RTCA, Inc.
1150 18th Street, NW, Suite 910
Washington, DC 20036-3816 USA

Minimum Operational Performance Standards (MOPS) for Nickel-Cadmium, Nickel Metal-Hydride and Lead-Acid Batteries

RTCA DO-293A
December 2, 2009

Prepared by: SC-211
© 2009 RTCA, Inc.

Copies of this document may be obtained from

RTCA, Inc.

Telephone: 202-833-9339
Facsimile: 202-833-9434
Internet: www.rtca.org

Please visit the RTCA Online Store for document pricing and ordering information.

FOREWORD

This document was prepared by RTCA Special Committee 211 (SC-211). It was approved by the RTCA Program Management Committee on December 2, 2009.

RTCA, Incorporated is a not-for-profit corporation formed to advance the art and science of aviation and aviation electronic systems for the benefit of the public. The organization functions as a Federal Advisory Committee and develops consensus based recommendations on contemporary aviation issues. RTCA's objectives include but are not limited to:

- Coalescing aviation system user and provider technical requirements in a manner that helps government and industry meet their mutual objectives and responsibilities;

- Analyzing and recommending solutions to the system technical issues that aviation faces as it continues to pursue increased safety, system capacity and efficiency;

- Developing consensus on the application of pertinent technology to fulfill user and provider requirements, including development of minimum operational performance standards for electronic systems and equipment that support aviation; and

- Assisting in developing the appropriate technical material upon which positions for the International Civil Aviation Organization and the International Telecommunication Union and other appropriate international organizations can be based.

The organization's recommendations are often used as the basis for government and private sector decisions as well as the foundation for many Federal Aviation Administration Technical Standard Orders.

Since RTCA is not an official agency of the United States Government, its recommendations may not be regarded as statements of official government policy unless so enunciated by the U.S. government organization or agency having statutory jurisdiction over any matters to which the recommendations relate.

TABLE OF CONTENTS

1	**INTRODUCTION**	**1**
1.1	Purpose	1
1.2	References	1
1.3	Scope	2
1.3.1	Power Sources	2
1.4	Regulatory Issues	3
1.5	General Requirements	3
1.5.1	Safety	3
1.5.1.1	Safety Philosophy	3
1.5.1.2	Factors Influencing Safety	4
1.5.2	Manufacturing Standards	5
1.5.3	Application Design Review and Verification	5
1.5.4	Quality	5
1.5.4.1	Quality Control	5
1.5.4.2	Configuration Control	6
1.5.4.3	Re-Qualification	6
1.5.5	Storage, Shipping and Disposal	6
1.5.5.1	Storage	6
1.5.5.2	Shipping	7
1.5.5.3	Disposal	7
1.5.6	Testing	7
1.5.7	Application	7
1.6	Design Consideration	7
1.6.1	General Construction Requirements	7
1.6.2	Corrosion Prevention	8
1.7	Electrical Bonding	8
1.8	Dissimilar Metals	8
1.9	Venting Arrangements	8
1.10	Marking	9
1.10.1	Battery Marking	9
1.10.2	Cell Marking	9
1.10.3	Polarity Marking	9
1.11	Design Life	10
1.12	Deleted	10
1.13	Test Considerations	10
1.13.1	Test and Verification Philosophy and Goals	10
1.13.2	Qualification Test Goals	10
1.13.3	Operational Tests	10
1.13.4	Unspecified Tests	11
1.14	Assumptions for the Determination of Charge and Discharge Values	11
1.15	Instructions for Continued Airworthiness	11

