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JUNE 1975

LAW ENFORCEMENT STANDARDS PROGRAM

BATTERIES
FOR
PERSONAL/PORTABLE TRANSCEIVERS

STANDARD

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Law Enforcement Assistance Administration
National Institute of Law Enforcement and Criminal Justice

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LAW ENFORCEMENT STANDARDS PROGRAM

NILECJ STANDARD FOR BATTERIES FOR PERSONAL/PORTABLE TRANSCEIVERS

A Voluntary National Standard Promulgated by the National Institute of Law Enforcement and Criminal Justice.

JUNE 1975

U.S. DEPARTMENT OF JUSTICE
Law Enforcement Assistance Administration
National Institute of Law Enforcement and Criminal Justice

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This standard was formulated by the Law Enforcement Standards Laboratory of the National Bureau of Standards under the direction of Marshall J. Treado, Program Manager for Communications Systems, and Jacob J. Diamond, Chief of LESL. NBS Electromagnetics Division staff members responsible for the preparation of the standard were Harold E. Taggart, project manager, Ramon L. Jesch, and Winston W. Scott, Jr.

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NILECJ STANDARD FOR BATTERIES FOR PERSONAL/PORTABLE TRANSCEIVERS

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FOREWORD

Following a Congressional mandate [1] to develop new and improved techniques, systems, and equipment to strengthen law enforcement and criminal justice, the National Institute of Law Enforcement and Criminal Justice (NILECJ) has established the Law Enforcement Standards Laboratory (LESL) at the National Bureau of Standards. LESL's function is to conduct research that will assist law enforcement and criminal justice agencies in the selection and procurement of quality equipment.

In response to priorities established by NILECJ, LESL is (1) subjecting existing equipment to laboratory testing and evaluation and (2) conducting research leading to the development of several series of documents, including national voluntary equipment standards, user guidelines, state-of-the-art surveys and other reports.

This document, NILECJ–STD–0211.00, Batteries for Personal/Portable Transceivers, is a law enforcement equipment standard developed by LESL and approved and issued by NILECJ. Additional standards as well as other documents are being issued under the LESL program in the areas of protective equipment, communications equipment, security systems, weapons, emergency equipment, investigative aids, vehicles and clothing.

This equipment standard is a technical document, consisting of performance and other requirements together with a description of test methods. Equipment which can meet these requirements is of superior quality and is suited to the needs of law enforcement agencies. Purchasing agents can use the test methods described in this standard to determine firsthand whether a particular equipment item meets the requirements of the standard, or they may have the tests conducted on their behalf by a qualified testing laboratory. Law enforcement personnel may also reference this standard in purchase documents and require that any equipment offered for purchase meet its requirements and that this compliance be either guaranteed by the vendor or attested to by an independent testing laboratory.

The necessarily technical nature of this NILECJ standard, and its special focus as a procurement aid, make it of limited use to those who seek general guidance concerning batteries for personal/portable transceivers. The NILECJ Guideline Series is designed to fill that need. We plan to issue guidelines to this as well as other law enforcement equipment as soon as possible, within the constraints of available funding and the overall NILECJ program.

The guideline documents to be issued are highly readable and tutorial in nature in contrast to the standards, which are highly technical and intended for laboratory use by technical personnel. The guidelines will provide, in non-technical language, information for purchasing agents and other interested persons concerning the capabilities of equipment currently available. They may then select equipment appropriate to the performance required by their agency. Recommendations for the development of particular guidelines should be sent to us.

NILECJ standards are subjected to continuing review. Technical comments and recommended revisions are invited from all interested parties. Suggestions should be

[1] Section 402(b) of the Omnibus Crime Control and Safe Streets Act of 1968, as amended.

addressed to the Program Manager for Standards, National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, U.S. Department of Justice, Washington, D.C. 20531.

