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EFFECTS OF WATER SALINITY AND TEMPERATURE ON MK 72 SEA WATER BATTERY FUNCTION

Tom J. Sanders, et al

Naval Ammunition Depot
Crane, Indiana

24 July 1973

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Recommendations are made to modify the marker specification for the static test to meet minimum test conditions of 1.5% and 40°F. Any future flight tests should be preceded by testing of the water for the necessary salinity and temperature requirements.

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ABSTRACT

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Recommendations are made ` modify the marker specification for the static test to meet minimum test conditions of 1.5% and 40°F. Any future flight tests should be preceded by testing of the water for the necessary salinity and temperature requirements.

EFFECTS OF WATER SALINITY AND TEMPERATURE ON MK 72 SEA WATER BATTERY FUNCTION

BACKGROUND

Flight testing of the Mk 25 Marine Location Marker, Lot 2-KC-72 from the Kilgore Corporation, resulted in four no ignitions of 32 units tested at NATC Patuxent River, Maryland (Pax River). Acceptance tests, according to paragraph 3.3.1.3 of MIL-M-81392, at NAD Crane resulted in no failures in static function testing of 40 units (20 units static functioned unconditioned and 20 units after vibration tests).

The four failures were recovered and the fuse covers were removed. The Mk 72 Sea Water Batteries were disconnected from the squib wires and a new power source consisting of a 1.5 volt dry cell battery was used to function the four units. All four units functioned satisfactorily. This indicated an inadequate voltage output from the Mk 72 battery.

Water taken from the test area on the day of the test was returned to NAD Crane where it was titrated for the chloride content. From the titration, the salinity was calculated to be .98 percent for the water sample. A second sample, taken a week later, was received and tested. Results indicated a salinity of 1.34 percent.

An investigation was initiated to determine the effect on voltage output when the salinity and temperature is varied.

TESTING

Tests were conducted using the Mk 72 Sea Water Battery and the Mk 25 MLM which uses the Mk 72 as the power source. The batteries were dropped from the battery test fixture (SA Drawing 2522918) into five saline solutions. Tests were also conducted using the Mk 25 MLM by dropping the markers into a larger quantity of the same solutions after the blow plugs in the base had been pushed into the battery cavity. The markers were tested to obtain more realistic data on the voltage rise times since batteries tested in the battery fixture are subjected to a sudden immersion into the water, whereas the batteries in the markers are activated after the battery cavity has filled with water flowing in through the base plug holes.

MK 72 SEA WATER BATTERY

Solutions were mixed according to A.S.T.M. D-1141-52 at the standard sea water concentration (approximately 3 percent), .5, 1.0, 1.5, and 2.0 percent. All solutions were conditioned to 32°F. A load of 1.98 ohms was placed across each battery in the battery test fixture as specified by OS 8765. Eight batteries were dropped into each of the .5, 1.0, 1.5 and standard sea water solutions; five from battery lot 16 and three removed from lot 6-CIL-71 Mk 25 MLM's. Five batteries from battery lot 1 were tested in the 2.0 percent solution. The voltage versus rise

time was monitored using a Mosley recorder with settings of 60 divisions per minute and one volt per inch.

The five solutions were warmed to 38°F and 45°F. Ten batteries were dropped from the fixture into each of the .5, 1.0, and 1.5 percent solutions at each temperature. Five batteries were dropped into the standard solution. Voltage versus time was recorded. The solutions were then warmed to 55°F and eight batteries dropped into each of the standard, .5, 1.0, and 1.5 percent solutions.

Water samples taken at Pax River near the test area were also used as test solutions. Sample #1 was taken on the day lot 2-KC-72 was tested. Sample #2 was taken a week later. Sample #1 was shown to contain .54% chlorinity by titration while Sample #2 tests showed .74%. Salinities of .98% and 1.34% were calculated for Samples #1 and #2, respectively, by multiplying the chlorinity by 1.807 in accordance with the method outlined by Publication #607 of the Naval Oceanographic Office, Washington, D. C. Due to the limited quantity of each sample available, tests were run by hand dropping batteries into the solutions. Testing was done at 76°F for Sample #1 and 78° and 32° for Sample #2.

