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Law Enforcement and Corrections Standards and Testing Program

Rechargeable Batteries for Personal/Portable Transceivers

NIJ Standard-0211.01

ABOUT THE LAW ENFORCEMENT AND CORRECTIONS STANDARDS AND TESTING PROGRAM

The Law Enforcement and Corrections Standards and Testing Program is sponsored by the Office of Science and Technology of the National Institute of Justice (NIJ), U.S. Department of Justice. The program responds to the mandate of the Justice System Improvement Act of 1979, which created NIJ and directed it to encourage research and development to improve the criminal justice system and to disseminate the results to Federal, State, and local agencies.

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Rechargeable Batteries for Personal/Portable Transceivers

NIJ Standard-0211.01
Supersedes NILECJ-STD-0211.00 dated June 1975

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National Institute of Justice

Jeremy Travis
Director

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This standard was formulated by the Office of Law
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for Communications Systems, and Lawrence K. Eliason, and
Kathleen M. Higgins, successive Directors of OLES. NIST staff
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standard was sponsored by the National Institute of Justice,
David G. Boyd, Director, Office of Science and Technology.
The standard has been reviewed and approved by the
Law Enforcement Technology Advisory Council
(formerly the Technology Assessment Program Advisory Council).

FOREWORD

This document, NIJ Standard-0211.01, Rechargeable Batteries for Personal/Portable Transceivers, is an equipment standard developed by the Office of Law Enforcement Standards of the National Institute of Standards and Technology. It is produced as part of the Law Enforcement and Corrections Standards and Testing Program of the National Institute of Justice. A brief description of the program appears on the inside front cover.

This standard is a technical document that specifies performance and other requirements equipment should meet to satisfy the needs of criminal justice agencies for high-quality service. Purchasers can use the test methods described in this standard to determine whether a particular piece of equipment meets the essential requirements, or they may have the tests conducted on their behalf by a qualified testing laboratory. Procurement officials may also refer to this standard in their purchasing documents and require that equipment offered for purchase meet the requirements. Compliance with the requirements of the standard may be attested to by an independent laboratory or guaranteed by the vendor.

Because this NIJ standard is designed as a procurement aid, it is necessarily highly technical. For those who seek general guidance concerning the selection and application of law enforcement equipment, user guides have also been published. The guides explain in nontechnical language how to select equipment capable of the performance required by an agency.

NIJ standards are subjected to continuing review. Technical comments and recommended revisions are welcome. Please send suggestions to the Director, Office of Science and Technology, National Institute of Justice, U.S. Department of Justice, Washington, DC 20531.

Before citing this or any other NIJ standard in a contract document, users should verify that the most recent edition of the standard is used. Write to: Director, Office of Law Enforcement Standards, National Institute of Standards and Technology, Gaithersburg, MD 20899.

David G. Boyd, Director
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National Institute of Justice

NIJ STANDARD
FOR
RECHARGEABLE BATTERIES
FOR PERSONAL/PORTABLE TRANSCEIVERS

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1. PURPOSE AND SCOPE

The purpose of this document is to establish performance requirements and test methods for rechargeable (secondary) batteries used in personal/portable transceivers by law enforcement agencies. The scope of this standard is limited to nickel-cadmium secondary batteries.

This revision supersedes NILECJ-STD-0211.00 dated June 1975 and modifies the service life requirements given in the original standard. It further eliminates performance requirements and test methods for disposable (primary) batteries.

2. CLASSIFICATION

Rechargeable batteries covered by this standard are classified into two types:

2.1 Type I, Capacity Rating

Rechargeable batteries for which the manufacturer specifies only the nominal capacity, usually in milliampere-hours.

2.2 Type II, Service Life Rating

Rechargeable batteries for which the manufacturer specifies the nominal service life when used with a specific transceiver at a specified duty cycle.

3. DEFINITIONS

The principal terms used in this document are defined in this section. Additional definitions relating to law enforcement communications are given in LESP-RPT-0203.00, Technical Terms and Definitions Used with Law Enforcement Communications Equipment (Radio Antennas, Transmitters, and Receivers) [1].[1]

3.1 Available Capacity

[1]Numbers in brackets refer to the references in appendix A.

The total battery capacity, usually expressed in ampere-hours (Ah) or milliampere-hours, (mAh), that is available to perform work. This depends on factors such as the end-point 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 A) to a current (in A) numerically equal to the rated capacity of the battery (in Ah).

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 End-Point Voltage

The closed-circuit voltage per cell at the end of the service life (available capacity) test; nominally, the voltage below which connected equipment will not operate properly 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 Value

The numerical value of a device characteristic, such as nominal voltage, as specified by the battery manufacturer.

