IN THIS ISSUE

17th Annual Meeting, Institute of Nuclear Materials Management, Inc., Washington Plaza Hotel, Seattle, Wash., June 23-25, 1976.

INMM

NUCLEAR MATERIALS MANAGEMENT

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SUMMER 1975

JOURNAL OF THE INSTITUTE OF NUCLEAR MATERIALS MANAGEMENT

THE INMM CHAIRMAN SPEAKS

Mr. Soucy

After New Orleans

By Armand R. Soucy

Most of you will probably agree that our New Orleans annual meeting (June 18-20, 1975) was the most successful technical meeting sponsored by the Institute of Nuclear Materials Management. Major accomplishments of the meeting included: attendance of approximately 350, a large number of high quality papers, and a panel discussion of recognized experts who freely exchanged philosophies on the issues related to safeguards.

The past year has also been a successful year for INMM. Some of the highlights are: the addition of approximately 100 new members to our organization thereby increasing our membership to over 400. A financial structure which is the strongest in our history, and the continuance of a major effort to the development of standards.

Special recognition should also be given to the creditability of our certification program. Through these efforts we have succeeded in establishing an ANSI Standard for the certification of nuclear materials managers and initial drafts of the standard are currently out for review. Additionally, the Institute for the first time sponsored a safeguards education program. The results of our initial endeavor in the area of education from both a financial and educational standpoint were most gratifying.

The question which INMM now must answer is, "What comes after New Orleans? What are the next programs which we should undertake in the year 1975-1976?" During the next few months your new officers will give considerable thought to this question. On a preliminary basis, it is my view that the Institute of Nuclear Materials Management must recognize that it is now a mature organization. Therefore, we must look at the future of the Institute from a different prospectus. With this thought in mind, I will propose at the next executive committee meeting that the number of officers and executive committee members who manage the Institute should be expanded from nine to thirteen members. We should also establish a special ad hoc committee to brainstorm the future of the Institute. Our involvement in education should only be considered an initial step in this area. To expand our activities it is my proposal that a special three-member standing committee on education be organized to review additional educational opportunities in nuclear materials management. We must also recognize that an increased membership adds to the managerial responsibilities of the officers of the Institute. This increase in responsibility is especially evident in the area of financial control. It will therefore be proposed that each standing committee submit a budget to the executive committee for approval before the treasurer is authorized to make payments for the various committee activities.

The INMM members who organized the New Orleans meeting deserve special accolades for their outstanding work. Because of their efforts, the Institute has received more recognition from the public and responsible government officials for its work than ever before. However, as you know, the safeguards problem is also more complex today than ever before in the history of the nuclear power industry. The Institute, therefore, has a tremendous responsibility during the next year if it is going to contribute to the solution of the problems of safeguarding nuclear materials. I know that our organization has more know-how in safeguards than any other professional organization in the world. It is my view that although New Orleans was an extremely successful meeting it merely opened the door to a greater participation by the Institute of Nuclear Materials Management in the science of safeguards.

GUEST EDITORIAL

Mr. Lovett

'Safeguards . . . Seriously Underpublished'

By James E. Lovett
INMM Past Chairman

In recent weeks I have found myself arguing that the safeguards field is seriously underpublished, and that fact, along with others, justifies a certain modification of the IAEA's normal publication policies. The modification is unimportant here; what is important is the essential truth of the argument. The safeguards field **is** seriously underpublished.

There appear to be several reasons. One is that it is both a new field and an inter-disciplinary field. None of the classic journals overlap with the field of safeguards enough to justify their purchase, assuming that articles directly related to safeguards are your only interest. If you don't read a journal, you tend to assume that your colleagues don't either, and therefore you don't choose that journal when you look for a place to publish your own work. This of course makes the journal even less interesting to safeguards.

The Journal of the INMM is, to my mind, a major step toward correcting this deficiency. It is of direct interest to safeguards, and it is becoming widely read. The result is an increase in the number of articles submitted to it, leading to wider circulation, leading to more articles, etc. The Journal is not as widely known in Europe as I would like, but I am working on that. If you have any ideas, let me know.

However, I think there are at least two additional reasons why the safeguards field is underpublished. One is that it is under-read. Most of us make rather little effort to discover what is published, and become aware of work by others only by word of mouth or by having someone send us a copy of his technical report. When, for example, was the last time you looked in Nuclear Science Abstracts? When was the last time you visited your company's technical library? Are you struggling to re-invent something that was invented ten years ago? If you haven't read the literature, how do you know for sure?

Finally, I think that as a broad general statement we tend to be very lax in giving credit where the work of others is involved. Very few safeguards articles have more than five or six references in them, and those usually are either to standard texts or to other work by the same author. This has two undesirable effects. The author whose work was used without reference tends to get a little peeved at times, but we are all friends and these incidents tend to be forgotten as fast as they occur. More important, to my mind, is that it makes it difficult for someone to develop a thorough knowledge of a subject by following the literature. Take a calorimeter, or a neutron coincidence counter for example. (I haven't tried either one lately, so they are strictly hypothetical examples.) It should be possible for someone to pick up one of the most recent articles on the subject and by following the references backward, rather quickly come to a fairly thorough grasp of the subject. He should, for example, quickly identify the three or four laboratories that are most active in the field, and the names of maybe a dozen men who are doing the most important work. A quick literature search on those names, plus the references that each of them quotes, should quickly identify almost all of the pertinent references.

(Continued on inside back cover)

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Mr. Cardwell

ANNUAL MEETING REPORT

317! Record Attendance At New Orleans

By Roy G. Cardwell
INMM Vice Chairman

Our Sixteenth Annual Meeting has "come and went," as they say around here; and, like it or not, INMM has grown another foot.

With a registered attendance of 317, an increase of 27% over last year, and the obvious attention our society is now receiving as the focal organization for nuclear materials safeguards and management, it is obvious that our thinking must now take another step up with our situation.

I was particularly gratified by the response to the questionnaire—not so much by the number responding as in the sincerity of comment and the excellent suggestions. At any rate, 138 returned the questionnaires to provide us with a good sampling.

On Question 1, "Would you prefer to have our Annual Meeting extended to four days with shorter daily schedules?", 60 (43%) of those responding said YES, while 78 (57%) said NO.

On Question 2, "Would you prefer to have our Annual Meeting in another month besides June?", the split was more pronounced with a 2-to-1 preference. Of those responding, 45 (34%) said they preferred another month, while 86 (66%) indicated a preference for June—although several commented that June meetings should be held in a cooler climate.

Question 3, "Would you be interested in having and attending a Regional Meeting during midyear?", again resulted in a closer vote; 62 of those responding (45%) indicated a favorable attitude toward such meetings while 75 (55%) were against them. Several of the NO votes, however, commented in favor of the "one subject" seminar-type meeting, where a very current problem could be discussed. (The numbers in Questions 2 and 3 do not add to the total respondents because some were left blank; everyone responded to Question 1.)

There is no question that this meeting offered the most comprehensive program in our history. **Bob Keepin** put many hours into its preparation, and the results were obvious. He and other LASL personnel also set up the demonstration as a cooperative conjuncture between INMM and ERDA, which attracted a goodly number of additional individuals to New Orleans. The few problems that occurred, I feel, were mostly due to the much larger attendance than we expected—and I was delighted to be faced with this type of problem. I do apologize for any inconveniences caused any of you as a result of some of our crowding problems; but if you will forgive and bear with me I'm sure **Bill DeMerschman** has taken notes and will have us in a more spacious environment in Seattle.

Your individual comments, now being classified and assembled, I felt were a sincere attempt to help us improve the Annual Meeting. As I said in the Business Session, we can assemble the best program going but if you don't come to the meeting we've wasted our time.

Several excellent suggestions were made which no doubt will be incorporated in future assemblies. Some, such as the pros and cons of concurrent sessions, can be debated **ad infinitum** where the best that can be done is a reasonble compromise. All will be given serious consideration by the Annual Meeting Committee as we look toward Seattle.

We hope you are looking toward it with us!

Mr. DeVito

Soucy Re-Elected INMM Chairman At June New Orleans Meeting

BY V. J. DeVITO

Secretary of INMM

According to Article III, Section 6, of the INMM Bylaws, "The Secretary shall notify each member in good standing of the results of the election by November 15 of each year." For the record, this notice in the Journal shall be construed as having fulfilled that obligation.

