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ELECTROMAGNETIC ANECHOIC CHAMBERS

**A Fundamental Design
and Specification Guide**

LELAND H. HEMMING

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FOREWORD

At last, a handbook for electromagnetic anechoic chambers! A single source for fundamentals, design, specification, and testing of anechoic chambers written by one of the leading experts in anechoic chamber design and practice. Leland Hemming has brought together many disparate references to fill a void in the art of electromagnetic measurement: the anechoic chamber.

This handbook presents all major types of anechoic chambers including: rectangular, tapered, and double horn. It includes all major measurement techniques such as far-field, compact, and near-field testing. It also addresses all major types of measurements, including: antenna, radar cross section, electromagnetic compatibility, radiated susceptibility, and radiated emissions.

A key component of electromagnetic anechoic chambers is the material used to cover all interior surface of the chamber. The design of a chamber hinges on the proper selection and placement of the absorber on the various surfaces of the chamber, including the back wall, the side-wall specular zones, the floor, and corners of the chamber. The handbook includes in-depth discussion of the types of absorber, the shapes of absorber, their reflectivity properties, and the measurement techniques used to test the absorber.

Overlooked issues such as lighting, ventilation, fire protection, high power testing, and electromagnetic shielding are important in the final design and specification of an anechoic chamber. This handbook supplies this information as well.

This handbook also includes the important topics of chamber test procedures and acceptance testing. The testing techniques presented include: absorber testing, free space VSWR, pattern comparison, X-Y scanner, and RCS evaluation. The basis for each technique and the procedure to carry out each technique is presented. I have found that without periodic testing and documentation, and subsequent refurbishment, chamber performance can degrade significantly.

I have become acutely aware of the scarcity of information regarding the design, proper use, performance measurement and specification for anechoic chambers, in my teaching and research on antenna, radome and radar cross section measurement techniques over the last 35 years. This is especially true for the newer measurement techniques such as compact and near-field measurements performed in an anechoic chamber. It is with great pleasure that there is now an authoritatively written handbook that can supply the needed information for this important part of electromagnetic measurement.

Hemming has chosen to include only the well-established, time-tested techniques and information. I recommend this handbook to all students and practitioners of electromagnetic measurement.

EDWARD B. JOY

*Professor Emeritus
Georgia Institute of Technology*

PREFACE

I first became involved in the design and/or procurement of anechoic chambers in 1972 when I was responsible for procuring a dual-mode anechoic test facility. The facility was designed to house a compact range for apertures up to 1.5 m and a low-frequency tapered chamber that could operate down to 200 MHz. The physical arrangement that we developed utilized a common antenna test positioner located in the test region of the tapered chamber. The back wall of the tapered chamber was designed to open up and reveal the compact range reflector. Since that time, I have collected material on anechoic materials and chambers. Subsequently, I became chief designer for two different anechoic chamber manufacturers over a 10-year period. In 1985, I returned to my primary career activity as an antenna engineer. However, I have kept in touch with the anechoic chamber field by working as a part-time consultant and have kept my files current on the technology. This book is based on that experience.

The need for indoor testing of electromagnetic radiating devices, which began in the early 1950s [see Chapter 1, Ref. 1], has led to a number of companies providing chambers and absorber products supporting a range of electromagnetic testing requirements. The testing requirements range from hand-held telephone antennas to whole vehicle testing of automobiles or aircraft. In recent years, the proliferation of portable electronic devices has led to the potential for extensive electromagnetic interference between various products. Because of this potential interference, various government agencies throughout the world have had to set up emission and immunity test requirements. This has led to the extensive use of indoor electromagnetic test facilities [see Chapter 2, Ref. 2]. These facilities, including the more conventional chambers used for testing of intentional radiators, such as antennas, continue to add to the number of anechoic test chambers world-

wide. In the aerospace industry, it is common to test missiles, aircraft, or similar weapons platforms for their radar cross-section in an attempt to reduce detectability by means of radar. All of these various testing requirements have led to a series of specialized test facilities to accomplish the required testing. This book reviews the current state of the art in indoor electromagnetic testing facilities and their design and specification.

A glossary relating to electromagnetic measurements and anechoic chambers is included at the back of the book, so that the reader will be able to follow the terminology used in conjunction with a particular anechoic chamber design.

The purpose of this handbook is to provide the designer/procurer of electromagnetic chambers with a single source of practical information on the full range of anechoic chamber designs. Included are chapters on a large variety of anechoic chambers used for a broad range of electromagnetic measurements that are commonly conducted in indoor test facilities. Sufficient information is given on measurement theory to support the chamber design procedures provided in each of the specific chamber designs. Test facilities for the measurement of antennas, scattering (RCS,) and electromagnetic compatibility are detailed, for a variety of anechoic chamber configurations. An extensive set of photographs is provided and demonstrates the broad range of anechoic test facilities that have been built to measure various types of equipment. A special color section is provided which highlights some of the more interesting anechoic test facilities that have been built to solve various measurement problems. Finally, design/procurement checklists are provided for each of the various chamber configurations.

I am solely responsible for the technical information included in this handbook. This information was solicited from the many suppliers who responded to my request for detailed data on their absorber products and for pictures of their anechoic chamber installations.

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I thank my wife, Valda, for her unending support during the three years it took to complete this project. I am especially thankful for the help provided by Donald J. Martin, a co-worker at Boeing-Mesa, who processed all the artwork and photographs into digital format and created many of the drawings. Many thanks go to Edward Pelton, my former supervisor at McDonnell Douglas Technologies, who proofread the final manuscript, and for his suggestions on some of the technical and presentational issues. Finally, my thanks to the volunteer reviewers for their suggestions and recommendations on the various revisions of the book, to the IEEE Press, and to the John Wiley & Sons staff who worked with me on the final preparation and publication of this design/procurement guide.

LELAND H. HEMMING

*Mesa, Arizona
May 2002*

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