LESTER D. SHUBIN, *Manager*
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NILECJ STANDARD FOR BATTERIES FOR PERSONAL/PORTABLE TRANSCEIVERS

1. PURPOSE AND SCOPE

The purpose of this document is to establish performance requirements and methods of test for batteries used in personal/portable transceivers by law enforcement agencies. The requirements of this standard are stated with reference to the transceiver model with which the batteries are intended to be used.

2. CLASSIFICATION

Batteries covered by this standard are classified into the following categories:

2.1 Primary Batteries (Disposable)

2.1.1 Mercury (Mercuric Oxide)

2.1.2 Alkaline (Alkaline Manganese)

2.1.3 Carbon-Zinc (Leclanche)

2.2 Secondary Batteries (Rechargeable)

2.2.1 Nickel-Cadmium, Slow Charge

2.2.2 Nickel-Cadmium, Fast Charge

3. DEFINITIONS

The principal terms used in this document are defined in this section. Additional definitions relating to law enforcement communications are available [1].

3.1 Available Capacity

The total battery capacity, usually expressed in ampere-hours or milliampere-hours, that is available to perform work. This depends on factors such as the endpoint voltage, quantity and density of electrolyte, temperature, discharge rate, age, and the life history of the battery.

3.2 C-Rate

A normalized unit of current defined as the ratio of a particular charging (or discharging) current in amperes to the rated capacity of the battery in ampere hours.

3.3 Closed-Circuit Voltage

The voltage at the terminals of a battery when a current is flowing.

3.4 Constant-Current Charge (Discharge)

A charging or discharging method in which current does not change appreciably in response to changes of circuit parameters such as battery voltage or load resistance.

3.5 Endpoint Voltage

The closed-circuit voltage per cell at the end of the service life test; nominally, the voltage below which connected equipment will not operate or below which continued operation may injure the battery. Sometimes called cutoff voltage.

3.6 Lot

A group of items identifiable as a unit by a logical criterion such as the same code date, or same manufacturing run.

3.7 Nominal Voltage

A designation by the battery manufacturer which serves to identify a particular battery model and indicates its approximate voltage.

3.8 Rated Capacity

A designation by the battery manufacturer which serves to identify a particular battery model and also indicates its approximate capacity in ampere-hours or milliampere-hours at typical transceiver discharge rates.

3.9 Service Life

The length of time required for an unused primary cell (or battery) or a fully charged secondary cell (or battery) to discharge to a specified endpoint voltage under specified conditions.

3.10 Standby Mode

The condition when a transceiver is energized but is not transmitting or receiving.

3.11 Transceiver

The combination of radio transmitting and receiving equipment in a common housing, usually for portable or mobile use.

4. REQUIREMENTS

4.1 Battery-Transceiver Compatibility

4.1.1 Design

The battery voltage, physical dimensions, and electrode configuration shall be such

that the battery fits and properly operates the transceiver model with which it is to be used.

4.1.2 Current Drain

The transmit current, receive current, and standby current shall correspond to the currents required in those modes by the transceiver model with which the battery is to be used.

4.2 Labeling

The battery or transceiver manufacturer shall label each battery to include:
(a) name of manufacturer
(b) nominal voltage
(c) battery type and model
(d) rated capacity
(e) indication of polarity
(f) indication if battery is rechargeable
(g) recharge rate (secondary batteries only)
(h) month and year of manufacture

4.3 Sampling for Test

A sample shall be taken for test at random, using a set of random numbers or equivalent procedure. The sample size shall depend on the lot size and is given in table 1 for secondary batteries. A double sample shall be taken of primary batteries, one-half to be used for each of the service life tests required by paragraph 4.5. In each case, the sample shall comprise the entire lot when the required sample exceeds the lot size.

TABLE 1. *Sample size*

Lot Size	Sample Size	Lot Size	Sample Size
Up to 300	3	801–1300	7
301–500	4	1301–3200	10
501–800	5	3201–8000	15

4.4 Closed-Circuit Voltage

The purpose of this test is to check the electrical condition of a primary battery by sampling a small part of its discharge curve without substantially discharging the battery.

