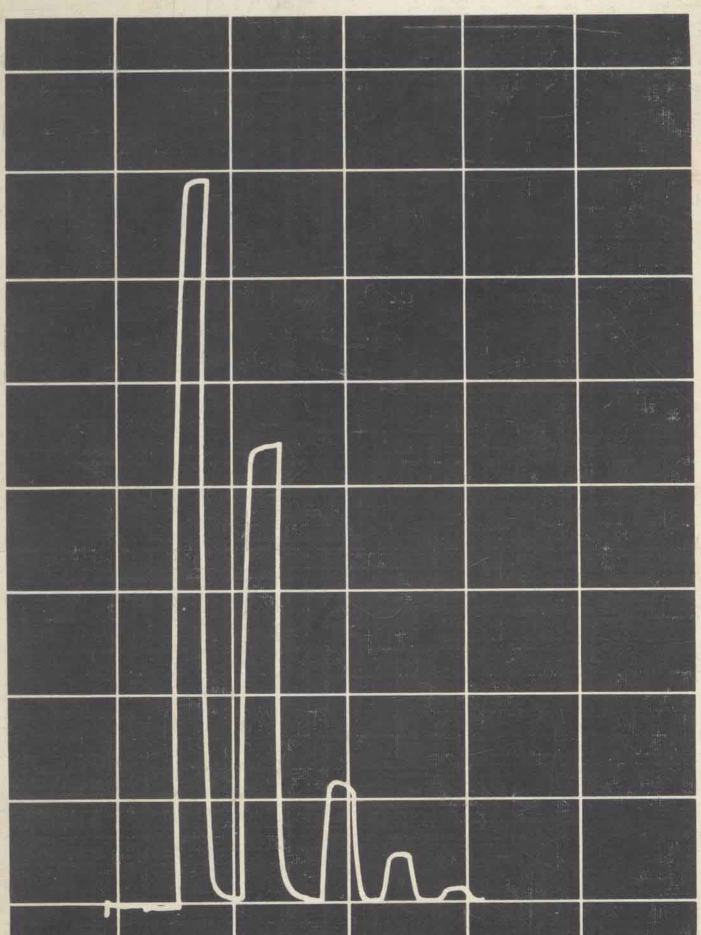
Handbook of Commercial Scientific Instruments



Volume 1: Atomic Absorption

Claude Veillon

Handbook of
COMMERCIAL SCIENTIFIC INSTRUMENTS

Volume 1
ATOMIC ABSORPTION

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Volume 1. ATOMIC ABSORPTION, *by Claude Veillon*

Volume 2. THERMOANALYTICAL TECHNIQUES, *by Wesley W. Wendlandt*

OTHER VOLUMES IN PREPARATION

INTRODUCTION TO THE SERIES

Many persons and organizations, when contemplating the purchase of a scientific instrument, are often unaware of just what is available. They frequently do not have the time or the inclination to assemble information on all of the available instruments for a particular purpose. For example, a production laboratory might have a troublesome trace metal analysis problem, for which their present analytical methods are too time-consuming, inaccurate, or not sensitive enough. So they wish to consider atomic absorption spectrometry. Now come the questions: How much will it cost? What will it do? What are the specifications of available instruments? What accessories are available? Could we get by with an atomic absorption attachment on our Model X spectrometer? And so on.

For this exemplary organization, it could be very difficult to accumulate all the information on all the commercially available atomic absorption instruments or accessories. Consequently, they might consider only two or three instruments, buy one of these, and later discover that another instrument (of which they were not initially aware) could do their particular job better.

To alleviate this rather commonplace problem, the authors of the Handbook of Commercial Scientific Instruments will present information furnished by all known manufacturers of selected groups of instruments. The Handbook will be a multi-volume series devoted to commercially available scientific instruments of various types. Each volume will fully describe the instrumentation available for a particular field. Specifications, descriptions, schematic drawings, photographs, approximate prices, accessories, etc. of each type of instrument will be included in the Handbook volumes. Material presented will be essentially that furnished by the manufacturers, plus some evaluative, objective comparisons of the instruments by the volume authors.

All of the volume authors are actively engaged in research in their respective areas and are familiar with the available instrumentation. None represents any instrument manufacturer.