MK 25 MARINE LOCATION MARKER

Forty units from lot 6-CIL-71 were wired to monitor voltage output versus time. Squib resistance (static) was measured

using a Simpson Model 27 Ohm meter. Larger quantities of the five solutions were mixed. Dry ice was used to cool the solutions to 32°F. The blow plugs were pushed into the marker base. The units were dropped from the Mk 25 test fixture to achieve a uniform entry velocity into the solution. Voltage versus rise time was monitored. The units functioned in the test solutions and were removed immediately to another barrel to keep the contamination of the test solutions to a minimum. Delay time from water entry to the emission of smoke and flame was recorded.

TEST RESULTS

Mk 72 Sea Water Battery

All batteries and markers were at ambient conditions for all tests. Internal resistance of the batteries was considered a constant and for purposes of the tests, negligible. Resistances for the squibs and 1.98 ohm resistor were measured static resistances. The assumption was made that the static and the dynamic resistances were equivalent. Figure 1 shows successes and failures at varying salinity and temperature for the battery tests. Figures 2 through 5 show a plot of voltage versus time for varying percent salinity at 32°, 38°, 45°, and 55° obtained from battery test data.

FIGURE 1

Mk 72 Sea Water Battery Results

Salinity %	32°	38°	45°	55°
.5	XXXXXXXX	XXXXXXXXXX		XXXXX
1.0	XXXXXXXX	**********	X**********	*****
1.5	XXXXXXX*	**********	**********	*****
2.0	X*********			
3.0	********	*****	*****	*****

X - Failed to meet voltage or rise time requirement of 1.0 volt within 2.5 seconds with a load of 1.98 ohms.

* - Voltage and rise time within spec.

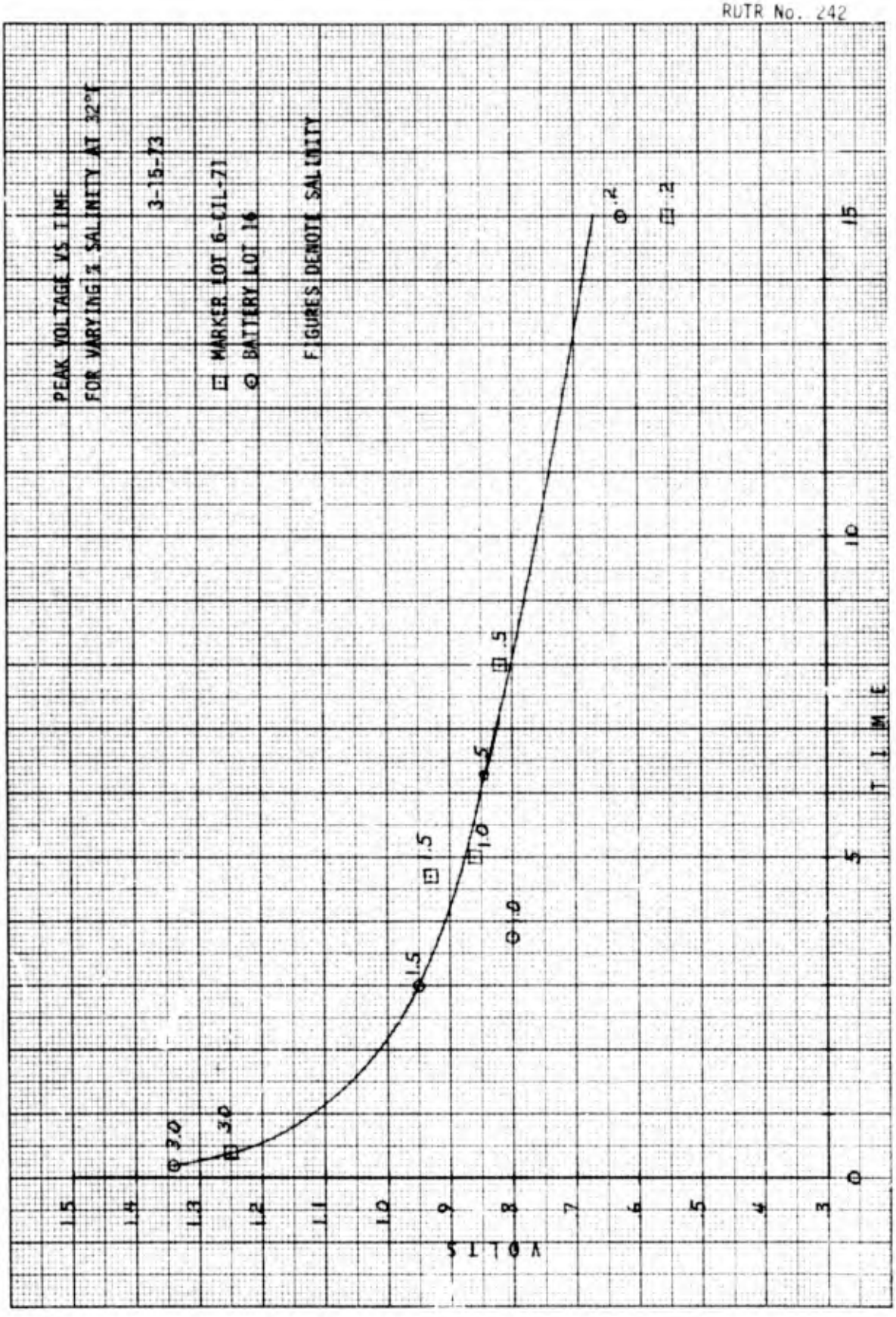
PEAK VOLTAGE VS TIME
FOR VARYING SALINITY AT 32°F
3-15-73
MARKER LOT 6-CIL-71
BATTERY LOT 16
FIGURES DENOTE SALINITY
VOLTS
TIME
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
0
5
10
15
30
30
1.5
1.5
1.0
.5
.5
0
.2
.2

