

The Association of Official Analytical Chemists

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The Association of Official Analytical Chemists (AOAC), a non-profit making scientific organisation, provides a mechanism by which scientists work together to develop, test, and collaboratively study methods of analysis. AOAC methods have a world-wide reputation for reliability and are often specified by government agencies and industry in several countries for research, quality control, and determining compliance with law.

Origins and Development

The Association of Official Analytical Chemists (AOAC) was organised in 1884 as the Association of Official Agricultural Chemists by state and federal chemists in the United States of America to establish methodology for analysing fertiliser. Under Harvey W. Wiley in 1890, the scientific activities of AOAC were expanded to include feeds, foods, and pesticides. AOAC methods played an important role in the enforcement of state food laws and the first U.S. Food and Drug Act (1906). The *Journal of the AOAC* appeared in 1915, and the first edition of *Official Methods of Analysis* appeared in 1920.

The AOAC was managed by scientists in the United States Department of Agriculture (USDA), and then in the U.S. Food and Drug Administration (FDA), and was quartered in government offices from the late 1880s until 1978. In 1979, the AOAC became an independent organisation, hired its own management staff and moved its offices to Arlington, Virginia, adjacent to Washington D.C.

The AOAC's income is derived from the sale of publications, meeting and exhibit fees, support agreements by 49 government agencies, and the sustained membership of 58 companies. There are 2000 individual members. Through the years, the AOAC has broadened its scope of activities, including international participation.

Inter-laboratory Collaborative Studies

In the last 5 years, the AOAC has adopted, officially, 180 analytical methods based on inter-laboratory collaborative studies conducted within and outside North America. In 1981 the AOAC published 29 collaborative studies involving 317 laboratories in 23 countries—studies in which industry, government, and university laboratories participated.

From the beginning, AOAC scientists recognised that inter-laboratory collaborative studies are needed to provide unbiased information on the precision, accuracy, and other measures of the performance of a method. Experience has shown that good repeatability of a method within one laboratory has no relationship to its reproducibility among laboratories. Differences between laboratories may result from interpretation of instructions, reagents, laboratory environment, and, most often, from the analysts' technique. The AOAC also recognises the importance of publishing collaborative study data to enable informed choices on the use of methods. Figure 1 shows how this system works.

How Does the AOAC System Work ?

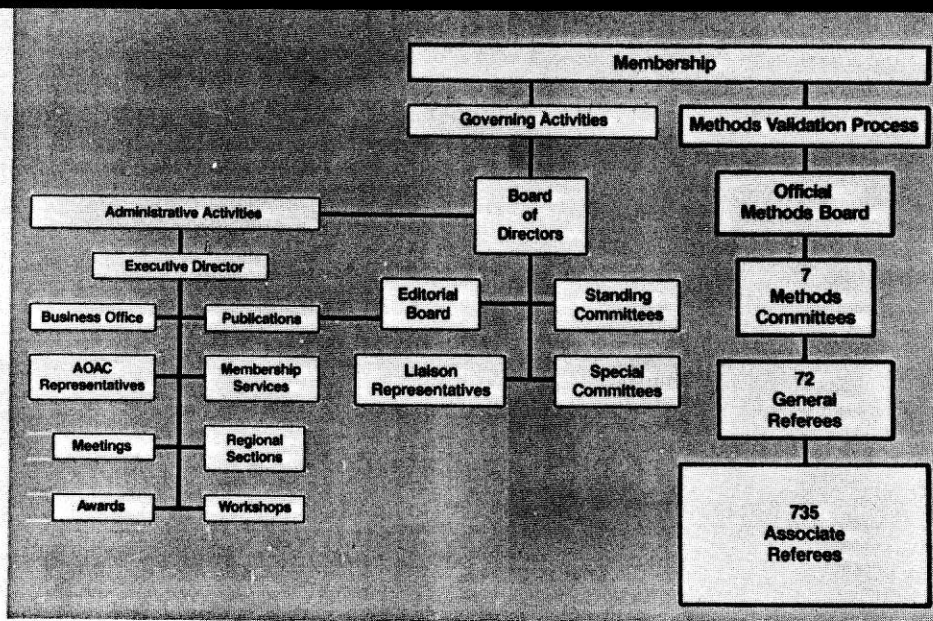


Fig. 1.