2 ELECTRICAL QUALIFICATION REQUIREMENTS AND TEST PROCEDURES 13
2.1 Test Conditions and Apparatus 13
2.1.1 General Test Conditions 13
2.1.2 Measuring Apparatus 13
2.1.3 Voltage Measurement 13
2.1.4 Current Measurement 13
2.1.5 Temperature Measurement 13
2.1.6 Time Measurement 13
2.1.7 Additional Test Equipment 13
2.1.8 Mass Test Equipment 14
2.1.9 Charging Method 14
2.1.10 Physical Examination 14
2.2 Electrical Requirements and Test Procedures 14
2.2.1 Capacity Tests at the $1I_1$ Rate 14
2.2.2 Rated Capacity C1 14
2.2.3 Capacity at $1I_1$ and -18 °C 15
2.2.4 Capacity at $1I_1$ and -30°C 15
2.2.5 Capacity at $1I_1$ and 50°C 15
2.2.6 Constant Voltage Discharge (high rate batteries only) 16
2.2.6.1 Constant Voltage Current at 23 °C 16
2.2.6.2 Constant Voltage Current at –18 °C 16
2.2.6.3 Constant Voltage Current at –30 °C 17
2.3 Rapid Discharge Capacity (for high rate batteries only) 17
2.3.1 Rapid Discharge Capacity at 23 °C 17
2.3.2 Rapid Discharge Capacity at –30 °C 17
2.4 Charge Retention 18
2.5 Storage 18
2.6 Charge Stability 19
2.7 Short-circuit Test 19
2.8 Charge Acceptance 20
2.8.1 Ambient Temperature (23°C) 20
2.8.2 Low Temperature (for Batteries Containing Internal Heaters) 21
2.8.2.1 Charge and Discharge Test at –18 °C 21
2.8.2.2 Charge and Discharge Test at –40 °C 21
2.9 Insulation Resistance and Dielectric Strength 22
2.9.1 Insulation Resistance 22
2.9.2 Dielectric Strength 22
2.10 Duty Cycle Performance (for engine start batteries only) 22
2.11 Water Consumption Test 24
2.12 Cyclic Endurance (for all batteries) 24
2.13 Deep Discharge Test 25
2.14 Induced Destructive Overcharge. 25
2.15 Electrical Emissions 26

3 ENVIRONMENTAL QUALIFICATION REQUIREMENTS AND TEST PROCEDURES 27
3.1 Vibration 27
3.1.1 Battery Mounting 27
3.1.2 Random Vibration Test (Section 8 of RTCA/DO-160) 27
3.1.2.1 Initial Resonance Search 27
3.1.2.2 Vibration Test 27
3.2 Deleted 28
3.3 Operational Shock and Crash Safety (Section 7 of RTCA/DO-160) 28
3.3.1 Operational Shock 28
3.3.2 Crash Safety (Section 7 of RTCA/DO-160) 29
3.4 Explosion Containment (Section 9 of RTCA/DO-160) 29
3.5 Temperature and Altitude 30
3.5.1 Altitude 30
3.5.2 Rapid Decompression 30
3.6 Temperature Shock 31
3.7 Fungus Resistance (Section 13 of RTCA/DO-160) 32
3.8 Humidity (Section 6 of RTCA/DO-160) 32
3.9 Fluid Contamination 33
3.9.1 General 33
3.9.1.1 Spray Test (Section 14 of RTCA/DO-160) 33
3.9.1.2 Immersion Test 33
3.10 Salt Spray (only applicable where the battery installation is subject to a salt atmosphere, see DO-160 Category S) 34
3.11 Physical Integrity at High Temperature (85 °C) 34
3.12 Electrolyte Resistance 35
3.13 Thermal Sensors 36
3.14 Component Qualification Tests 36
3.14.1 Vent Valve Test 36
3.14.1.1 For Vented Nickel-Cadmium Vent Valves 36
3.14.1.2 For Vented Lead-Acid Vent Valves 36
3.14.1.2.1 For Valve Regulated Vent Valves (Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid) 37
3.14.1.3 Cell Container Test 38
3.14.1.4 For Nickel-Cadmium and Nickel Metal-Hydride Cell Containers 38
3.14.1.5 For Lead-Acid Battery Containers 38
3.14.2 Battery Electrolyte Containment Test 39
3.15 Strength of Connector Receptacle 39
3.16 Handle Strength 40

4 QUALITY ASSURANCE REQUIREMENTS 41
4.1 General Quality Requirements 41
4.1.1 Order of Testing 41

5 DEFINITION OF TERMS 45

Appendix A, Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid Battery Safety Guidelines 51

MEMBERSHIP 53

List of Tables

Table 1-1 Workmanship Requirements 8
Table 4-1 Approval Test Schedule 41

List of Figures

Figure 1 Vibration Orientation 43

1 INTRODUCTION

Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid batteries of a number of different, sizes, and construction details are widely used today. Among their desirable characteristics are high energy density per unit weight and per unit volume, high cell voltage (Lead-Acid), relatively constant voltage during discharge (NiCd), good low-temperature performance and long shelf life. Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid batteries provide power for aircraft engine or Auxiliary Power Unit (APU) starting and other equipment including avionics and emergency and standby systems. Because of their high energy content, they can present hazards if improperly designed, tested, used, or stored.