In accordance with Article III, Section 4, of the Bylaws, the Nominating Committee selected the following candidates for each office and position:

Chairman .... Armand Soucy
Vice Chairman .... Roy Cardwell
Secretary .... Vince DeVito
Treasurer .... William Gallagher

Executive Committee:
Larry Dale
John Jaech
Robert Keepin
Gary Molen

There were no petitions for candiates to be added to the ballot. However, there were several write-ins.

In accordance with Article III, Section 5, a ballot was mailed to each of the Institute's 403 members, of which 229 returned valid ballots.

As a result of the balloting, the officers and members of the Executive Committee for fiscal year 1976 will be as follows:

Chairman .... Armand Soucy
Vice Chairman .... Roy Cardwell
Secretary .... Vince DeVito
Treasurer .... William Gallagher

Executive Committee:
Thomas Bowie to June 30, 1976
Sheldon Kops to June 30, 1976
John Jaech to June 30, 1976
Robert Keepin to June 30, 1976
Harley Toy—Immediate Past Chairman

PHOTO HIGHLIGHTS

New Orleans INMM Meeting June 18-20, 1975

Dr. William A. Higinbotham, who is Editorial Editor and Technical Editor of Nuclear Materials Management, gave the annual Institute paper Wednesday afternoon. His was one of nine invited papers for the meeting. Technical Program Chairman Bob Keepin was roundly applauded for his efforts in putting together the finest program ever at an INMM annual meeting . . .

INMM Awards Committee Chairman (right) Tom Bowie presented a plaque to Battelle Memorial Institute, Columbus, Ohio, for its many years of outstanding contributions to INMM activities and programs. Past INMM Chairman Harley L. Toy, a member of the Institute Executive Committee, accepted the award for Battelle during the annual business meeting on Wednesday afternoon . . .

Ella Werner edited many of the early issues of the INMM Newsletter, a publication which preceded this Journal, Nuclear Materials Management. She posed with INMM Chairman Armand R. Soucy at the annual meeting . . .

With added duties in the NRC Office of Standards Development, Ralph J. Jones (left) resigned as INMM Treasurer after three years in the position. Bill Gallagher (right) of U.S. ERDA in Oakland, Calif., was elected to succeed Mr. Jones. Jones and Gallagher handled registration at the annual meeting . . .

Charles Moeller (left) with Charles Bean checking out a cassette tape recorder . . .

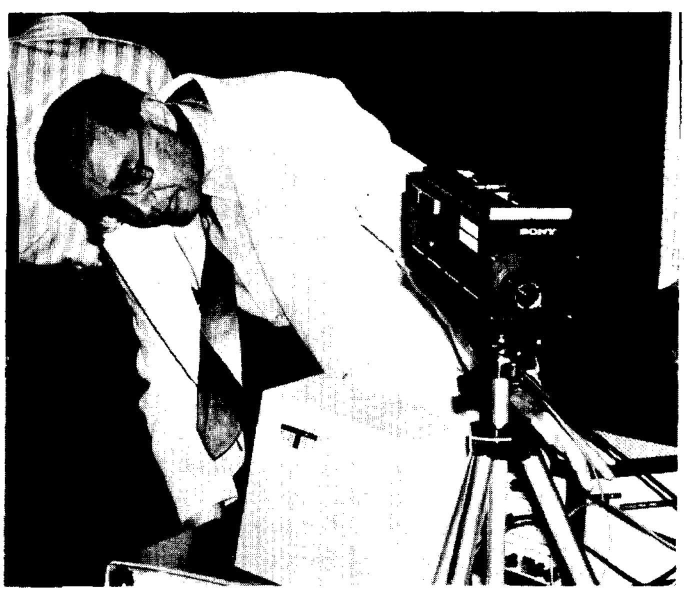
Dick Brouns (left), the Jerry Handshuhs, and Bob Sorenson (right) visited at length during the Thursday evening social hour and buffet . . .

Lew Fields shown examining one of the industrial exhibits at the INMM annual meeting in New Orleans.

Dick Bramblett, Ken Osborn and Si Smiley . . .

Lynn Hurst (left) who has been studying the INMM Constitution and By-Laws for the Executive Committee visited with Gen. Del Crowson of Middle South Services. Gen. Crowson served as local coordinator for the 16th INMM annual meeting . . .

INMM Chairman Armand R. Soucy (right) of Yankee Atomic with INMM Vice Chairman and Mrs. Roy G. Cardwell.



Herman Markowitz of D B M Associates, El Paso, Tex., was one of several exhibitors at the INMM annual meeting . . .

There was a festive spread for those at the INMM annual meeting who took in the complimentary cocktails and buffet Thursday evening.

Dennis Wilson, Chairman of the INMM Safeguards Committee, has his eye fixed on some hors d'oeuvres during the Thursday evening social affair at 1975 annual meeting.

THREE AREAS OF ACTIVITY

By Dennis W. Wilson, Chairman

The Safeguards Committee has continued to develop goals listed in the Winter and Spring Journals. Since the last report, the Committee has better quantified some of its activities. A very productive meeting—with nearly all Committee members present—was held in New Orleans prior to the annual meeting. Results of this meeting have given better direction to coming activities. Specifically, plans for activity can be summarized as follows:

1. **INMM Safeguards Information Medium**—Active consideration has been given to the most effective method of spreading the "gospel of safeguards." After examining a number of possibilities, three were selected for further evaluation including:

News Articles—Several positive articles for use in a variety of magazines and newspapers will be prepared. These will be made available for solicited and unsolicited material to numerous sources such as airline magazines, newspapers, etc. Availability of the first articles is scheduled for fall.

Question and Answer Booklet—Work is continuing with determining the feasibility of preparing a Q&A booklet—possibly in conjunction with the ANS. Practicality of this approach will be determined by early fall. If found practical, the booklet should be available by the first of the year.

Individual Information Helps—Some interest has been expressed in making available to the INMM membership specific information on safeguards such as that useful in writing letters-to-the-editor, neighborhood information sheets to offer alternatives to anti-nuclear petitions, etc. If found feasible, examples of such materials may be distributed to the INMM membership with the Fall issue of the Journal.

2. **Speaker's Bureau**—A solicitation of INMM membership is being made to determine availability of members to present factual safeguards information to various audiences at various levels. If the concept is found practical, a list of available participants will be sent to INMM members. Any member who can participate in such a program but who was not contacted for inclusion in the INMM list should contact the Safeguards Committee Chairman.

3. **Regulatory Guide Review**—Comments on published Division 5 Regulatory Guides are being generated by Committee members. The next level involvement is structured to encourage INMM participation before guide issuance. It is felt that this type interaction will be of more overall benefit.

We on the Committee repeat what we have said in the past: We need "input from capable and willing INMM members. Each Institute member is encouraged—no, solicited—to participate in these activities." As of this writing, our request has yet to produce a single response. Is Institute membership really that apathetic or is it that the Committee is not doing its job? In any event, we do not wish to work in a vacuum. This is your Institute, your committee and your profession. Give us your comments now before you forget!

Mr. Jaech

N15 REPORT

Need to Go from 'Commendable' to 'Impressive'

By John L. Jaech, Chairman

	Subcommittee	Chairman	Organization
INMM-1	Methods of SNM Control	E.J. Miles	Westinghouse
INMM-3	Statistics	L.T. Hagie	G.E.
INMM-4	Records	R.E. Weber	ERDA
INMM-6	Inventory Techniques	R.A. Schneider	Battelle
INMM-7	Audit Techniques	R.J. Sorenson	Battelle
INMM-8	Calibration Techniques	L.W. Doher	Rockwell International
INMM-9	Nondestructive Assay	D.W. Bishop	G.E.
INMM-10	Physical Protection	W.J. Shelley	Kerr McGee
INMM-11	Certification	F. Forscher	Consultant

In reviewing the progress we have made as an organization with respect to the production of ANSI standards, we cannot ignore the appraisal of these activities given in the article by Powers and Norderhaug that appeared in the Winter, 1975, issue of this journal. In summary, this article was not complimentary, but was rather critical of INMM performance with respect to standards activities.

I, as chairman, have a mixed reaction to this article. On the one hand, when it is kept in mind that INMM is a relatively small organization with only about 400 members to draw on for standards work, I feel that our overall performance record is indeed commendable. There have been many individuals who have exerted considerable effort in support of standards work, and I personally am most appreciative of such efforts. Their contributions have resulted in a number of standards of significant importance.

On the other hand, we must admit that there are areas in which we as an organization have been slow to act. We, as individuals, have accepted assignments and then failed to carry out the attendant responsibilities. By accepting the assignments in the first place, we have excluded others who might have been able to proceed at a faster pace. The message is: do not accept responsibilities for standards activities unless you intend to work at it. With this in mind, it is hoped that our performance during the next INMM year will change from "commendable" to "impressive."