Specifications, descriptions, etc. of similar instruments will be essentially those supplied by the individual manufacturers. Of course, some editing may be necessary, perhaps to put an important specification for several similar instruments on the same basis. For example, resolution is defined several ways by the various manufacturers of mass spectrometers. These might be recalculated and all defined in a consistent manner, so that the user of the Handbook volumes can more conveniently evaluate and compare the various instruments.

The authors hope to include in each volume all instruments of a given type that are commercially available in the United States, regardless of their national origin.

The first volume deals with commercially available atomic absorption instruments. Volume 2 will describe commercially available thermal analysis instrumentation. Subsequent volumes will deal with nuclear magnetic resonance instruments, gas chromatographs, mass spectrometers, x-ray instruments, spectrophotometers, various types of electronic equipment, and many others.

The editors sincerely believe that the Handbook of Commercial Scientific Instruments will fulfill a definite need, a need very often expressed as a question by individuals and or-

PREFACE

The first volume of the series, Handbook of Commercial Scientific Instruments, deals with commercially available atomic absorption instruments. Seventeen companies are listed. About half of these are companies whose instruments are manufactured outside the United States; and two are foreign companies with no United States representative and/or sales and service organizations, but which advertise in the United States and sell instruments to United States customers. Initially, we had hoped to include listings on instruments from Eastern European countries, especially Russia, for comparative purposes; however, such information proved impossible to obtain. Therefore, the volume includes only those instruments which are sold directly, or can be obtained, in the United States.

All of the information presented is based on material supplied by the manufacturers or their representatives. Many other companies which manufacture accessories for atomic absorption instruments, but not complete instruments, have not been included.

The first section includes a general introduction and comments by the author, followed by descriptions of each company's models in a form digested from the information supplied. Photographs are included, and comments are made about the applicability of each instrument to various situations, its good features, and its shortcomings. In a summary chapter various models are briefly compared according to price categories, and general recommendations are made. The tables in Appendix 1 present optical features, electrical features, mechanical features, accessories, and prices of the various models for convenient comparison. Appendix 2 lists the addresses of the manufacturers of the instruments discussed.

Hopefully the material presented in this volume will allow the reader contemplating the purchase of an atomic absorption instrument to make a selection suited to his purposes and budget, or at least to narrow down the possibilities. The views and opinions expressed herein are those of the author alone, and no responsibility for their accuracy is assumed by the editors, publisher, or instrument manufacturers (or their representatives). The author has attempted to be objective, practical, and impartial in the comments made. Conclusions drawn and comments made are based on the instrument specifications and descriptions provided by the companies, as well as the experience of the author in the field of atomic spectroscopy.

ganizations -- which one should we buy? We feel that if the reader knows what instruments are available and what they will do, then the correct decision can be made.

Claude Veillon
Wesley W. Wendlandt

FOREWORD

In 1955 Alan Walsh at CSIRO in Australia and C. T. J. Alkemade at Utrecht independently proposed atomic absorption spectroscopy as a means of chemical analysis. In his now classic paper, Walsh described the theory and apparatus for using light absorption by atoms in the gas phase in the analysis of metal atoms. Prior to this time, flame atomic emission spectrometry was used to a great extent in analyzing samples in solution for metals down into the parts-per-million (ppm) or μg/ml level, and even lower in some cases. While the flame emission technique worked well for perhaps twenty or thirty elements, detection limits for the other elements were not spectacular and numerous interferences were encountered. These limitations were primarily due to the available instrumentation prior to 1955, rather than to the technique itself. Especially important were the poor -- by today's standards -- monochromators, detectors, and readout electronics available at the time.