The voltage of primary batteries, when measured in accordance with 5.3, shall not be less than (Item A, table 2).

4.5 Service Life

The mean service life of primary and secondary batteries, when discharged to the endpoint voltage given in (Item B, table 2) in accordance with paragraph 5.4, shall be greater than (Item C) when tested at 20° to 30°C (68 to 86°F), (Item D) when tested at −30±2°C (−22±3.6°F) (secondary batteries only), and (Item E) when tested at 60±2°C (140±3.6°F). In addition, for each of the three tests, the difference between the mean service life and the service life listed in table 2, divided by the root mean square deviation of the measured service lives, shall be equal to or greater than the following criterion. See Appendix B for a sample calculation.

Sample Size	*Criterion*	*Sample Size*	*Criterion*
3	0.958	7	1.15
4	1.01	10	1.23
5	1.07	15	1.30

TABLE 2.—*Minimum performance requirements for batteries used in personal/portable transceivers*

Characteristic	Minimum Requirement			
	Primary			Secondary
	Mercury	*Alkaline*	*Carbon-Zinc*	*Ni-Cad*
A. Closed-Circuit Voltage	1.2 V/cell	1.3 V/cell	1.3 V/cell	N.A.
B. Endpoint Voltage	0.9 V/cell	0.9 V/cell	0.9 V/cell	1.0 V/cell
C. Service Life at 20° to 30°C	40 hrs	20 hrs	4 hrs	8 hrs
D. Service Life at −30°C	N.A.	N.A.	N.A.	2 hrs
E. Service Life at 60°C	40 hrs	24 hrs	5 hrs	7 hrs
F. Voltage at Terminals	N.A.	N.A.	N.A.	1.0 V/cell

N.A.—Not Applicable

4.6 Internal Connection

The purpose of this test is to determine which secondary batteries might fail prematurely because of poor quality internal construction.

The voltage of secondary batteries, when measured in accordance with 5.5, shall be not less than (Item F, table 2).

5. TEST METHODS

5.1 Test Conditions

Unless otherwise specified, tests shall be conducted under the following conditions.

5.1.1 Atmospheric Conditions

The temperature shall be between 20°C and 30°C (68 to 86°F). The relative humidity shall be between 10 and 85 percent.

5.1.2 Standard Charge

Prior to testing, secondary batteries shall be discharged to 1.0 volt per cell at a C-rate of 1.0 or less. Slow-charge batteries shall then be recharged at a C-rate of 0.1 for 14 to 16 hours. Fast-charge batteries shall be recharged to full capacity in accordance with the manufacturer's instructions.

5.1.3 Standard Test Cycle

The standard test cycle shall be 10 percent in transmit mode, 10 percent in receive mode and 80 percent in standby mode. For every minute of use, 6 seconds shall be under transmit current drain, 6 seconds under receive current drain, and 48 seconds under standby current drain.

5.2 Test Equipment

The test equipment described is that equipment which is critical to the measurements required by this standard. All other test equipment shall be of comparable quality.

5.2.1 Constant Current Supply

The constant current supply shall be programmable and capable of supplying the maximum current required from the battery under test, substantially independent of changes in the battery voltage.

5.2.2 Electrical Indicating Instruments

The voltmeter and ammeter used in these tests shall have an overall measurement uncertainty of 0.5 percent or less. The voltmeter shall have a sensitivity of 10,000 ohms per volt or more.

5.2.3 Standard Battery Load Resistor

The value of the standard battery load resistor shall be calculated by dividing the battery voltage by the required transmit current (4.1.2). The battery voltage for the purpose of this calculation shall be 1.20 volts per cell for mercury batteries, 1.05 volts per cell for alkaline and carbon-zinc batteries, and 1.15 volts per cell for nickel-cadmium batteries.