Although I hesitate to measure progress by numbers of standards approved or in some step of the approval route, these statistics are some measure of performance and are cited here. Through 1974, there have been 13 approved standards. Four additional standards have been approved thus far in 1975 (N15.9, N15.19, N15.20, N15.22), two more are at ANSI for final approval (N15.17, N15.18), an additional one is in the writing group for resolution of ballot comments (N15.26), and one is out for ballot (N15.23).

In citing these statistics, special thanks are given **Lou Doher** and the members of INMM-8 for carrying to completion four very difficult standards in 1975. Their many hours of effort are noted and appreciated. And, while handing out accolades, a special note of thanks is extended to our hardworking N15 Secretary, **Dick Alto,** whose conscientious efforts on behalf of INMM standard activities have been and continue to be an important factor in the success of our standards work.

40 NEW MEMBERS

The following 40 individuals have been accepted for INMM membership as of August 7, 1975. To each, the INMM Executive Committee extends its congratulations.

New members not mentioned in this issue of the Journal will be listed in the Winter 1976 (Volume IV, No. 4) issue to be sent out next January or February.

Francis M. Alcorn, Supervisor of Nuclear Materials, Babcock & Wilcox Company, Lynchburg Research Center, P.O. Box 1260, Lynchburg, VA 24505.

Etoy Alford, Battelle Pacific Northwest Laboratories, P.O. Box 999, Richland, WA 99352.

Vahe N. Apelian, Nuclear Engineer, Gibbs & Hill, Inc., 393 Seventh Avenue, New York, NY 10001.

John H. Birden, 6013 Jassamine Drive, Dayton, OH 45449.

Richard J. Brouns, Research Associate, Battelle Pacific Northwest Laboratories, P.O. Box 999, Richland, WA 99352.

Charles R. Condon, 1532 Thayer Drive, Richland, WA 99352.

John Hunter Cusack, TSO, Department of Applied Science, Brookhaven National Laboratory, Upton, Long Island, NY 11973.

Thomas A. Glubrecht, 18151 -145th, S.E., Renton, WA 98055.

James R. Griggs, Goodyear Atomic Corporation, P.O. Box 628, Piketon, OH 45661.

Leo E. Hansen, Physical Security Specialist, Exxon Nuclear Company, Inc., 2101 Horn Rapids Road, Richland, WA 99352.

A. Lee Harkness, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439.

W.E. Hawkins, Manager, Wackenhut Services, Inc., 2753 South Highland Drive, Las Vegas, NV 89114.

Horace L. Henry, 75 McMurray, Richland, WA 99352.

Jack A. Hind., U.S. Nuclear Regulatory Commission, Region III, 799 Roosevelt Road, Glen Ellyn, IL 60137.

Akihiro Kitano, Representative, Tokyo Electric Power Company, Inc., 1725 Eye Street, N.W., No. 215A, Washington, DC 20006.

Avi J. Kraft, 23 Adlai Circle, Staten Island, NY 10312.

Lorenz A. Kull, 7180 La Jolla Scenic Drive South, La Jolla, CA 92037.

Victor W. Lowe, Jr., Los Alamos Scientific Laboratory, P.O. Box 1663, Los Alamos, NM 87544.

Norman J. McCormick, University of Washington, Department of Nuclear Engineering, BF-10, Seattle, WA 98195.

Ronald M. Mann, 3307 N.E. 10th Place, Renton, WA 98055.

Harold R. Martin, U.S. ERDA, Idaho Operations Office, 550 - 2nd Street, Idaho Falls, ID 83401.

Albert J. Moellenbeck, E.V.P., Nuclear Power Services, Inc., 26 Broadway, New York, NY 10004.

Charles E. Moeller, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439.

Emory L. Musselwhite III, Security Superintendent, Nuclear Fuel Services, Inc., P.O. Box 218, Erwin, TN 37650.

Theron G. Odekirk, Energy, Inc., P.O. Box 736, Idaho Falls, ID 83401.

Frank G. Pagano, Jr., Senior Plant Protection Analyst, U.S. Nuclear Regulatory Commission, Washington, DC 20555.

Richard E. Parks, 9207 N.E. 24th, Bellevue, WA 98004.

Phillip L. Paull, Nuclear Engineer, Oregon Nuclear & Thermal Energy Council, 4263 Commercial S.E., Salem, OR 97310.

James E. Rushton, Union Carbide Company, Nuclear Division, Oak Ridge National Laboratory, Oak Ridge, TN 37830.

Kenneth E. Sanders, U.S. Nuclear Regulatory Commission, Office of Standards Development, Washington, DC 20555.

Clark P. Sanger, Virginia Electric Power Company, Nuclear Fuels Resources, 7th & Franklin Building, Richmond, VA 23219.

Marvin F. Schnaible, Accountant, Exxon Nuclear Company, Inc., 2101 Horn Rapids Road, Richland, WA 99352.

Roger R. Sharp, Exxon Nuclear Company, Inc., 2101 Horn Rapids Road, Richland, WA 99352.

Roger M. Smith, 7 McWilliams Place, Pinawa, Manitoba, Canada.

Walter W. Strohm, Monsanto Research Corporation, Mound Laboratory, Miamisburg, OH 45342.

Larry H. Taylor, 1103 Catskill, Richland, WA 99352.

Nancy M. Trahey, U.S. ERDA, New Brunswick Laboratory, P.O. Box 150, New Brunswick, NJ 08903.

John L. Vogt, 3676 Yosemite Drive, Salt Lake City, UT 84109.

Don J. White, U.S. Department of the Army, TE-AN, White Sands Missile Range, NM 88002.

David W. Zeff, Licensing Engineer, Babcock & Wilcox Company, P.O. Box 1260, CNFP, Lynchburg, VA 24505.

The following changes of address of members of the Institute have been received by the INMM Publications Office as of August 7, 1975.

David M. Elliott, 9 Michael Lane, Box 525, Zoar, OH 44697.

Billy T. Kraemer, 2711 Clark Street, Paducah, KY 42001.

Marvin R. Schneller, 2401 West Canal Drive, Kennewick, WA 99336.

Dean D. Scott, 424 North 4th Street, Apt. 8, Pasco, WA 99301.

Special Nuclear Materials Specialists

Attractive new positions working in the regulation of civilian nuclear power with the U.S. Nuclear Regulatory Commission, Bethesda, Maryland.

- Special Nuclear Materials Measurement Specialist (NDA) — Reviews and prepares criteria and procedures for organization and implementation of an inventory verification sampling measurements program utilizing primarily nondestructive methodology and techniques for the confirmatory measurement of special nuclear materials. B.S. or M.S. degree in nuclear physics or nuclear engineering, electrical or electronic engineering with nuclear specialties. Sound knowledge of the technology of nondestructive measurement of fissile materials. Requires at least 3 years' direct experience in the application of NDA techniques and methods to materials measurements.

- Special Nuclear Materials Accounting Specialist (ADP) — Develops new and improved methods for the application of automated information available from the Nuclear Materials Information System (NMIS) data base to the inspection function of the licensee materials accounting program. Prepares and maintains the "Special Instructions to Licensees" for input of special nuclear material transfer data into the system. B.A. or equivalent in Accounting with ADP experience preferably IBM 360 and at least 2 years' experience with Nuclear Materials Information Systems or equivalent.

- Senior Material Control Specialist — Develops procedures to be employed in implementing NRC regulations, license conditions, and inspection and enforcement policies for the control and accounting of special nuclear material in the licensee sector. Evaluates licensee program accounting problems and recommends feasible courses of regulatory action. Coordinates abnormal inventory information. B.S. or M.S. in nuclear or chemical engineering with specialty studies in statistical methods. Sound knowledge of technology of destructive and nondestructive measurement of fissile materials. Requires at least 5 years' experience with nuclear material accounting and control in the nuclear industry.

Mail Application (Standard Form 171 — available at most Federal Offices) or resume including salary history to:

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- URANIUM MANAGEMENT ASSISTANCE
- FABRICATION and CERTIFICATION OF CALIBRATION STANDARDS FOR USE WITH NON-DESTRUCTIVE ASSAY SYSTEMS

For Further Information Contact:

UNC UNITED NUCLEAR CORPORATION
RECOVERY OPERATIONS
Wood River Junction
Rhode Island 02894
TELEPHONE: 401/364-7701

An Equal Opportunity Employer

Kenneth D. Cohen Appointed

Falls Church, Va.—Dr. Ralph F. Lumb, President of NUSAC, Inc., has announced the appointment of **Kenneth D. Cohen** as Manager of the recently-established Security Programs Division of the company.