3.8 Rated Capacity

A designation by the battery manufacturer which serves to identify approximate capacity of the battery in ampere-hours or milliampere-hours usually at typical transceiver discharge rates.

3.9 Service Life

The length of time required for a fully charged secondary cell (or battery) to discharge to a specified end-point 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

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.

4.2 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 for type I batteries; service life for type II batteries
e) indication of polarity, unless the contact configuration prevents reversed polarity installation
f) recharge rate
g) production lot and/or month and year of manufacture (which may be in coded form)

4.3 Sampling for Test

A random sample of three batteries shall be selected for test. Samples shall be tested within 18 months of the date of manufacture.

4.4 Service Life (Available Capacity)

4.4.1 Type I Batteries

When tested in accordance with section 5.3, at ambient temperature, the average available capacity of the three required determinations shall equal or exceed the available capacity rating specified by the manufacturer, and none of the three available capacity intervals measured shall be less than 95 percent of the manufacturer-specified available capacity.

When tested in accordance with section 5.3 at 60°C (140 °F), the average available capacity shall be no less than 90 percent of the available capacity specified by the manufacturer, and no single measured available capacity shall be less than 85 percent of the manufacturer-specified available capacity.

When tested in accordance with section 5.3 at -30°C (-22 °F), the average available capacity shall be no less than 40 percent of the available capacity specified by the manufacturer, and no single measured available capacity shall be less than 35 percent of the manufacturer-specified available capacity.

4.4.2 Type II Batteries

When tested in accordance with section 5.3 at ambient temperature, the average service life (time interval for a fully charged battery to reach an end-point voltage of 1.0 V/cell) of the three required determinations shall equal or exceed the service life specified by the manufacturer. In addition, none of the three service life intervals measured shall be less than 95 percent of the manufacturer-specified service life.

When tested in accordance with section 5.3 at 60°C (140 °F), the average service life shall be no less than 90 percent of the service life specified by the manufacturer, and no single measured service life shall be less than 85 percent of the manufacturer-specified service life.

When tested in accordance with section 5.3 at -30°C (-22 °F), the average service life shall be no less than 40 percent of the service life specified by the manufacturer, and no single measured service life shall be less than 35 percent of the manufacturer-specified service life.

4.5 Internal Connection

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

The voltage of the batteries, when measured in accordance with 5.4, shall be not less than 1.0 V per cell.

5. TEST METHODS

5.1 Standard Test Conditions

Allow all measurement equipment to warm up until the system has achieved sufficient stability to perform the measurement. Unless otherwise specified, tests shall be conducted under standard test conditions.

5.1.1 Standard Atmospheric Conditions

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

5.1.2 Standard Charge

Prior to testing, secondary batteries shall be fully charged in accordance with manufacturer instructions and then discharged to 1.0 V per cell at a C-rate of 2.0 or less. Both slow-charge and fast-charge batteries shall be recharged to full capacity in accordance with the manufacturer's instructions.

Testing shall be initiated between 1 and 2 h following battery recharging. Otherwise, a complete discharge/charge cycle must be accomplished prior to testing.

5.1.3 Standard Test Cycle

The standard test cycle for service life/capacity determinations shall be 10 percent in transmit mode, 10 percent in receive mode, and 80 percent in standby mode as specified in table 1. For each minute of operation, 6 s shall be under transmit current drain, 6 s under receive current drain, and 48 s under standby current drain.

Table 1. Standard test cycle current

Battery Capacity (mAh)	Transmit current (mA)	Receive current (mA)	Standby current (mA)
Less than 700	400	75	15
700 or greater	700	175	30

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 an input resistance 15 k times the number of cells in the battery under test.

5.2.3 Environmental Chamber

The environmental chamber(s) shall produce air temperatures of -30 and 60°C (-22 and 140 °F) while shielding the item under test from heating or cooling air currents in the chamber. The temperature of the test item shall be measured with a thermometer separate from the sensor used to control the chamber air temperature.

5.3 Service Life Test (Available Capacity)

Conduct the service life test on each battery in the sample at ambient, high, and low temperature. For the ambient temperature tests, connect the battery under test by timed switching to three programmable resistors, R_T, R_R, and R_S, as shown in figure 1. Determine the values of these resistors for the voltage of the battery under test required to obtain the transmit, receive and standby current drains, respectively as specified in table 1. Control the supply by means of programming resistors (R_t, R_r, R_s) or voltages that are independent of the battery load. If a bipolar constant current supply is used, the protective diode in the circuit (see CR in fig. 1)

may not be needed. If available, a suitable automatic service-life measurement setup as shown in figure 2 [2,3] may be substituted for the programming resistors as a means of controlling the supply.

