1. INTRODUCTION

The quality of data must be known and established beyond a reasonable doubt before it can be used logically in any application. Data ordinarily are obtained for use in some decision process. In every such case, the questions of how good and how sure must be answered in quantitative terms. Data quality may be judged by comparison of its uncertainty with acceptable uncertainties related to its use. If the uncertainty of the data is negligible or relatively small, it may be considered to be of good or acceptable quality; if too large it may be considered poor quality or even useless. Obviously, the uncertainty must be known for data to be used in any logical way. Because absolute certainty can never be achieved, the limits of uncertainty are key issues and they must be estimated. It is the goal of laboratory quality assurance programs to provide the basis by which measurements can be carried out to produce reproducible results for which statistically supported uncertainty statements can be made.

The question of measurement assurance has been of prime concern to the National Bureau of Standards throughout the entire period of its existence. When calibration capabilities were transferred to the States, NBS also initiated a number of activities to assure the continuing quality of calibration data. These included the presentation to the States of primary standards of the highest quality, the development of minimum specifications for State laboratory facilities, presentation of basic and advanced training courses for metrologists, initiation and continuation of a series of laboratory problems to assist in the maintenance of competence, and a plan for certification of the capabilities of State weights and measures laboratories (21).

The system for certification of laboratories includes the development and implementation of a quality assurance program as a prime requirement. This handbook brings together, for the first time, much of the essential information needed in the development of a viable program. A brief overview of quality assurance as it is related to measurement programs is presented. A collection of good laboratory practices (GLPs) is presented next, followed by a series of documents describing good measurement practices (GMPs) related to physical measurements.

One of the features of the handbook is a compilation of standard operations procedures (SOPs) for calibrations and measurements made frequently by the State laboratories. These SOPs are detailed instructions for carrying out such measurements according to procedures recommended by the National Bureau of Standards. They comprise much of the instructional material of the basic and intermediate metrology seminars offered by NBS. The SOPs follow a standard format designed to specify all of the important steps to be followed in a sequential manner. SOPs are a basic part of any quality assurance program and are considered to be essential for systematic measurement leading to the attainment of a state of statistical control. The adoption and use of the SOPs included here will fully meet the requirement of the NBS Certification Plan for State Weights and Measures Laboratories for the use of documented test procedures.

A chapter containing miscellaneous subjects includes a discussion of how NBS supports the national measurement system (of which the State laboratories are key components), a discussion of the theory of tolerance testing as

contrasted to calibration, a simplified discussion of the concepts of mass and apparent mass, and a practical overview of the method of construction and use of control charts which are a basic part of any quality assurance program.

The handbook concludes with a review of the statistical techniques that are most often useful for the evaluation of measurement data, a collection of tables of statistical and physical data, and a glossary of a number of terms used in physical metrology and quality assurance. A bibliography of papers and books selected for their specific applicability to the quality assurance of measurements is included, as well.

This publication is not intended to replace but rather to complement basic sources of information. Indeed, it is assumed that the user is already familiar with elementary physics and metrology and has taken the NBS basic seminar, at the least. For example, equations are presented but not derived, since their derivation is presumed to be already familiar. In fact, if the reader has any difficulty in following the material presented here, it is recommended that he or she consult the corresponding material in the manuals of the basic or intermediate seminars or in general text books of physics.

As in any collection, the choice of material included is somewhat arbitrary. The selection principles followed included judgments of the frequency of need and degree of availability. The convenience resulting from collection of scattered materials into a single volume was a major consideration. Material that is readily available in numerous locations, was considered to be common knowledge, or was believed to be only rarely needed was intentionally excluded.

Because of the selectivity and the personal judgment involved, it is likely that some users of the handbook will find gaps in the information or may find some that is included to be of limited usefulness. Reader feedback on this Handbook is welcomed and will be very useful in influencing the contents of future editions.

One section that will be updated and added to is that containing the SOPs. The Office of Weights and Measures intends to develop SOPs for all measurements commonly made by State laboratories. The present edition contains SOPs for the measurements most frequently made. The Handbook is organized so that additional SOPs, GLPs, GMPs, and supplemental material may be easily inserted at a future date.

NOTE: Certain commercial equipment, instruments, or materials are identified in this handbook to specify adequately the experimental procedure. Such identification does not imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.