FIGURE 2

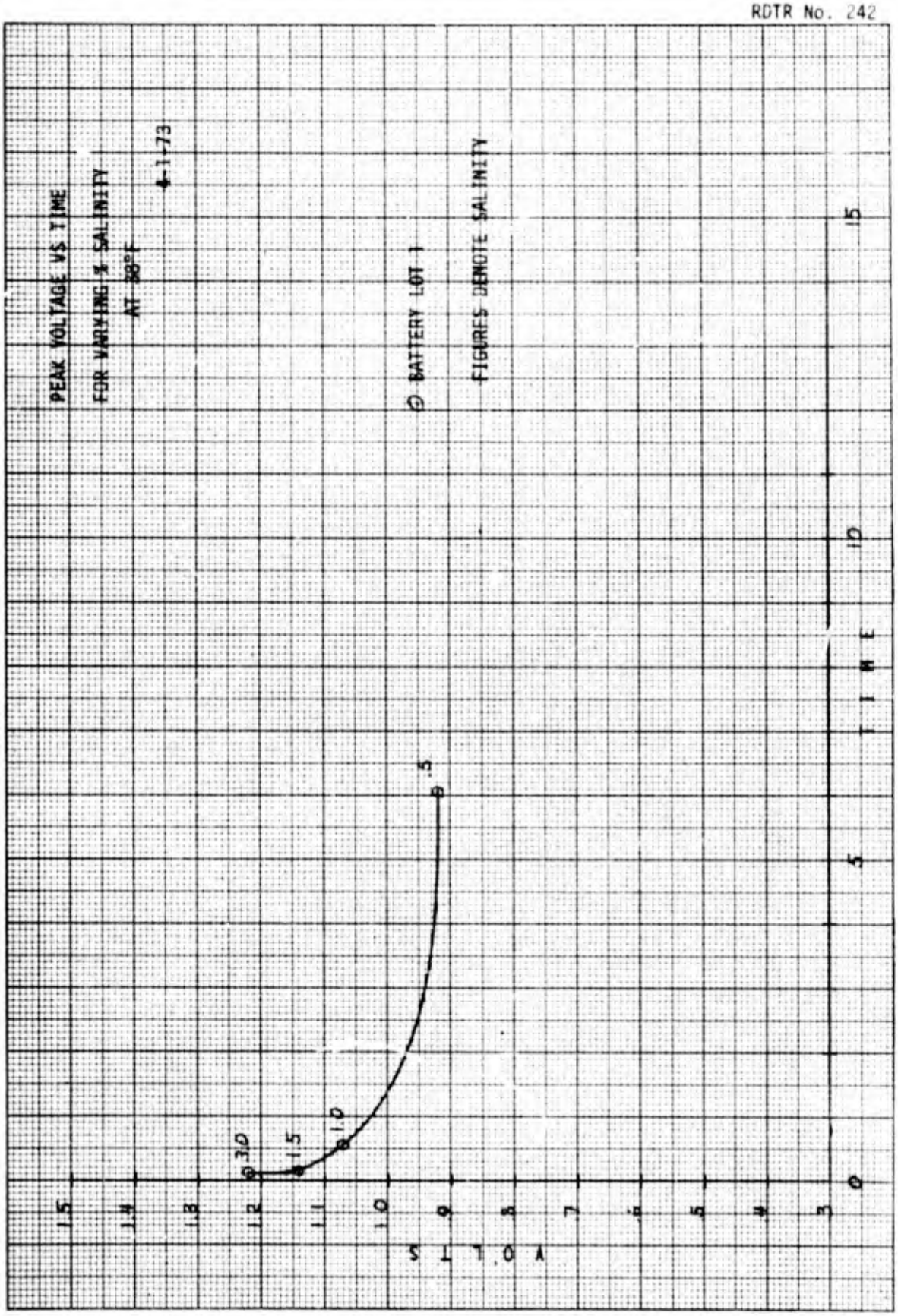
PEAK VOLTAGE VS TIME
FOR VARYING % SALINITY
AT 80°F
1-173
BATTERY LOT 1
FIGURES DENOTE SALINITY
.5
1.0
1.5
2.0
VOLTS
TIME
0
5
10
15