In this capacity, Cohen will report to Lawrence D. (Dave) Low, Vice President for Materials and Plant Protection. Mr. Cohen has been with NUSAC for a year. His extensive security experience prior to joining NUSAC included five years in security with the U.S. Marine Corps and serving as Nuclear Security Representative with Carolina Power and Light Co. He also had a security operation with Union Security Services, Inc.

Lumb also announced that Capt. (Ret.) **Jeffe B. Hall** has joined NUSAC as a member of the staff of the Security Programs Division. Twenty-two of Hall's 27 years with the Marine Corps were devoted to security and counter-intelligence. He has served as a consultant to a number of foreign military and civilian organizations on security problems.

NUSAC provides security consulting services to utilities, fuel fabricators and fuel reprocessors in the nuclear field.

Dr. Forscher

INMM Certification Program Is Progressing

By Dr. Frederick Forscher, Chairman
INMM Certification Committee

The Certification Committee met 16 June 1975 at the Hotel Monteleone, New Orleans, prior to the Sixteenth Annual Meeting of the INMM at the same place.

Present were: Thomas B. Bowie, C-E Inc., 203-688-1911; Frederick Forscher, Chm., Consultant, 412-521-0615; *Lynn K. Hurst, E.R. Johnson, 703-893-7378; John L. Jaech, Exxon Nucl., 509-946-9621; *Syl C. Suda, TSO-BNL, 516-345-2925; Ralph J. Jones, NRC-Stds, 301-443-6973; and *William Kenna, NRC-Operations, 404-526-6323.

* part time

1. Forscher described briefly the events since the last meeting 21 May, 1975 at the Century XXI Bldg., Germantown. Minutes of this meeting had been mailed 23 May, 1975 to all committee members.

All changes to Draft #0, Rev. 3, as reflected in these minutes, were incorporated by Norm Wittenbrock in a new Draft: Rev. 4. In addition, the Foreword was revised as per Gaughran's draft and also included in Draft #0, Rev. 4. Enough copies were mailed to the Hotel to allow distribution to all members of the INMM Executive Committee and INMM-11 members. The Executive Committee met the following day, 17 June 1975, to review our progress and to consider the recommendations of our committee. Jones made the presentation to the Executive Committee, since Forscher could not attend this meeting.

2. NSMB (formerly NTAB) Study Group on Nuclear Certification Programs has not met since the last report to this committee. However, in a telecon between Forscher and William Rockwell, in charge of ANSI's accreditation programs, it was learned that ANSI is not looking toward an early resolution of who would accredit professional certification boards (in the nuclear field or in any other scientific/technical field). Contenders are: ANSI, EJC, NSPE, and possibly others.

Information received so far is reassuring that our certification program is right in line with all the other certification programs in the nuclear area, and that—like those—our program should be "accreditable" by whatever agency will eventually accept the responsibility for accreditation.

The following paragraphs were drafted by Forscher for the Study Group. They are reported here for your information and our interest in "professionalism."

Eligibility for Certification

Certification procedures shall be available to all qualifed persons, independent of race, creed, sex, religion, age, or national origin. Acceptance criteria shall be based on performance, and demonstrated knowledge and understanding of the functions and responsibilities of persons engaged in the profession to be certified.

(It was suggested at the meeting that we modify our Foreword accordingly. ff)

Rules of Professional Conduct
(often referred to as Code of Ethics. ff)

In order to establish and maintain a high standard of integrity, skills and practice in the profession, and to safeguard the life, health, property, and welfare of the public, Rules of Professional Conduct shall be promulgated, and shall be binding upon every person holding a certificate of proficiency.

All certified persons shall be charged with having knowledge of the existence of those Rules of Professional Conduct, and shall be deemed familiar with their several provisions. Such knowledge shall encompass the understanding that the practice of the profession is a privilege, as opposed to a right. All certified persons shall be forthright and candid in their communications with the Board on matters pertaining to professional conduct.

The Rules of Conduct shall, as a minimum address the following subjects: 1) Responsibility to the Public; 2) Competency of Assignment; 3) Public Statements; 4) Conflict of Interests; 5) Solicitation and Compensations.

The Board shall have the right to revoke a certification or censure a certified professional only after due process (hearing) by a court of at least three certified peers.

3. The Educational Testing Service (ETS) of Princeton submitted a formal proposal to the INMM. The proposal covers a two year test development period (July 1975-June 1977) with an estimated price tab of $41,710. This figure does not include any fee and travel expenses of the consultant, advisory committee, and examination committee. Their services and functions are part of the proposed test development program and are detailed in the submitted proposal. It is estimated that these functions will add an additional $20,000 to $30,000 to the above cost.

NRC has informally indicated that it would be receptive to financing this effort as part of the FY76 budget. The committee agreed to recommend to the Executive Committee of the INMM that the Institute should indeed prepare and submit a proposal to the NRC as soon as possible. Such a proposal would be in the best interest of the members of the Institute, the Regulatory Commission and the nuclear industry at large. Energy Management Consultants, Inc. (Forscher's firm) will make a supplementary proposal to the Institute covering all those functions not included in the ETS proposal. The joint proposal from ETS and Emc[i] will then be submitted to the NRC by the Institute.

4. (from Nucleonics Week, June 26, 1975): At the business meeting in conjunction with the INMM conference, Frederick Forscher, head of a subcommittee, reported on the work of developing a standard for certification of nuclear materials managers. A first draft has been written, under a charter from the American Standards Institute; a revised draft will be out by August, and then a hopefully final version will be ready for a vote in Oct. Then there would be the process of//developing the test itself//and testing the standard before final adoption in possibly 18 or 24 months. Although the INMM has issued certifications since 1963, it has been a rather easy-going procedure heretofore. The attempt now is to upgrade the certification—basing it on prerequisites of knowledge, experience and competence—to enhance the stature of those who are certified.

Solicited (all committee members) and unsolicited comments and corrections to Draft #0 Rev. 4 will be considered if received before the end of July. Forscher and Jones will meet July 31 and Aug. 1 to resolve any conflicts and comments, and incorporate all appropriate editorial changes in Draft #1.

Draft #1 will then be circulated for additional comments to all committee members, designated reviewers, and the Executive Committee of the INMM. Forscher will incorporate all these comments or resolve any differences of opinions for the next draft. Draft #2 should be ready for a formal N15 ballot by October 1975.

The next committee meeting will probably be in September, to finalize Draft #2. It is hoped, that this meeting can coincide with the first meeting of the Advisory Committee to the test development program under ETS. For continuity and efficiency it was decided that these two committees should have identical membership; i.e. The INMM-11 Certification committee will become the Advisory Committee under the ETS program.

If the INMM receives approval from the NRC to go ahead with the test development program as outlined in our forthcoming proposal, we expect to meet soon thereafter at the Conference Center of the Educational Testing Service (ETS) in Princeton, N.J.

I.T.I. REPORTS MAJOR ADVANCEMENT

Waltham, Mass.—Ion Track Instruments has made a major advancement in rapid screening, versatile security systems with a minimum of operation personnel requirements, according to Mr. Tom Theohary (179 Bear Hill Road, Waltham, Mass. 02154. Phone: 617-890-4343).

The ITI TRI-SCAN automated luggage and package checking system is the first and only security system available that combines a unique and proven detection technique for concealed explosives together with a standard x-ray for the detection of concealed weapons and contraband.

The new and improved one-second Explosives Detector utilized is based on the proven concept employed in the ITI Portable Explosives Detectors currently in operational use by recognized agencies and organizations in over forty countries throughout the world.

The TRI-SCAN also houses an x-ray system that is completely sealed during operation and fail-safe. Presentation can be either a high resolution fluoroscopic image or television viewing for rapid processing. The television system also incorporates a "zoom-in" isolation feature for intensive screening. If desired, the entire system can be configured for remote control.

For access control locations where personnel metal detectors are also required, they can be supplied as optional equipment. If already installed, they can be integrated into the system.

Fred Forscher: INMM Delegate to International Safeguards Organization

Dr. Fred Forscher is the INMM delegate to TC/85, the ISO (International Standards Organization) Committee for Nuclear Standards. The USA has the Secretariate. SC-5, the subcommittee on Fuel Technology was only organized last fall. Germany has the Secretariate. SC-5 decided to form five ad hoc committees to recommend priority items that should be worked on at the international level as soon as possible.

