform to the requirements of the specification in that the moisture indicators on two of the three samples changed color. However, the watches continued to run and there was no evidence of water or fogging on the underside of the crystals. In the case of the original watches, the cases actually began to fill with water and, during ascent from 392 feet, bubbles were observed coming out at the stem as the pressure in the case reduced. No bubbles were experienced in the current series of runs.

4.1.2 No attempt has been made to check the time-keeping accuracy of the watches in which the color indicator recorded moisture nor have the cases been opened to check for internal moisture. The watches should be so checked and opened to observe water, if any, which may have entered the case. It may be that the moisture indicators changed, not as a consequence of the test runs to depth, but rather from inadequate elimination of moisture when initially sealed. It is noted that there is no requirement in the MILSPEC for duration of shelf-life during which no color change is to take place in the indicator. It may be wise to determine if a group of watches all hold their color for a long term (several months) shelf-life. If this is the case, it would then follow that a color change recorded in depth tests is definitely as a consequence of the test.

4.2 Luminosity

4.2.1 The general configuration of the watch's face, bezel, and hands appears to be satisfactory and the numerals and positions of the hands resolvable with no difficulty, except for the second hand. The readability in darkness is adequate except for the second hand.

4.2.2. The second hand is too fine and can not be seen at all by most divers and only with difficulty by a few. The second hand, if it were made somewhat wider, would probably be as easily discerned as the minute hand.

4.3 Bezel Ring

4.3.1 Once a diver has tried-out and understands the operation of the adjustment of the bezel ring (push-in-to-turn) beforehand, there is no difficulty in setting it underwater. Surprisingly, there was no difficulty observed in the ring jamming through it is suggested that more severe usage may be expected when worn by UDT swimmers working in sand and coral.

4.4 General

4.4.1 The initial reaction of the divers who tested the watch was that it was too heavy. After swimming and use, however, they became accustomed to the watch and no longer critical of its weight. It is noted that the companion swimmer's wrist depth gage was reported by Leyden (EDU Evaluation Report 9-57, "Bendix-Friez Wrist Depth Gage," 8 Nov 1956) weighs 5.28 ounces dry compared to the subject watch's 3 ounces.

4.4.2 There was general agreement that the watch strap supplied was not satisfactory. It was far too long and could not be adjusted to normal wrist diameter. It appears that the strap has been designed for use over a rather thick gauntlet or exposure suit though even with this additional diameter, the strap is still too long. It is suggested that the strap be shortened, provided with holes for adjustment to normal wrist size and made of one piece with the strap passing beneath the case and providing additional protection from chafing a rubber exposure suit.

4.4.3 Several of the subjects expressed a concern over the exposed position of the stem and suggest a removable guard or cap for physical protection (not for additional watertightness). A possible solution to this would be to move the stem 180 degrees and place it "up-arm" rather than towards the hand by merely reorienting the watch face. This latter position would afford more protection at the expense of ease of winding and setting. It may, however, be assumed that the underwater watch, when used exclusively for its special purpose (underwater), will nearly always be wound and set before being placed on the wrist. There is little or no need to require ease of winding and setting while on the wrist.

4.4.4 No difficulty was experienced in either winding or setting the watch on the surface with bare fingers. The watch can not be wound or set wearing swimmer's gloves. This feature of the watch appears to be acceptable. The stem pulls out to set and it is suggested that repeated use (axial movement) may, in time, reduce the watertightness of the "O" ring seals. In view of this, it is suggested that the watches should not be used as a casual time-piece, but, rather, should be retained by the

operational units for use only when actual underwater operations are involved.

4.4.5 As noted above, the watch can not be wound or set underwater or on the surface by a swimmer wearing gloves. However, the bezel ring can, after practice, be manipulated wearing the thin rubber gloves of an exposure suit. No attempt has been made to test the ability of a swimmer in very cold water to adjust the ring, with or without gloves.

5. CONCLUSIONS

5.1 Conclusions

5.1.1 It is concluded that the watertightness of the revised watches (tested in February 1958) is far superior to that of the watch originally submitted (May 1957), but that moisture is still entering the case, though in small, and possibly, insignificant quantity. Two of three watches tested indicated leakage.

5.1.2 The readability of the watch is satisfactory with the exception of the second hand which is too thin to permit easy resolution.

5.1.3 The various subjective or physical aspects of the watch are generally satisfactory though it is suggested that the strap be improved and that protection be provided the stem.

5.2 Recommendations

5.2.1 It is recommended that the watch not be accepted until it is definitely determined that no water or moisture is entering the case. It is recommended that the two watches in which the indicators changed color be given an after-test time-check and that they be opened and inspected to determine the amount of moisture inside and damage or corrosion which may have occurred. A reduced, interim pressure acceptance criteria may be in order.

5.2.2 It is recommended that the second hand be made slightly wider to improve its readability in darkness.

5.2.3 It is recommended that an improved strap be provided and that a means of protecting the stem be devised.

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