Collaborative Studies—Basic Requirements

The AOAC has established the following basic requirements for inter-laboratory collaborative studies.

OPTIMISATION OF METHOD

The method to be studied must be written *in detail* and must be thoroughly tested in a single laboratory before submission to inter-laboratory study. The AOAC recommends that the method undergo "ruggedness testing" to identify and optimise the critical variables. Interferences must be identified. The originator (Associate Referee) of the method should ask another analyst in his or her own laboratory to use the method to determine its performance before beginning an inter-laboratory study. If two or more analysts in the same

laboratory cannot obtain consistent results by the same method, neither will analysts in other laboratories. Failure to optimise performance causes collaborative studies to fail, which creates ill-will and wastes expensive laboratory time and resources.

DISTRIBUTION OF SAMPLES

The Associate Referee initiating the inter-laboratory collaborative study must supply identical sets of samples to the co-operating laboratories (collaborators). The concentration of analyte(s) and/or composition of the samples is known only to the Associate Referee. Experience has shown that the standard deviation of repeatability and of reproducibility are minimised when the collaborators know beforehand which samples are the same concentrations. Homogeneity of the samples is essential for a successful study. Random labelling of samples is recommended.

Samples should include matrices and concentration ranges of interest. Inclusion of a blank sample (matrix without analyte(s) of interest) among the samples provided is highly recommended in most studies and essential in all studies of residue methods. Sets of samples for studies of residue methods often include those with added analyte(s) and "incurred residues".

Extra sets of samples should be prepared to replace those lost in shipment, spoiled, or mishandled by the collaborators.

The stability of the samples during anticipated storage and shipping should be established. Samples should be packed, marked, and shipped correctly, and delivery should be verified by the recipients. It is wise to check customs and other requirements before shipping samples to ensure prompt delivery.

Practice and/or qualification samples are highly recommended to offer collaborators a chance to practise the method and/or show they can perform the analysis using the method. Often a method will contain tests to verify that instrumentation and/or chromatographic columns and materials are performing correctly. Samples may be included for this purpose.

SUFFICIENCY OF DATA

The number of collaborators and samples must be sufficient to ensure that not less than 30 data points will be obtained from not less than six different laboratories. More samples and collaborators are recommended. The statistical design should allow determination of both within- and between-laboratory precision. The AOAC recommends the use of independent or blind duplicates to determinate repeatability according to Youden and Steiner¹.

Thirty data points are the minimum needed for application of large-sample statistical techniques. A minimum of six laboratories allows a reasonable estimation of reproducibility; that is, if the relative standard deviation between laboratories is 0.20, the 95 per cent. confidence limits are 0.15–0.25 or 25 per cent. of 0.20. Extra samples and laboratories should be included to allow for collaborators who do not complete the study, or for procedural or statistical outliers.

Additional samples and/or laboratories can often be included with little extra effort. The AOAC will provide assistance in study design.

The AOAC will assist in locating collaborators with announcements in "The Referee". The AOAC is assembling a scientific talent and interest file to help locate collaborators. To afford collaborators recognition, the AOAC includes their names and affiliations in the published study.

EVALUATION OF DATA

Collaborative study data are reviewed for evidence of procedural outliers, and are statistically evaluated.

The AOAC recommends that the Associate Referee reviews each collaborator's raw data, recorder charts, chromatograms, etc. for arithmetical accuracy, deviation from the method, and transcription errors. Where the method was not followed, data are procedural outliers and may be excluded before statistical analysis is done.

Most collaborative study data are evaluated statistically according to Youden and Steiner¹. The average and standard deviations are calculated and often the ranking and Dixon test are used to locate outliers. Horwitz² recommends plotting the data to locate outliers visually.

Experience has shown that about 5–15 per cent. of the data in a study are outliers; 20 per cent. indicates the method is not rugged or problems have been encountered in the study.

PUBLICATION OF METHODS AND PERFORMANCE DATA

The AOAC requires that methods and data from successful collaborative studies be published in the open literature to give all methods users access to underlying data. Availability of performance data allows users to make more informed decisions about the use of the method. Figure 2 shows the process for the validation of methods.