Another limitation of the flame emission technique is the temperature attainable with most chemical flames. Of the approximately seventy elements which are frequently analyzed for, about twenty have their primary emission lines (resonance lines) in the wavelength region below 3000 Å. This wavelength region corresponds to excitation energies for the atoms of 4.5-5 eV and higher. At temperatures attainable with ordinary chemical flames -- such as acetylene-oxygen, nitrous oxide-acetylene, and hydrogen-oxygen -- the flame gas molecules (and atoms) do not have an appreciable number of molecules with sufficient kinetic energy to excite a useful fraction of these elements. In other words, elements with resonance lines below about 2800 Å exhibit very poor sensitivity by flame emission because of insufficient temperature in the flame excitation source. For these elements, the improvement in sensitivity and minimum detectable concentration (detection limit) that can be obtained by atomic absorption is most significant. Elements having resonance lines in the visible region (above about 4000 Å) can usually be determined at lower concentration levels by emission rather than by absorption, due to the relatively low excitation energy required. In the region between 3000 and 4000 Å, sensitivities and detection limits by either method are comparable with today's instruments.

During the past ten years, both the use of atomic absorption spectrometry for trace metal analysis and the production of atomic absorption instruments have increased at a phenomenal rate. From this standpoint, atomic absorption spectrometry and gas chromatography are probably the most successful analytical techniques ever devised. Atomic absorption has all but completely replaced techniques like polarography in analyzing for low concentrations of metals. It has assumed many types of analysis performed by other techniques, such as emission spectrography, electrochemical methods, colorimetry and others.

In its early stages of development, atomic absorption promised to be (or so the brochures implied) the ultimate analytical tool. It had "no interferences" and could "do everything." Naturally, it could not and never will achieve this goal. It took a few years to find out what it could and could not do well, or even at all. Remember that the same things were said about polarography in the early years of its development. Atomic absorption has limitations, as does any technique, not the least of which is the need for a separate light source for each element to be analyzed. Atomic absorption does not lend itself to multielement analysis. It is sensitive and quantitative, but only treats one element at a time. Nor has it yet been well adapted to analyzing solid materials. The technique is still greatly hampered in many ways by the chemical flames used to atomize the sample. These have been highly developed, but they still have very serious limitations. Some nonflame vaporization techniques are on the horizon, but it will be a few more years before their potential can be developed to a point where these techniques can be adequately evaluated and compared. It is my personal belief that the future will bring instruments capable of analyzing samples by atomic emission, atomic absorption, and atomic fluorescence, each concentrating on the group of elements it can handle best. At the present stage of development, it appears unlikely that simultaneous multielement analysis will be developed extensively, except for some specialized instruments to analyze a few elements routinely. Hopefully, the nonflame vaporization techniques will be adequately developed in the future.

With this unprecedented growth in atomic absorption technique and instrumentation came confusion on the part of many scientists, who realized that the technique could solve some of their analytical problems, but were not yet sufficiently familiar with the technique to decide which instrument would best fit their needs. With all of the manufacturers promoting and praising the virtues of their products and pointing out the shortcomings of their competitors', many potential buyers and users of atomic absorption equipment wanted a relatively unbiased opinion on just what instruments to obtain. This author has had numerous persons interested in atomic absorption say, "We want to buy an atomic absorption instrument to do such and such; what instrument should we buy?" An answer to this question cannot, obviously, be based on firsthand experience in the use of each of the available instruments, but rather on personal use of a few instruments of representative design and knowing what instruments are available and their individual specifications. This information can be used to try to steer the person toward a few instruments that might do the required job with a minimum expenditure of funds. Because of these experiences, and similar experiences of persons actively working in other instrumental areas, the editors decided to publish the present Handbook of Commercial Scientific Instruments.

This volume deals specifically with commercially available atomic absorption instruments. Detailed descriptions, photographs, specifications, accessories, etc., provided by the manufacturers will be presented in a slightly digested form. Some commentary will be provided where appropriate. Following this, tables will be presented so that pertinent features and specifications of the instruments can be compared rapidly. It is hoped that this information will enable someone planning the acquisition of an atomic absorption instrument to make a reasonably good choice. The instruments covered are those normally available in the United States, either manufactured here or represented and sold by a United States concern. A few foreign manufacturers without United States representatives but who do export their instruments to the United States, are included also. All manufacturers known to the author were contacted, and the amount of information presented is a function of both the number of instruments and accessories manufactured and the amount of information supplied. The information and comments will be presented as objectively as possible and will be based on specifications supplied by the manufacturer, on the assumption that they are correct. Cases in which manufacturers' specifications are obviously incorrect, or are suspected of being incorrect, will be noted.

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