5.3 Closed-Circuit Voltage Test

Connect the battery through a switch to the standard battery load as shown in figure 1, and close the switch for six seconds. The minimum voltage indicated by the voltmeter during that time is the closed-circuit voltage.

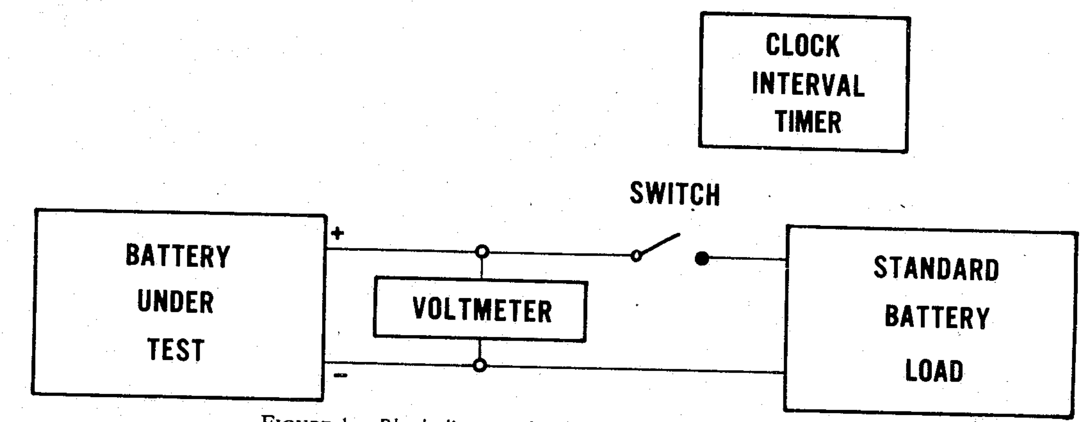

FIGURE 1. *Block diagram for closed-circuit voltage test.*

5.4 Service Life Test

Connect the battery under test by timed switching to three resistors, R_T, R_R, and R_S, as shown in figure 2. Determine the values of these resistors for the appropriate battery

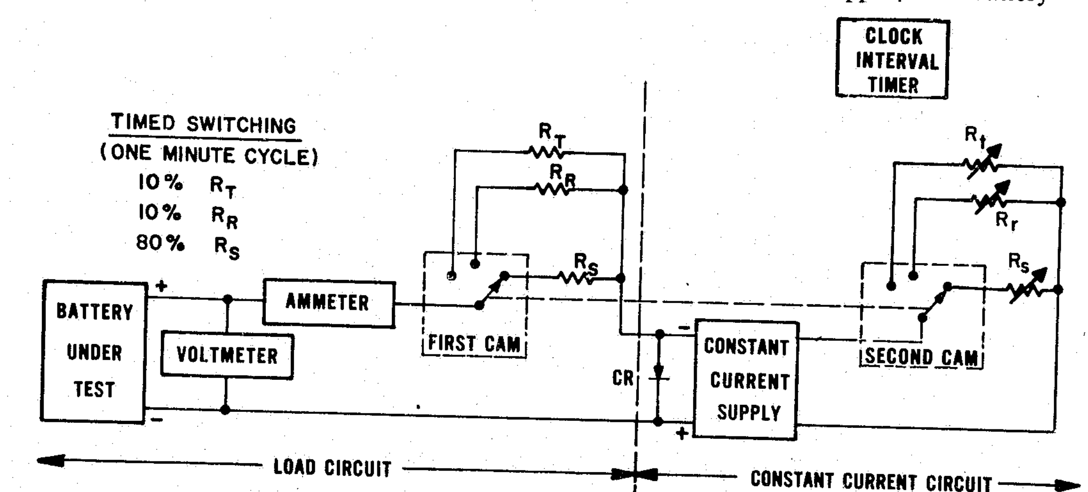

FIGURE 2. *Block diagram for service life test.*

voltage (5.2.3) and the transmit, receive and standby current drains, respectively (4.1.2). If a bipolar constant current supply is not used, include a protective diode in the circuit (see CR in figure 2). Control the supply by means of programming resistors (R_t, R_r, R_s) or voltages which are independent of the battery load circuit. The wiring schematic of a suitable automatic service life measurement setup is shown in figure 3 [2, 4].