FIGURE 3

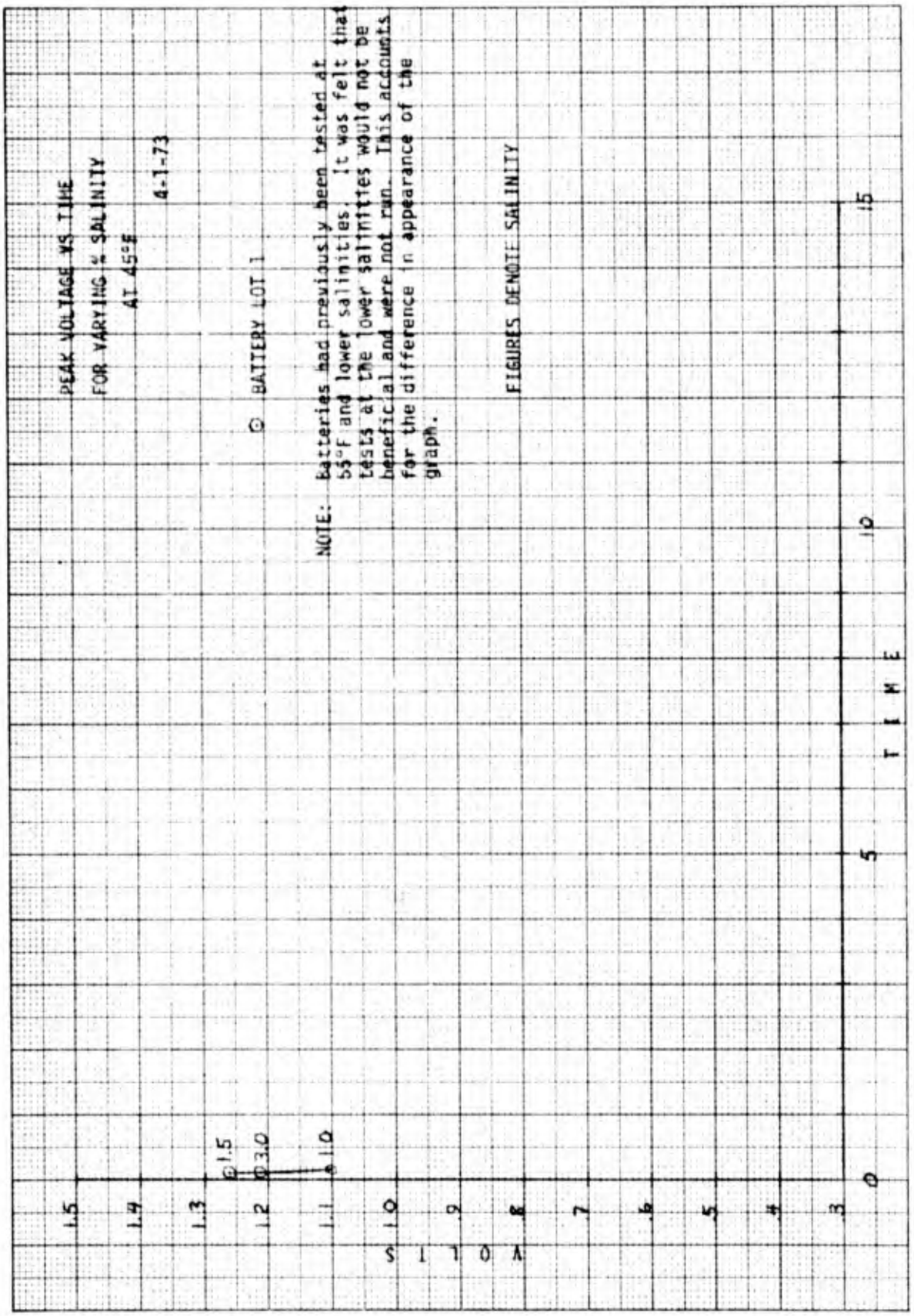
PEAK VOLTAGE VS TIME
FOR VARYING % SALINITY
AT 45°F
4-1-73
BATTERY LOT 1
NOTE: Batteries had previously been tested at 55°F and lower salinities. It was felt that tests at the lower salinities would not be beneficial and were not run. This accounts for the difference in appearance of the graph.
FIGURES DENOTE SALINITY
VOLTS
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
1.5
3.0
1.0
0
5
10
15
TIME