Forscher was honored to be one of the two U.S. delegates to ad hoc committee No. 1 on Fuel Manufacturing. Sweden has the Secretariate. The other U.S. delegate is Dr. C. Bingham of the New Brunswick Laboratory. He did not attend the Stockholm meeting.

The next meeting of SC-5 will take place October 13-14, 1975 in Berlin. Dr. Bingham will attend. A summary report from the Stockholm meeting, June 10-11, 1975, follows.

The agenda of the two-day meeting followed essentially the original eight points plus modifications and additions as suggested in the correspondence.

The meeting took place June 10 and 11, 1975 at the Sveriges Mekanforbunds Standardcentral, at Jungfrugatan 10, Stokholm. Present were: Olle Eckstrand, AB ASEA-ATOM, Vasteras, Sweden; Heinz Fleischhacker, Babcock-Brown Boveri Reactor GmbH, Mannheim, Germany; Frederick Forscher, Consultant, Pittsburgh, U.S.A.; Siegfried Reschke, Babcock-Brown Boveri Reactor GmbH, Mannheim, Germany; and Hans Scharf, Kraftwerk Union AG., Erlangen, Germany.

The committee established 13 recommendations; some are general statements and some are indicated priority items for the future working groups.

1. Already standardized or virgin areas (general)
2. Standards on design versus standards for procedures (general)
3. Utilizing existing standards (general)
4. Measurement of UO_2 (priority item)
5. Measurement of UF_6 (priority item)
6. Measurement of PuO_2
7. Measurement of Pu-nitrate solution
8. Measurement of enrichment of U-235 by non-destructive means
9. Definition and measuring the density of pellets (priority item)
10. Testing and measurement of pellet densification.
11. Measurement of Zircaloy material
12. Quality assurance methods (priority item)
13. Standards for materials or products.

I.R.T. TO DEVELOP ANALYSIS SYSTEM

San Diego, Calif.—IRT Corporation has been selected by the U.S. Bureau of Mines to perform technology assessments and to develop an information analysis system to help determine future research needs in geophysics techniques.

"The system will provide a rational basis for decisions on future research in borehole assaying by considering mining industry needs as well as technical, social and economic factors," said Dr. Joseph John, manager of IRT's Nondestructive Inspection Department.

The $150,000 project will extend over an eight-month period, during which IRT will assist the Bureau of Mines in formulating a program plan for cost-effective development of borehole assay systems, John said.

The project is directed toward evaluation of geophysical techniques that obtain data about mineral deposits at a lower cost and in less time than current core-boring techniques.

IRT's study will provide the Bureau of Mines with a means of impartial justification for the allocation of its research and development funds for an orderly development of borehole assay systems. The long range objective of this program is to provide advanced borehole assay techniques to support the mining industry.

IRT Corporation, specializing in research and development, is involved in a number of systems analysis and technology assessment programs.

In managing a unique technology transfer program for the U.S. Government, IRT has developed a close working relationship with the academic and industrial communities. This relationship allows the company to evaluate existing and future borehole assay technologies based on the mining industry's needs.

June 20 INMM Paper

MEETING THE CHALLENGE

By William A. Higinbotham
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Abstract

National and international activities affecting safeguards, which took place during the last year, are listed. The Institute activities for the same period are briefly reviewed. The view is presented that the problems of international proliferation and of possible terrorist attempts to misuse nuclear materials in the USA cannot be avoided by negative steps such as freezing international shipments or postponing the use of plutonium. These problems must be faced squarely. Institute members understand the nuclear risks and safeguards measures to reduce the risks to acceptably low levels.

Introduction

This is the sixteenth annual meeting of The Institute of Nuclear Materials Management. Through these sixteen years the Institute has grown in size and broadened its scope. The program of this meeting is the most ambitious to date. What is the challenge to us who are engaged in safeguards and how well are we meeting that challenge?

Let us start by noting some of the more significant events which have taken place since our last annual meeting in Atlanta and which should be of concern to us:

1. Certainly a major event was passage of The Energy Reorganization Act which established The Nuclear Regulatory Commission and The Energy Research and Development Authority. In the long run the reorganization should be beneficial. Inevitably it has led to short term confusion, reshuffling of people and programs, newcomers trying to understand safeguards and a raft of reviews and policy studies.

2. Safeguards issues have been of special concern to legislators. NRC has been mandated to make a study of facility siting and of the possible need to establish a Federal security agency for nuclear materials. ERDA has been instructed to study policies relating to foreign transfers of materials and technology and to consider whether the nuclear weapons program should be retained by ERDA or transferred.

Many bills relating to safeguards have been introduced in Congress, a number of which would postpone Pu-recycle or foreign shipments until safeguards have been reassessed by Congress or other agencies. Are safeguards systems all that bad?

3. Last August the AEC released The Generic Environmental Statement on Mixed Oxide (GESMO) which said: "It is judged that this objective would not fully be met for Pu-recycle by current safeguards measures" and listed 17 measures for study.

4. Regulatory issued new requirements for quality assurance for measurement, proposed additional protection for shipments and issued a proposal to delay the decision on whether to proceed with Pu-recycle.

5. Earlier this month the 5 year review of the Non-Proliferation Treaty took place in Geneva, as described above by IAEA Inspector General, Rometsch.

And what has INMM been doing?

The INMM Safeguards Committee studied GESMO and sent comments to the AEC (See the spring issue of the Journal for text).

For many years INMM has issued Nuclear Materials Manager certificates to qualified individuals. This certification program is being completely redesigned as an ANSI standard in order to achieve the highest possible status for INMM certificates.

Almost half of the members are listed on ANSI Standards Committees. Substantial progress was made in the last 12 months (see the Journal).

You will recall the discussion last year at Atlanta about the President's offer to sell a reactor to Egypt. We passed a resolution offering to advise the Government on safeguards factors relating to such transfers. The subject of international transfers is still very much in the public eye.

Finally, the Institute has tried in various ways to educate the public about safeguards matters. Thanks to Roy Cardwell, Bob Keepin and many others, this meeting should contribute significantly to improved public understanding as well as to a stimulating exchange of technical information among our membership.

Probably none of us feels that we have adequately met the challenge this past year. I think we have to recognize our strengths and our weaknesses. We are still a small organization, 430 members, operating on a budget of about $25,000 a year and depending entirely on volunteer effort. Our strength, or rather opportunity comes from the fact that most of the working safeguarders in government, industry and independent institutions belong to INMM. I shall return to this later.

At this point I want to make some personal observations and comments which are intended to be provocative. Different people view safeguards from different angles and some, if not many of the proposals for improving safeguards are inconsistent if not in conflict with one another. A lot of people seem only recently to have become aware of the fact that nuclear materials pose serious hazards and many of these people are still ignorant of the safeguards that have been developed to reduce the hazards to very low levels.

Before we start to criticize the critics we had better make sure that we know what we are talking about.

I would point out to the newcomers that the safeguards problems aren't new, nor can they be exorcised by cutting back on or eliminating nuclear power. The die was cast in 1939 when scientists in several nations persuaded their governments to embark on nuclear weapons research. The power reactor was demonstrated in 1942 and nuclear weapons in 1945. The Smyth Report (Sept. '45) explained how to separate isotopes, to build reactors and to fabricate weapons.

As several of the previous speakers have emphasized, there is little that the USA can do unilaterally to limit the spread of nuclear materials and nuclear technology to other nations. I agree with them that the most promising policy is one of cooperation with other nations technically and in the development of international safeguards.

In my opinion the NPT Review Conference achieved little just because the nuclear weapons powers have not carried out their part of the agreement. The US, the UK and the USSR promised to negotiate in good faith on reduction of strategic nuclear weapons. The proposed limitations on the size of underground tests and on numbers of strategic weapons (more than they presently are) make a mockery of this promise. I don't see how horizontal proliferation is to be restrained unless the big powers really begin to wind down the strategic nuclear weapons race. The nuclear arms race is the biggest threat. Those who worry about international transfers should worry even more about the arms race.

This past year the focus has been on safeguards for the nuclear industry. This is important, of course, but it is only a part of the operation. Right now it is only a small part. What are we to make of the AEC statement in GESMO that the objective would not fully be met for Pu-recycle? Pu-recycle will involve transportation and processing of tons of Pu per year. Right now tons of Pu pass through the weapons facilities and one ton a year goes into FFTF. Does the AEC statement imply that current measures are inadequate for these programs? Should those who oppose Pu-recycle also oppose the weapons and research programs?