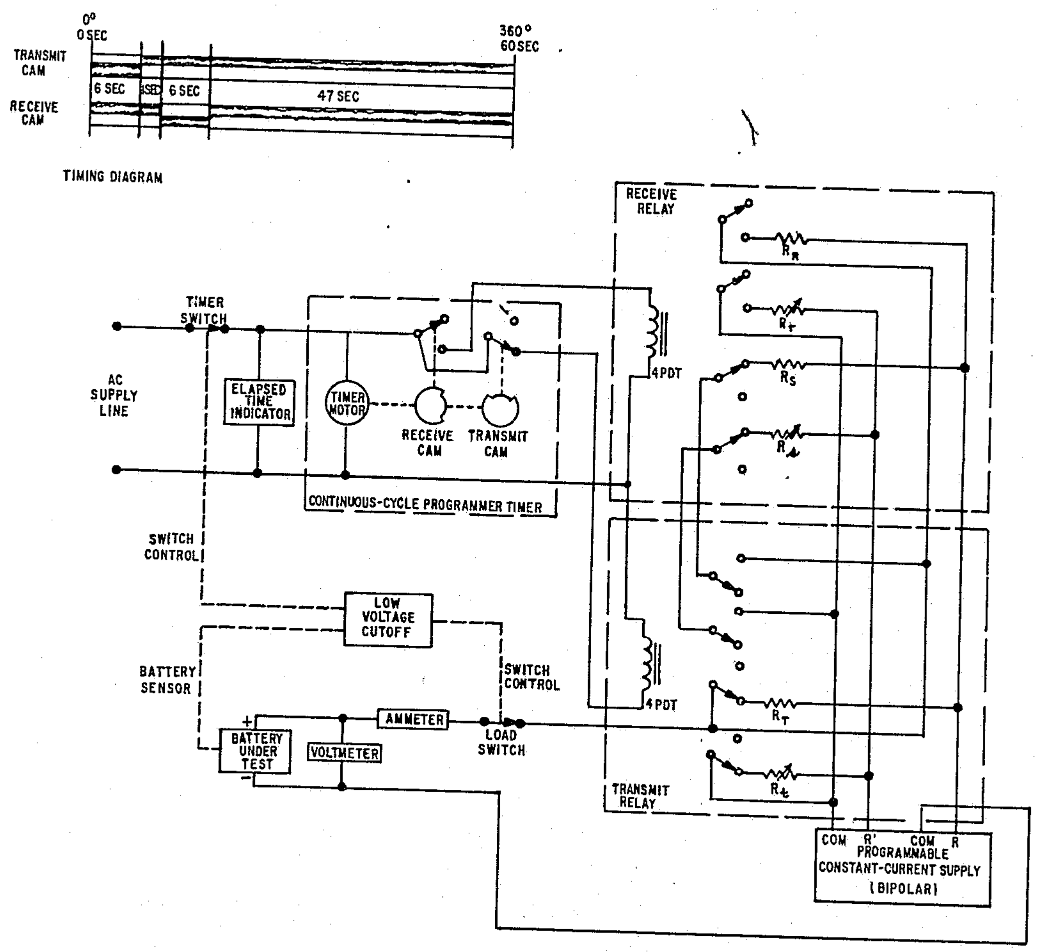

FIGURE 3. *Wiring diagram for automatic service life measurements.*

Use a fully charged battery, other than the one under test, to adjust the programming resistors until the required currents are indicated by the ammeter. Place the battery to be tested in a chamber at the required conditions for two hours and then, while still under these conditions, connect it to the test circuit and start the clock interval timer. Use a sensor such as the ammeter to insure that the correct current drains are maintained throughout the test. Disconnect the battery and stop the timer when the battery voltage reaches the endpoint voltage. This will usually occur during an interval of transmit-mode current drain. The elapsed time indicated on the clock interval timer is the service life.