FIGURE 4

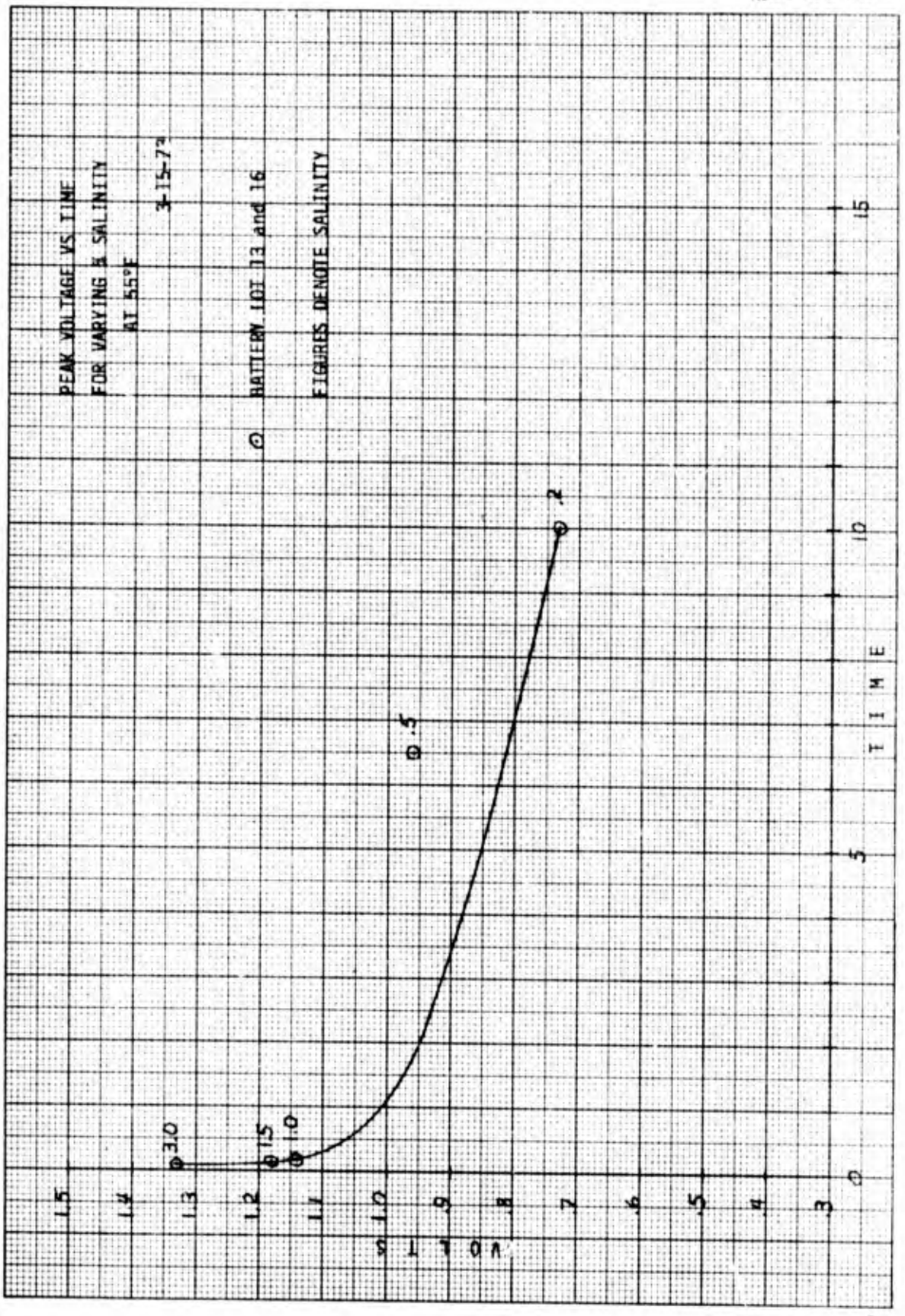
PEAK VOLTAGE VS TIME
FOR VARYING % SALINITY
AT 55°F
3-15-72
BATTERY LOT 13 and 16
FIGURES DENOTE SALINITY
3.0
1.5
1.0
.5
.2
VOLTS
TIME
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
0
5
10
15