Highly enriched uranium will be used in the high temperature gas cooled reactors. It is presently used in large amounts in Naval reactors. The Naval fuel is fabricated by licensees: NFS, Numec, UNC and B&W. Since 1967, the major problems for Regulatory inspectors have been these licensee facilities and those that have fabricated experimental Pu-fuels for the AEC.

Regarding hijacking of shipments, I would suggest that the risk function is very non-linear. There are now hundreds of shipments of highly enriched uranium and plutonium each year. As soon as there were several, the hijacker had targets. If Pu-recycle should double this number it would not change the situation, something to bear in mind when thinking about co-location.

Sometimes I feel that we, in the safeguards business, try the easy way by suggesting that the other fellow should be responsible for this or that. I will only cite a couple of examples. First, let me take transportation of licensee material. In an earlier paper, Carl Walske proposes that the Government take over responsibility for transportation of highly enriched uranium and plutonium on the grounds that theft of such material poses a threat to the national security. If you follow that argument through, all facilities that possess such materials should also be Government operated.

On the other side, it seems to me that Regulatory overdid it when it placed all the responsibilities for protection and communication on the individual licensees. How much more effective it would be to have one central office to notify in advance, to monitor and to call state police in case of a problem! The licensees could band together to set up a central system but it seems more efficient and effective to me to have one communications and control center for all shipments, government and private and to charge licensees for services rendered.

It may indeed be necessary to require that armed guards accompany the shipments. But it does not seem reasonable and it may not be possible for a private company to make arrangements with the state and local governments along a route so that its private armed guards are legal.

To go back to licensees, many of them seem to feel that Big Daddy should develop all new measurement techniques to the point that a plant can just go out and buy the systems. I am convinced that every major facility must have a staff of safeguards engineers. Every plant is different. The AEC spent a lot of money developing analytical techniques and NDA instruments. I think it is industry's job to install and to refine and to fit them into the plant's system.

A somewhat different subject was brought up by Commissioner Gilinsky this morning. He said that NRC was looking into the question of whether information on MUF's, LEMUF's and plant design should be withheld from the public by classifying it as "national security classified information" or through special legislation. Perhaps it was in connection with this study that Brookhaven and other ERDA contractors recently received for comment a draft classification guide which proposed to classify such information and also amounts of special nuclear materials in MBA's as "confidential, national security information." Obviously one should not notify the adversary that 100 kg of plutonium will be shipped at 8 a.m. Tuesday, but what sense does it make to classify the exact amount of material on hand, the MUF or the LEMUF? An insider could find out such information anyway and an outsider only cares to know that you process SNM. There must be some way to keep design of the physical security system confidential (the bank vault combination that Gilinsky referred to) without calling on "national security information." I haven't felt that armed guards or Federal guards posed a police state threat (consider the guards at airports and the invasion of privacy there). But this one does worry me.

Let me return to the role of INMM, as I see it. Just about all of the people who have safeguards responsibilities belong to The Institute and/or attend these meetings. You are dedicated and intelligent people and hard pressed to deliver, as I well know. What I have tried to suggest here is that you have to talk to each other (I deplore the word "communicate") and to understand each other or we are never going to make it. Overreacting, underreacting or passing the buck won't work. We are dealing with people—people who may try to use nuclear materials to destroy society and people who must prevent them from doing so. It is not enough that the technician or the plant manager follow the regulations to the letter. No government agency can prescribe the most effective measures in such detail. The Agency has to develop policies, to issue regulations and to enforce them. The licensee and the contractor have to provide feedback to the Agency, in fact to be partners in policy generation. And everyone, at every level, down to the janitor, has to realize that he is entrusted with the safety of his co-workers and his community.

The GESMO statement referred to above could be read to say that we don't know how to do safeguards well enough to proceed with Pu-recycle. I don't believe this to be the case at all. The people in this room have had a long history of protecting nuclear materials in the infrequent times when safeguards was of special concern up-top and the more frequent times when it wasn't. If you could agree on the goal or goals, you could put together a mighty effective system.

Any system will decay if there is a lack of interest and concern. I don't agree with those critics who say you can't do it. I appeal to all critics to keep on criticizing so that the system won't go to sleep. I would remind you that nuclear energy can be a blessing or a curse, domestically **and** internationally.

In conclusion I would like to suggest that the hazards associated with nuclear energy, and the promise, probably are not unique. My feeling is that this is but one of many such situations that mankind must face and learn to live with. Science and Technology provide understanding and control which generally are beneficial but also may permit outrageous abuse. That is the challenge for all mankind. In the case of nuclear power, I think we should learn how to exploit it and to control it—now. The challenge to INMM and to its individual members is to set a good example of responsible leadership. Talk to each other; then we can talk to the people.

Questions:

John Telford: Nuclear Fuel Services. You confused me somewhat with your contrast of government material versus that in private industry. Which, in your opinion, really presents the biggest problem?

Higinbotham: Let me try to run it a different way. Just to give you an example, take shipments. The numbers I happen to remember, approximately, are from 1972. There were something like 1200 or 1300 shipments over appreciable distances between facilities in the United States of high enriched uranium or plutonium in substantial amounts. Only 70 of these were privately owned materials. I think that ERDA is taking more responsibility for shipments of Navy fuel but in the past that was not the case. I happen to know the nuclear regulatory inspectors, I know that they have had real problems with Navy fuel. You also know, as well as I do, that the only major losses of SNM were of Navy materials. All I'm saying is that if you have tons of ERDA stuff in private licensee facilities, why are we worrying about having tons of private mixed oxide in licensee facilities? Why are we postponing these decisions? Let me make one more remark and I hope that Sy (Smiley) won't feel that this is unfair of me. My feeling is that it's probably a true statement that present safeguards are not quite up to what we would like for Pu-recycle. If it's not good enough for one, it's not good enough for another. What we do need is to take advantage of the knowledge and experience that we have. We don't need new inventions. What we have to do is take the things that you guys are the experts on, put them together, and make a system which we're proud of.

SOME STATISTICAL ASPECTS OF BIAS CORRECTIONS

By Kirkland B. Stewart
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ABSTRACT

An important practical question is whether bias corrections should always be made to a measurement process or should be made only when a test of the measurements of a standard indicates a statistically significant, non-zero bias. Some statistical aspects of this question are studied. The results are expressed in comparative terms, as ratios of mean-square deviations for the two procedures. It is assumed that the standard deviations involved with the measurement process and the standard are known.

Some Statistical Aspects of Bias Correction

The purpose of this paper is to compare some distribution properties induced by two different bias correction procedures. A bias estimate for a measurement process is obtained by making n statistically independent measurements of a standard. The difference between the average value obtained and the value of the standard is the bias estimate. In procedure I bias corrections are always made to the measurement process. In procedure II no bias corrections are made to the process measurement unless the difference between the average and the value of the standard is statistically significant. Bias corrections are made by subtracting the bias estimate from the values of the measurement process.

The distribution properties of the two procedures are compared by using the mean-square deviation as the measure of dispersion and the disadvantage coefficients as the measure of relative dispersion of the two mean-square deviations. The disadvantage coefficient is the ratio of the mean-square deviation under procedure II to the mean-square deviation under procedure I.

For the purposes here it is assumed the bias and random error variance are independent of the magnitude of the property being measured. The main results are expressed in normalized units but some special results are also shown. It is hoped that by focusing the study in this way it will help to clarify the relative performance characteristics of these two bias correction procedures.

The mean-square deviation of $\hat{\Theta}$, an estimate of Θ, is defined as

$$\sigma_d^2 = E(\hat{\Theta} - \Theta)^2 = E\left\{\hat{\Theta} - E(\hat{\Theta}) + E(\hat{\Theta}) - \Theta\right\}^2$$

$$= E\left\{\hat{\Theta} - E(\hat{\Theta})\right\}^2 + \left\{E(\hat{\Theta}) - \Theta\right\}^2$$

since $E(\hat{\Theta} - E(\hat{\Theta})) = 0$. The first term on the right-hand side is defined as the precision variance and the second as the square of the bias. Thus

$$\sigma_d^2 = \sigma_{\hat{\Theta}}^2 + b_{\hat{\Theta}}^2$$

where $\sigma_{\hat{\Theta}}$ is the random error of measurement and $b_{\hat{\Theta}}$ is the bias of $\hat{\Theta}$ is as estimate of Θ.