INITIATION AND ORGANISATION OF STUDIES

The AOAC Committee on Collaborative Studies has drafted protocols for the design, conduct, and evaluation of collaborative studies. The document has been sent to scientists in many countries for comment. Additional comments are invited; the document is available from the AOAC.

The AOAC has participated in two International Union of Pure and Applied Chemistry (IUPAC) Conferences on the Harmonisation of Collaborative Studies and intends to host a third conference in Washington, D.C., in October 1984, just prior to the AOAC Centennial celebration. Hopefully this conference will lead to internationally-recognised protocols for inter-laboratory collaborative studies so that the precision and accuracy of various methods can be compared. Harold Egan, Chairman of the Subcommittee on Harmonization of Collaborative Studies, is organising this conference.

The actual work of development, testing, collaborative study, and approval of methods is done by scientists as employees of government, industry, and university laboratories (Figures 1 and 2). The AOAC co-ordinates the effort, approves the method and publishes the results.

The AOAC publishes lists of topics under study, Associate Referees, General Referees, and committee members in each March issue of the *Journal*. Topics are chosen for study because individuals or laboratories ask that they be studied and are willing to do the work. Any scientist can suggest new topics and offer to serve as a General or Associate Referee or as a collaborator.

The AOAC appoints interested scientists as Associate Referees, General Referees, and committee members (with the permission of their laboratory directors to assure approval and support of the work). The Associate Referee develops or obtains a suitable method to solve the particular problem, tests the method, enlists collaborators, conducts the collaborative study, evaluates the study data, and makes a recommendation to the General Referee on official approval of the method. The timeliness and success of this effort depends on the interest of the originator, and, most important, the support of the laboratory director or management for the project. Associate Referees with strong management support complete their projects promptly.

Associate Referees working on similar topics, e.g. dairy products or organophosphorus pesticide residues, are co-ordinated by one of the General Referees. General Referees approve appointments of Associate Referees, guide them in the selection of methods and in the design and conduct of collaborative studies, evaluate their recommendations for official approval of methods, and then make a recommendation for adoption of the method to the appropriate committee of the Methods Board.

General Referee topics are assigned to one of seven Methods Committees, each consisting of five to seven experts in a field. These Committees further review the method, the collaborative study data, and the General Referee's recommendation, and then make their own recommendation on adoption of the method by the Association at the Annual Business Meeting. According to AOAC Bylaws, at the AOAC Business Meeting each agency of a national, state, provincial, or local government is entitled to one vote on the adoption of methods concerning commodities over which they have jurisdiction.

The AOAC publishes adopted methods in *Official Methods of Analysis* and its annual supplements, "Changes in Methods". Collaborative studies are published in the scientific literature, most often the *Journal of the AOAC*.

The methods and collaborative studies may also be orally presented at the AOAC Annual International Meeting, which is held each October in Washington, D.C.

BENEFITS OF PARTICIPATION

Associate Referees and their employers receive recognition for participation in a successful AOAC collaborative study through inclusion of an official method in *Official Methods of Analysis* and publication in scientific literature.

Additional benefits for the Associate Referee and collaborators are the contacts with other experts in the field and a chance to make a presentation at the AOAC Annual International Meeting. The contacts are often helpful in solving future methods problems. If the method is widely used in the Associate Referee's laboratory, official approval by AOAC will encourage its use in other laboratories.

Through the AOAC mechanism, many laboratories with similar analytical methods needs and interests share the effort and cost of a collaborative study. This co-operation between laboratories avoids overlap and duplication of effort in obtaining methods of high reliability and credibility.

CO-OPERATION WITH OTHER BODIES

The AOAC also gives official approval to methods based on inter-laboratory collaborative study data obtained by individuals and organisations outside the AOAC if the design and conduct of the collaborative study meet AOAC requirements. Based on collaborative study data submitted by other organisations, several methods are officially approved each year. The AOAC has co-operative arrangements with other organisations to conduct collaborative studies and officially approve methods.

The AOAC co-operates with the Collaborative International Pesticides Analytical Council (CIPAC). This co-operation includes exchange of collaborative study data and reciprocal adoption of methods. The AOAC hosted the 1979 CIPAC meeting in Baltimore, Maryland, U.S.A.