FIGURE 5

Insufficient voltage was obtained from batteries in the .5, 1.0, and 1.5 percent solutions at 32°F. Average peak voltage in 1.5% solution was near the required 1.0 volt at .944 volts but rise time was 3.06 seconds; above the maximum requirement of 2.5 seconds. The .5 and 1.0 percent solutions produced lower peak voltages with lower rise times as shown in Table 1. Voltages of 1.18 and 1.34 were recorded within the required 2.5 seconds in the 2.0 and standard solutions, respectively.

At 38°F the .5 percent solution failed to reach one volt within the prescribed time. The 1.5 percent solution produced a peak voltage of 1.14 with an average rise time of .12 seconds. Batteries in the standard solution continued to meet specifications. All solution tests, 1.0, 1.5, and 3.0 gave satisfactory results when warmed to 45°F.

Again at 55°F conditioning, all but the .5 percent solution produced the necessary battery output of 1.0 volts. The .5 solution approached this requirement with an average peak voltage of .97 volts but failed due to a rise time of 9.0 seconds.

TABLE 1

Battery Test Results

Salinity %	Water Temperature (F)	Battery Lot Number	Number Tested	Avg Peak Voltage (Volts)	Avg Time to Peak (Seconds)
.5	32	16	5	.84	6.30
1.0	32	16	5	.79	3.76
1.5	32	16	5	.94	3.06
2.0	32	1	8	1.18	.16
3.0	32	16	5	1.34	.18
.5	32	*	3	.82	8.00
1.0	32	*	3	.86	5.00
1.5	32	*	3	.93	4.70
3.0	32	*	3	1.25	.40
.5	38	1	10	.92	6.06
1.0	38	1	10	1.07	.56
1.5	38	1	10	1.14	.12
3.0	38	1	5	1.22	.11
1.0	45	1	10	1.10	.15
1.5	45	1	10	1.26	.11
2.0	45	1	5	1.21	.10
.5	54	13	5	.97	9.0
1.0	56	16	5	1.14	.16
1.5	55	16	5	1.18	.13
3.0	56	13	5	1.33	.27

* Batteries were removed from Lot 6-CIL-71 MLM's.