The problem in more detail is as follows. The value assigned to the standard is assumed to be an unbiased estimate of the value of the standard where the uncertainty of the assigned value, expressed as a standard deviation, is σ'. The model for the *ith* operator measurement of the standard is

$$w_i = \mu + \Theta + \varepsilon_i, \quad i = 1, 2, \ldots, n,$$

where μ is the true value. The assigned value of the standard is $\tilde{\mu}$, which has the model

$$\tilde{\mu} = \mu + \varepsilon'.$$

If $\varepsilon_i \sim N(0,\sigma^2)$, $\varepsilon' \sim N(0,\sigma'^2)$, the natural logarithm of the probability of occurrence of the w_i values and $\tilde{\mu}$ is

$$\ln P = G - 1/2 \sum_{i=1}^{n} (w_i - \mu - \Theta)^2/\sigma^2 - 1/2(\tilde{\mu} - \mu)^2/\sigma'^2$$

where $G = -\ln\left\{\sigma^n \sigma' (2\pi)^{\frac{n+1}{2}}\right\}$. The maximization of P occurs when $\partial \ln P/\partial\mu = 0$, $\partial \ln P/\partial\Theta = 0$, which relationships imply the equations

$$\frac{\sum^n w_i - n\hat{\mu} - n\hat{\Theta}}{\sigma^2} + \frac{\mu - \hat{\mu}}{\sigma'^2} = 0,$$

$$\sum^n w_i - n\hat{\mu} - n\hat{\Theta} = 0.$$

Thus $\hat{\mu} = \tilde{\mu}$ and $\hat{\Theta} = \overline{w} - \tilde{\mu}$ are, respectively, the maximum likelihood estimates of μ and Θ where $\overline{w}$ is the average of the w_i values. The variance of $\hat{\Theta}$ is $\sigma_{\hat{\Theta}}^2 = \sigma^2/n + \sigma'^2$.

It is assumed that σ and σ', the standard deviation of the measurement process and the value of the standard are known. Thus, $\sigma_{\hat{\Theta}}$ is also known.

Under procedure I the operator always uses the difference $\hat{\Theta} = \overline{W} - \mu$ to estimate the bias and to adjust the production measurements. Under procedure II the operator makes a statistical test, using the criterion $|\hat{\Theta}| > \sigma_{\hat{\Theta}} Z_{1-\alpha/2}$ to reject the null hypothesis that $\Theta = 0$, and corrects for bias only when the null hypothesis is rejected, where $Z_{1-\alpha/2}$ is the $100(1-\alpha/2)$ percentile point of the zero mean, unit variance, normal distribution. C, the disadvantage coefficient, is used as the index of comparison where

$$C = \frac{\text{the mean-square deviation under procedure II}}{\text{the mean-square deviation under procedure I}}$$

The concept of a disadvantage ratio arises in an article by Mosteller (1) on the pooling of data. If C is less than one for a given set of conditions it indicates that the advantage lies with procedure II, i.e., it is advantageous to make a test before making a bias correction. If C is larger than one for a given set of conditions, the advantage lies with procedure I, i.e., the operator has a smaller mean-square deviation if he routinely adjusts for bias. The case where the operator never tests nor adjusts for bias is the special case of procedure II where $\alpha = 0$, $Z_{1-\alpha/2} = \infty$.

The C value is the disadvantage ratio to the operator who tests before using bias corrections since the disadvantage under procedure II increases with increasing C.

Two cases are considered. In the first case the disadvantage coefficient is considered as a function of a bias value and the $Z_{1-\alpha/2}$ value, where the bias is presented in a form which is normalized by $\sigma_{\hat{\Theta}}$, the standard deviation of the estimate of Θ. In the second case the disadvantage coefficient is evaluated for a population of biases from a normal distribution with zero mean. In this case the results are expressed as a function of $\sigma_\Theta/\sigma_{\hat{\Theta}}$ and α. $\sigma_\Theta/\sigma_{\hat{\Theta}}$ is the ratio of the sampling standard deviation of Θ to the precision standard deviation of estimate of a particular Θ value. One can construe the consequences of the bias correction procedures in this latter case in several ways. The situation may occur where the bias Θ for a certain type of measurement at a given facility varies according to the assumed distribution over time. Another situation might be that interlaboratory tests have shown a statistically significant difference between laboratories mean square and the formulation provides a method of understanding the general effects of the two bias correction procedures over all laboratories under such conditions. The formulation takes on a Bayesian flavor in the sense that for a given set of conditions any bias which may occur can be considered to be randomly sampled from this prior distribution. Then again this formulation of the problem is simply a useful technique in gaining some added insight into the interplay of the influencing factors where it is desired to find out how robust or fragile certain types of bias adjustment procedures are.

Preliminary Results

Following is a theoretical discussion of the application of bias corrections involving the parameters Θ, $\sigma^2_{\hat{\Theta}}$, and σ^2. Simplifying assumptions are made to aid in the exposition of concepts and description of results.

If the model for an individual observation of a production value is

$$w_j = \eta_j + \Theta + \varepsilon_j, \quad j = 1,2,\ldots, N,$$

where η_j is the true value, the adjusted value w'_j has the model

$$w'_j = w_j - \hat{\Theta} = \eta_j - \bar{\varepsilon} + \varepsilon' + \varepsilon_j$$

with variance

$$\sigma^2_{w'j} = \sigma^2/n + \sigma'^2 + \sigma^2 = \sigma^2_{\hat{\Theta}} + \sigma^2.$$

If the operator always adjusts for bias using n statistically independent measurements in the bias estimate, the mean-square deviation for the sum of the N items to which this bias pertains and are adjusted is $\sigma^2_d = N\sigma^2 + N^2\sigma^2_{\hat{\Theta}}$. If the operator makes no bias adjustments the MSD for the N items is $\sigma^2_d = N\sigma^2 + N^2\Theta^2$. Then the mean-square deviation for the bias adjusted values is smaller or not according to whether $\sigma^2_{\hat{\Theta}}$ is smaller than Θ^2 or not.

If Θ is a random variable from a $N(0,\sigma^2_\Theta)$ distribution and an individual bias applies to N items and there are M different sets of N items, the MSD for the sum of the bias adjusted values is $\sigma^2_d = MN\sigma^2 + MN^2\sigma^2_{\hat{\Theta}}$. The expected value of Θ^2 is $E(\Theta^2) = \sigma^2_\Theta$ so that the expected mean-square deviation for the sum of the MN values when no bias adjustment are made is $\sigma^2_d = MN\sigma^2 + MN^2\sigma^2_\Theta$. In this case, the bias adjusted mean-square deviation is smaller when $\sigma^2_{\hat{\Theta}} < \sigma^2_\Theta$.

Bias Corrections When the Bias Is Fixed

The operator points out that there is another possibility, namely procedure II where the bias correction is made only when the statistical results on measurements of the standard indicate a significant bias. For a given Θ, the operator who makes bias corrections only when $|\hat{\Theta}| > Z_{1-\alpha/2}\sigma_{\hat{\Theta}}$ will have a mean-square deviation of

$$MSD_{II} = \int_{-\infty}^{-k} (x-\Theta)^2 f(x)dx + \int_{-k}^{k} \Theta^2 f(x)dx + \int_{k}^{\infty} (x-\Theta)^2 f(x)dx$$

where $x = \hat{\Theta}$, $\sigma_x = \sigma_{\hat{\Theta}}$, $k = \sigma_{\hat{\Theta}} Z_{1-\alpha/2}$ and

$$f(x) = \frac{1}{\sigma_x \sqrt{2\pi}} \exp - \frac{1}{2} \left(\frac{x-\theta}{\sigma_x}\right)^2$$

The mean-square deviation under procedure I is

$$MSD_I = \int_{-\infty}^{\infty} (x-\theta)^2 f(x)dx = \sigma_x^2 = \sigma_{\hat{\theta}}^2.$$