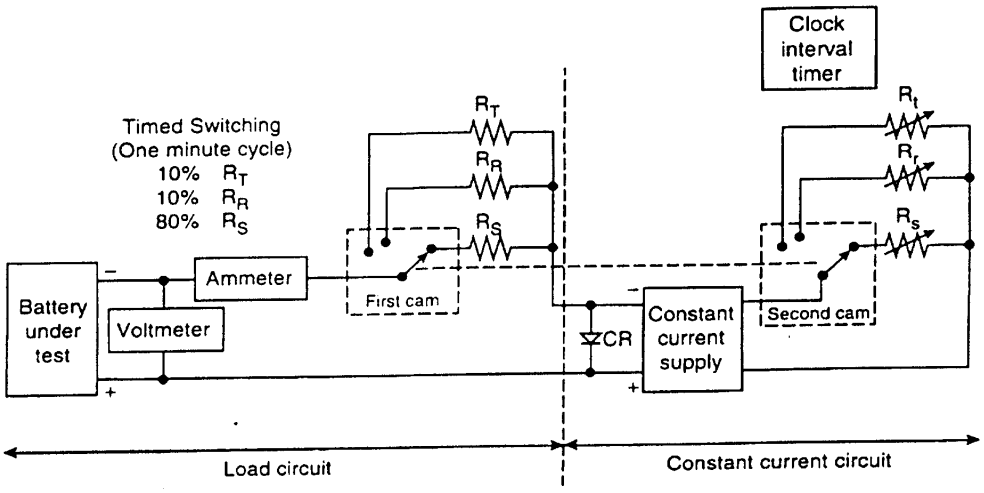

Figure 1. *Block diagram for service life test.*

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. Connect the battery to the test circuit and start the clock interval timer. Use the ammeter to ensure that the correct current drains are maintained throughout the test. Disconnect the battery and stop the timer when the battery voltage reaches the end-point voltage. This will usually occur during an interval of transmit-mode current drain. Record the elapsed time indicated on the clock interval timer to the nearest minute, and round the total interval up to the next highest 0.1 h. Calculate the available capacity by multiplying each of the current drains (in mA), in turn, by the elapsed time (in h) and the duty cycle percentage. Add the three products together to obtain the measured available capacity (in mAh) for type I batteries.

For type II batteries, determine from manufacturer specifications the currents during transmit, receive, and standby operation of the transceiver that will be used with the battery. Calculate the average current drain for operation at the specified duty cycle as the sum of the products of the current drains (in mA) and the respective duty cycle percentage. Determine the availability capacity (in mAh) as in the preceding paragraph and then divide it by the average current drain for the duty cycle to determine the service life in hours. Alternatively, conduct the test described above using the actual transmit, receive, and standby currents of a specific transceiver to measure the service life of the battery directly.

For the high temperature test, place the battery or batteries in the environmental chamber and adjust the chamber to the required high temperature ⇑2 ⁄C (⇑3.6 ⁄F). Condition the battery at the required temperature for at least 1 1/2 h prior to initiating the service life test. Maintain this temperature for the duration of the test described in the previous paragraph.

Repeat the above procedure for the required low temperature ⇑2 ⁄C (⇑3.6 ⁄F).