Conduct the service life test on each battery in the sample.

5.5 Internal Connection Test

The test setup is shown in Figure 4. Close the switch to load resistor R_{5C} and maintain the discharge current at 5C for a timed interval of two minutes [3] either by

constantly adjusting the value of R_{5C} or by making use of a constant current control. The minimum voltage indicated by the voltmeter during the test is the value sought.

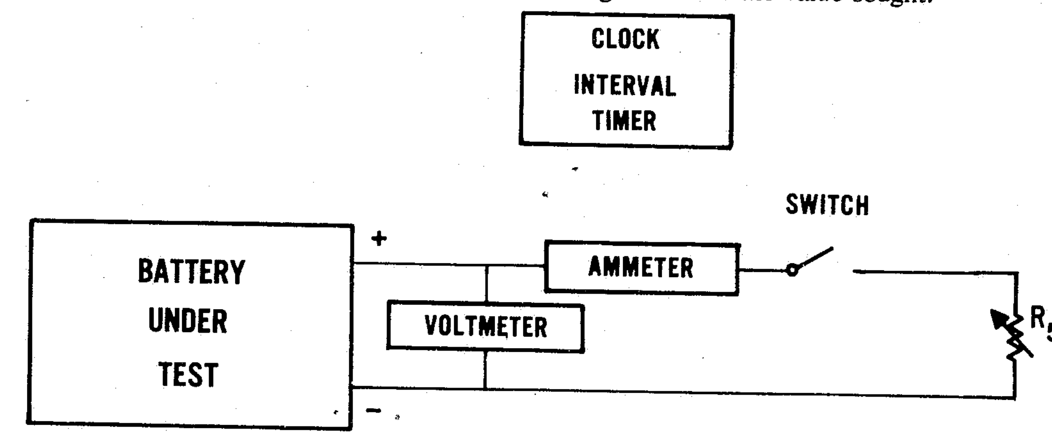

FIGURE 4. *Block diagram for internal connection test.*

APPENDIX A

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APPENDIX B

Sample Calculations

For a lot of 100 secondary batteries, the service lives of three batteries tested in accordance with paragraph 5.4 were found to be 8.0, 8.5, and 9.0 hours, respectively.

Process	*Calculation*
1. Calculate the sum of the service lives.	$8.0 + 8.5 + 9.0 = 25.5$
2. Divide by sample size (N).	$\frac{25.5}{3} = 8.5$
3. Subtract the specified service life from this result.	$8.5 - 8.0 = 0.5$
4. As the answer is positive, calculate the root-mean-square deviation as follows:	
a. Calculate the square of each of the measurements.	$(8)^2 = 64$; $(9)^2 = 81$ $(8.5)^2 = 72.25$
b. Calculate the sum of the squares.	$64 + 72.25 + 81 = 217.25$
c. Calculate the square of the sum of the measurements.	$(25.5)^2 = 650.25$
d. Divide the result by N.	$\frac{650.25}{3} = 216.75$
e. Subtract this result from the result of step 4.b.	$217.25 - 216.75 = 0.5$
f. Divide this result by N-1.	$\frac{0.5}{2} = 0.25$
g. Calculate the square root of the previous result.	$\sqrt{0.25} = .5$
5. Divide the result obtained in step 3 by the root-mean-square deviation.	$\frac{0.5}{0.5} = 1.0$
6. Since this value is greater than the criterion listed in paragraph 4.5 (0.958, in this case), the requirement is met.	

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