1.1 Purpose

The purpose of this document is to provide guidance on the construction, certification, production and use of Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid battery on aircraft. This guidance is provided to the designers and manufacturers of Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid batteries, aircraft designers and manufacturers, and users within the aviation community. This document contains minimum operational performance standards for rechargeable Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid batteries to be used as power sources on aircraft.

Compliance with these standards is recommended as a means of assuring that the battery will perform its intended function(s) safely under conditions normally encountered in routine aeronautical operations. Any regulatory application of this document is the sole responsibility of the cognizant government agencies.

These standards cover the chemical composition, cell size, cell construction, interconnection of the cells into batteries, venting, operational and storage environments, packaging, handling, test, storage and disposal of Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid batteries installed separately or in avionics equipment aboard aircraft. Its further purpose is to provide aircraft designers, and aircraft equipment designers with information on the performance characteristics and operating and environmental limitations of Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid batteries.

It is the responsibility of the aircraft and equipment designers and manufacturers to insure that the battery operating environmental limits defined in this document will not be exceeded during the intended use of the batteries and equipment on the aircraft.

1.2 References

The following normative documents contain provisions which, through reference in this text, constitute provisions of this Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to apply.

ANSI/ASQC M1-1996: American National Standard for Calibration Systems
IEC 60952-1 Aircraft Batteries, Part 1: General test requirements and performance levels
IEC 60952-2 Aircraft Batteries, Part 2: Design and construction requirements

© 2009, RTCA Inc.

IEC 60952-3 Aircraft Batteries, Part 3: Product standard and verification
RTCA DO-160: Environmental conditions and test procedures for airborne equipment
ISO-9000 Quality management principles
Title 14 Code of Federal Regulations for Aeronautics and Space, 1, I, 1-59 Federal Aviation Administration, Department of Transportation

Part 23 Airworthiness Standards – Normal Utility, Acrobatic, and commuter category Airplanes

Section 23-1301 Function and installation, 23-1309 Equipment, systems, and installations, and 23-1353 Electrical equipment and installations including Advisory Circular 23.1309-1C

Part 25 Airworthiness Standards: Transport Category Airplanes

Sect ion 25-1301 Function and installation, 25-1309 Equipment, systems, and installations, and 25-1353 Electrical equipment and installations including Advisory Circular 25.1309-1A

Part 27 Airworthiness Standards: Normal Category Rotorcraft

Section 27-1301 Function and installation, 27-1309 Equipment, systems, and installations, and 27-1353 Electrical equipment and installations including Advisory Circular 27 - 1A

Part 29 Airworthiness Standards: Transport Category Rotorcraft

Section 29-1301 Function and installation, 29-1309 Equipment, systems, and installations, and 29-1353 Electrical equipment and installations including Advisory Circular 29 - 2C

Part 21 Certification Procedures for Products and Parts

Section 21.303 – Replacement and Modification Parts
Section 21.143 – Quality Control Data Requirement - Prime Manufacturer

1.3 Scope

This document contains test, performance and safety evaluation requirements for secondary Nickel-Cadmium, Nickel Metal-Hydride, and Lead-Acid batteries. Guidance is also provided on design, test, safety, handling, storage, and disposal of these items. This document defines levels of severity of battery testing to enable battery manufacturers to qualify their products in accordance with their intended use. Equipment designers and manufacturers in turn can select batteries whose safety and performance have been demonstrated at levels appropriate to the battery environment within the equipment and to the required performance.

The object of this standard is to define test procedures for the evaluation, comparison and qualification of batteries and to state minimum operational performance standards (MOPS) for airworthiness. Additional requirements shall apply if specified in the design documentation or designated by the Design Authority.

1.3.1 Power Sources

The intended application of batteries described in this document is as power sources for aircraft equipment or instrumentation and emergency devices including emergency lighting, and engine or APU starting when required.

© 2009 RTCA Inc.