Pax River water Sample #1 at 76° and Sample #2 at 78° produced 5 of 5 successes in each solution. Sample #2 produced 2 of 5 successes when cooled to 32°F. The successes at the lower temperature may be attributed to the fact that the tests at 32° were run after those at 78°. The more batteries that are functioned in a small sample of solution, the higher the recorded voltages. This is due to ionization of the water. As a result, the more batteries functioned in a solution the less reliable the results. Test results for Samples #1 and #2 are shown in Table 2.

MK 25 MLM

Table 3 indicates the voltage necessary to fire the Mk 13 squib in the Mk 25 MLM. The units were wired to monitor voltage output with the squib as a load. The load was removed when the squib functioned, resulting in the peak voltage being recorded as that necessary to function the squib. At a solution temperature of 32°F, marker functioning was sporadic. Three for three failed in .5 percent, 2 of 4 in 1.0, 2 of 3 in 1.5 and 1 of 4 in 2 percent. All markers tested in standard solution at 32° were satisfactory as well as all those tested in each solution at 45°F. Tests of .5 and 1.5 percent were conducted at a solution temperature of 55°F. A thirty-three percent failure rate occurred in the .5% solution while 2 of 2 functioned in the 1.5% mixture.

TABLE 2

BATTERY TESTS IN PAX RIVER WATER SAMPLES

Sample	Water Temperature (°F)	Battery Lot Number	Number Tested	Avg Peak Voltage (Volts)	Avg Time to Peak (Seconds)
Pax #1 (.98%)	76	16	5	1.21	.78
Pax #2 (1.34%)	78	16	5	1.15	.32
Pax #2 (1.34%)	32	16	5	1.08	2.4

TABLE 3

MK 25 MLM TEST RESULTS

Salinity %	Water Temperature (°F)	Number Tested	Number Failed	Peak* Voltage (Volts)	Time to* Peak (Seconds)	Squib Static Resistance (ohms)
.5	32	3	3	.486	5.30	1.61
1.0	32	4	2	.690	4.30	1.66
1.5	32	3	2	.543	3.40	1.64
2.0	32	4	1	.700	3.39	1.62
3.0	32	3	0	.625	1.13	1.50
.5	45	4	0	.663	2.10	1.68
1.0	45	4	0	.715	1.34	1.56
1.5	45	4	0	.850	1.42	1.60
2.0	45	3	0	.693	1.97	1.60
3.0	42	3	0	.753	1.28	1.70
.5	55	3	1	.730	1.90	1.61
1.5	58	2	0	.652	.78	1.52

* Peak voltage and time to peak refer to the time necessary for the battery to reach the voltage necessary to function the squib.

All units failing to function after submersion in the saline solution were activated using an external power source. Figure 6 shows successes and failures at varying salinity and temperature for the marker tests.

FIGURE 6

MK 25 MLM Test Results

Salinity %	32°	45°	55°
.5	XXX	****	X**
1.0	XX**	****	
1.5	XX*	****	**
2.0	X***	***	
3.0	***	***	

X - Failed to function

* - Marker functioned according to spec

CONCLUSIONS

Variations in the resistance of the Mk 13 squib and the resistor placed as a load across the battery for the marker tests and the battery tests, respectively, were responsible for the differences in minimum salinity and temperature requirements.

At low temperatures (near 32°), peak voltage and rise time are highly dependent on percent of salts in solution. At 1.5% the average peak voltage was .94 in 3.06 seconds. In the standard solution a peak voltage of 1.34 volts in .18 seconds was recorded.

At higher temperatures the temperature of the solution is the major factor. Peak voltages and rise times in 1.0 and 1.5 percent solutions at 45° are approximately equal. Peak voltages and rise times in the 1.0 percent approximate those of the 1.5 percent solution at 55° also.

RECOMMENDATIONS

Revise the Mk 25 Marine Location Marker specification to specify minimum test conditions:

a. Specify minimum salinity of 1.5% (specific gravity 1.0115) and minimum temperature of 40°F for the static test.

b. Change minimum flight test requirements to 1.5 percent and 40°F.

c. Require testing of salinity and temperature of test water near test site before the flight test commences.