The AOAC participates in Technical Committee (TC) 34, Agricultural Food Products, and TC 134, Fertilisers, of the International Organisation for Standardisation (ISO). The AOAC is the Technical Advisory Group (TAG) administrator through the American National Standards Institute (ANSI) for ISO/TC 34 and its subcommittees (SC) and working groups (WG).

The AOAC circulates ISO documents through TAGs in the United States and returns their comments to ISO. The AOAC is represented at ISO subcommittee meetings and encourages inter-laboratory collaborative studies when methods have reached the Draft International Standards (DIS) stage.

The AOAC participates in a joint committee with the International Dairy Federation (IDF) and ISO Milk and Milk Products Subcommittee to develop and test methods for dairy products for the FAO/WHO CODEX Alimentarius Commission.

The AOAC has also been represented at CODEX Commodity Committee meetings, and the Committee on Methods of Analysis and Sampling. The CODEX Alimentarius now accepts only methods that have been collaboratively studied.

IDF Commission E, ISO/TC 34/SC5 Dairy Products, and the AOAC have participated in a joint committee on methods of analysis of dairy products for 20 years. Fourteen methods in the 13th Edition of *Official Methods of Analysis* are endorsed by all three organisations.

The American Association of Cereal Chemists (AACC) and the AOAC accept each other's methods if the collaborative study requirements of each are met.

In 1964, the American Oil Chemists Society (AOCS), AACC, IUPAC, and AOAC established a joint committee on mycotoxins which co-ordinates efforts on mycotoxin methods.

In 1981, the AOAC established a General Referee topic on Veterinary Analytical Toxicology in co-operation with the American Association of

Veterinary Diagnosticians (AAVD) and the American College of Veterinary Toxicologists (ACVT).

AOAC committees are engaged in a variety of activities. The AOAC Committee on International Co-operation has as its major goal the promotion and use of internationally acceptable methods approved by collaborative studies. At the present time, the Committee includes members from western and northern Europe, Canada, and the United States of America. Peter Martin of the Association of Public Analysts is a representative to this Committee. Participation is sought from South America, Africa, the Middle East, and the Far East. The Committee meets at the AOAC Annual International Meeting.

The Committee on Instrumental Methods and Data Handling is concerned with protocols for describing instrumentation and materials performance criteria and tests in the context of the methods in which they are used. For example, in a chromatographic method which includes a requirement for a column to separate a specific compound from the analyte, any equipment or materials meeting the performance test stipulated in the method could be used.

This Committee has been asked to operate the Reporting Secretariat for Pesticides and Toxic Substances for the International Organisation of Legal Metrology (OIML).

The AOAC promotes laboratory quality assurance through the Committee on Laboratory Quality Assurance, several Annual Meeting symposia, and publications.

The AOAC is investigating the development of a programme to certify food and feed analysis laboratories.

Collaborative studies, contributed papers on methods, and special symposia are presented at the AOAC Annual International Meeting. The forthcoming meetings are scheduled as follows: 25–28 October 1982; 3–6 October 1983; 29 October–1 November 1984 (the AOAC Centennial year). All will be held at the Shoreham Hotel in Washington, D.C.

The AOAC Spring Training Workshop and Exposition, held in a different location each year (19–21 April, 1983, Indianapolis, Indiana, U.S.A.), and Regional Section meetings are designed for informal papers and problem-solving sessions. The AOAC invites everyone to attend.

Chemists, microbiologists, and other scientists and their employers are invited to become individual members or sustaining members. All members receive "The Referee" and meeting announcements, programmes, etc.

Anyone can get involved in scientific activities of interest to them or their employers. To find out how to participate, telephone or write to Harold Egan, 49 Medway Gardens, Wembley HA0 2RJ, U.K., Telephone: 01-904 6229; or Margreet Tuinstra, Langhoven 12, 6721 SR Bennekom, The Netherlands, Telephone: 31-8389-8725; or David MacLean, AOAC Executive Director, 1111 North 19th Street, Suite 210, Arlington, Virginia 22209, U.S.A., Telephone: (703) 522-3032.

References

1. Youden, W. J., and Steiner, E. H., *Statistical Manual of the AOAC*, 1975.
2. Horwitz, W., "Evaluation of Analytical Methods used for Regulation of Foods and Drugs," *Anal. Chem.*, 1982, **54**, 67A-76A.