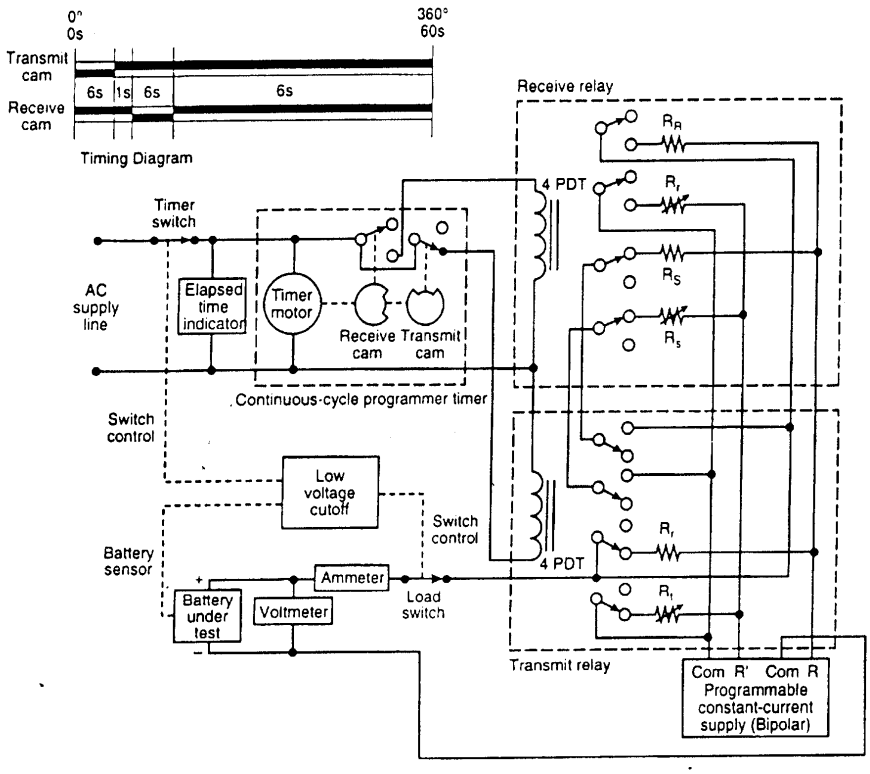

Figure 2. *Wiring diagram for automatic service life measurements.*

5.4 Internal Connection Test

The test setup is shown in figure 3. Close the switch to load resistor R and maintain the discharge current of batteries with a rated capacity of 700 mAh or less at 5C for a timed interval of 2 min [4] either by constantly adjusting the value of R or by making use of a constant current control. For batteries with a rated capacity greater than 700 mAh maintain a constant current of 3.5 A for a timed interval of 6 min. The minimum voltage indicated by the voltmeter during the test is the value sought.

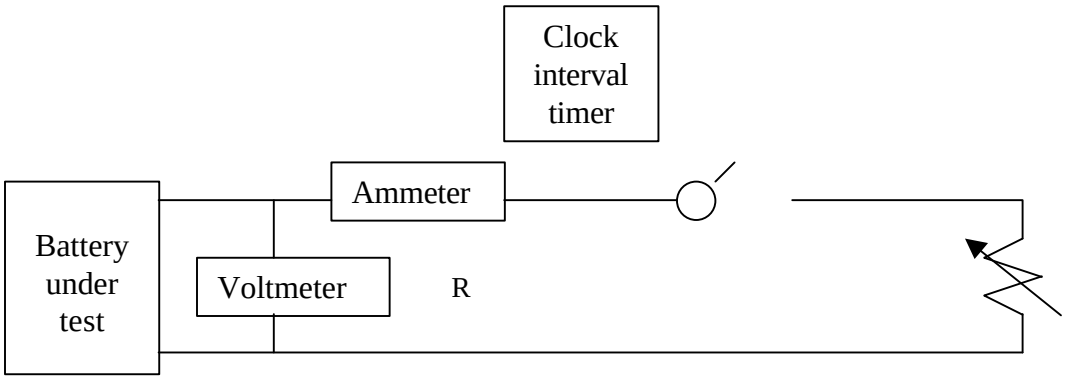

Figure 3. *Block diagram for internal connection test.*

APPENDIX A--REFERENCES

[1] Greene, F. M. Technical terms and definitions used with law enforcement communications equipment. LESP-RPT-0203.00. National Institute of Justice, U.S. Department of Justice, Washington, DC; 1973 July.

[2] Layte, Howard. Tunnel-diode detects battery voltage levels. Ideas for Design, Electronic Design; 1965 August 30, p. 44.

[3] Wilke, William. C-MOS voltage monitors protects Ni-Cd batteries. Electronics, 56, 5; 1973 March 1, pp. 85-86.

[4] Specification for aerospace nickel-cadmium storage cells. S-761-P6. Goddard Space Flight Center, Greenbelt, MD; 1971 March.

APPENDIX B--BIBLIOGRAPHY

Batteries, storage, vented, nickel-cadmium. MIL-B-55363 (1). 1982 April 5.

Jesch, Ramon L. and Berry, Ira S. Comparison and performance characteristics for batteries used with law enforcement communications equipment. LESP-RPT-0201.00. National Institute of Justice, U.S. Department of Justice, Washington, DC 20531; 1972 May.

Sampling procedures and tables for inspection by variables for percent defective. MIL-STD-414, Notice 1; 1968 May 8.

Scott, Winston W., Jr. Chargers and charging techniques for batteries used with law enforcement communications equipment. LESP-RPT-0202.00. National Institute of Justice, U.S. Department of Justice, Washington, DC 20531; 1973 June.

Specifications for dry cells and batteries. American National Standards Institute Publication C18.1; 1986.