Then

$$C = \frac{MSD_{II}}{MSD_I}$$

and it can be shown that

$$C = 1 + (\rho^2 - 1)\left[F(U) - F(L)\right] + Uf(U) - Lf(L)$$

where

$$\rho = \theta/\sigma_x = \theta/\sigma_{\hat{\theta}}$$

$$U = Z_{1-\alpha/2} - \rho, \quad L = -Z_{1-\alpha/2} - \rho,$$

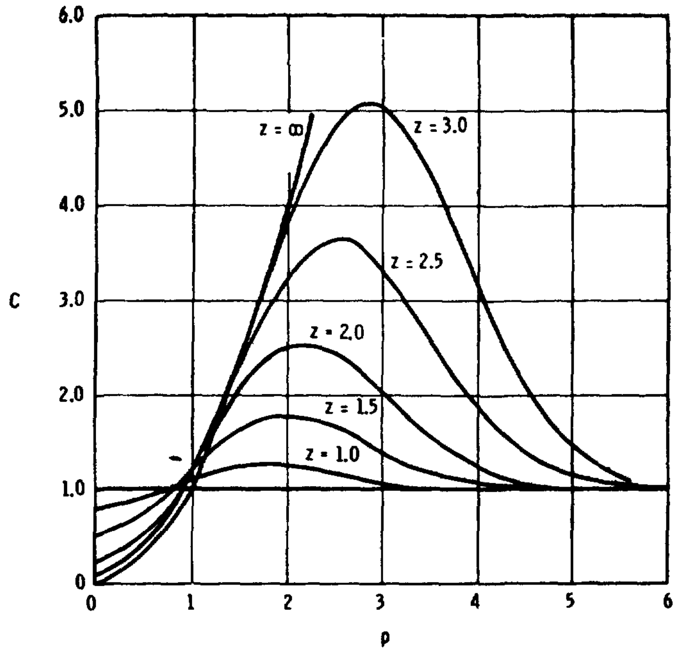
$$f(t) = (\exp - t^2/2)/\sqrt{2\pi},$$

$$F(t) = \int_{-\infty}^{t} f(r)dr.$$

The incomplete gamma function could also be used to evaluate C. Figure 1 shows C as a function of Z and $x = \theta/\sigma_x = \theta/\sigma_{\hat{\theta}}$. Because of symmetry negative values of ρ are not shown. These results lead to the following conclusions.

a. When the absolute value of the true bias is small ($|\theta| < \sigma_{\hat{\theta}}$) the operator who makes bias corrections only when statistical significance is evidenced, is at an advantage since the square of the bias is less than the mean-square deviation of $\hat{\theta} - \theta$, the residual systematic error after the bias correction has been made.

b. When the true bias approaches either of the two critical values $\pm\sigma_x Z_{1-\alpha/2}$, the disadvantage ratio is largest since in these regions there is only about a 50 percent chance of a bias adjustment being made. There are two effects at work here. As θ increases the mean-square deviation increases when no correction is made but the probability of making a correction also increases. The joint effect of these two individual effects results in a maximum disadvantage coefficient when the absolute value of the true bias is in the region of $\pm\sigma_x Z_{1-\alpha/2}$, the critical test points.



$$C = \frac{\text{THE MEAN-SQUARE DEVIATION FOR THE OPERATOR WHO MAKES BIAS CORRECTIONS ONLY AFTER A BIAS ESTIMATE IS SIGNIFICANT}}{\text{THE MEAN-SQUARE DEVIATION WHEN BIAS CORRECTIONS ARE ALWAYS MADE}}$$

$$\rho = \frac{\theta}{\sigma_{\hat{\theta}}} = \frac{\text{TRUE BIAS}}{\text{PRECISION STANDARD DEVIATION OF BIAS ESTIMATE}}$$

FIGURE 1. The Disadvantage Coefficient as a Function of the True Operator Bias and the Bias Precision Standard Deviation

c. When the absolute value of the true bias increases sufficiently the disadvantage coefficient approaches one since then a correction will almost always be made and the MSD_{II} approaches $\sigma_{\hat{\theta}}^2$.

d. When $\alpha = 0.0$, ($k = \sigma_x Z_{1-\alpha/2}$), the tester will never make a correction. Thus $(\theta/\sigma_{\hat{\theta}})^2 = \rho^2$.

The curve for $\alpha = 0$, ($Z = \infty$) makes a good reference curve for comparing the results of never making bias corrections with that of always making bias corrections. This procedure is advantageous when ρ is small ($\theta < \sigma_{\hat{\theta}}$).

Bias Corrections When the Bias Varies

For the purpose of understanding the joint effects of such factors as the testing limits and the true differences when comparing procedures I and II it is useful to consider a prior distribution of biases. Letting $y = \theta$, the distribution studied is of the form

$$h(y) = \frac{1}{\sigma_y \sqrt{2\pi}} \exp - \frac{1}{2} (y/\sigma_y)^2.$$

There are cases, of course, where the expected value of all the biases which would occur pertinent to a certain measuring process is not zero. The analysis of a particular situation when $E(y) \neq 0$ would not be difficult but a general representation of results in a way which would be very helpful and insightful is difficult. Another assumption here is that it would be known when a process changes and requires a different bias correction. Introducing the effects of these factors into the analysis would make a very complicated structure for the analysis and presentation of results.

The joint distribution of y and x, where $x = \hat{\theta}$, $\sigma_x = \sigma_{\hat{\Theta}}$, is

$$g(x,y) = \frac{1}{\sigma_x\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-y}{\sigma_x}\right)^2} \frac{1}{\sigma_y\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2}$$

Then MSD_{II} here is

$$MSD_{II} = \int_{-\infty}^{\infty}\left\{\int_{-\infty}^{-k}(x-y)^2 g(x,y)\,dx + \int_{-k}^{k} y^2 g(x,y)\,dx + \int_{k}^{\infty}(x-y)^2 g(x,y)\,dx\right\}dy$$

Changing the order of integration and integrating out the y variable results in a function of x alone. The integrations are tedious but the disadvantage coefficient turns out to be

$$C = 1 + (\rho^2-1)\left\{F\left(\frac{Z}{\sqrt{1+\rho^2}}\right) - F\left(\frac{-Z}{\sqrt{1+\rho^2}}\right) - \frac{2Z}{\sqrt{1+\rho^2}}\, f\left(\frac{Z}{\sqrt{1+\rho^2}}\right)\right\}$$

where

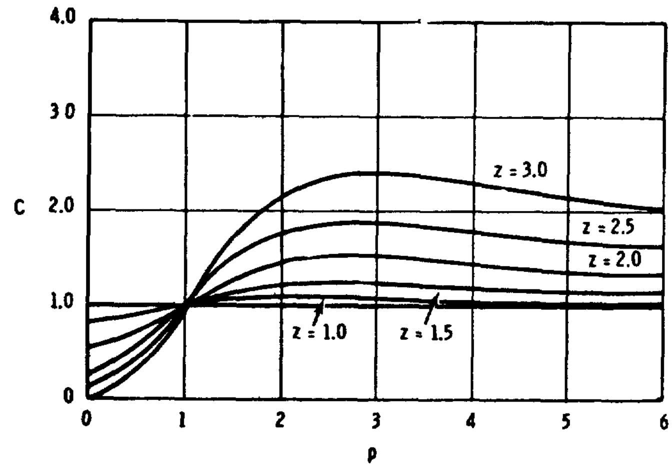
$$\rho^2 = \sigma_y^2/\sigma_x^2 = \sigma_\Theta^2/\sigma_{\hat{\Theta}}^2, \quad Z = Z_{1-\alpha/2}$$

and f(t) and F(t) are, respectively, the density and distribution functions of the zero mean, unit variance, normal distribution.

Figure 2 shows results for this situation which are somewhat similar to Figure 1 except that for a given $\rho = \sigma_\Theta/\sigma_{\hat{\Theta}}$ value the disadvantage coefficient gives a value which is averaged over the range of the biases according to the particular density. Thus the maxima are lower and the disadvantage coefficients are more spread out. This means that the average mean-square deviation effect over all cases does not have as high a maximum disadvantage coefficient as in the case with the bias fixed near the critical test value $\sigma_{\hat{\Theta}} Z_{1-\alpha/2}$. On the other hand, however, as ρ increases the disadvantage coefficient does not approach one as rapidly.

A Comment on One Aspect of the Robustness of the Two Procedures

Suppose a facility has a long-term bias of $\Theta = \sigma_{\hat{\Theta}} Z_{1-\alpha/2}$. Then slightly more than 50 percent of the time the test will prove to be significant. The resulting mean squared deviation will be about $(\Theta^2 + \sigma_{\hat{\Theta}}^2)/2$ and the average bias will be about $0.5\Theta - 0.4\,\sigma_{\hat{\Theta}}$. Thus in this situation, procedure II will lead to a long-term bias. Under procedure I the bias corrections, which are propagated as systematic errors for groups of values which occur sequentially, will be attenuated out in a probabilistic and percentage-wise sense.



$$C = \frac{\text{MSD WHEN BIAS CORRECTIONS ARE MADE ONLY AFTER A SIGNIFICANT STATISTICAL TEST}}{\text{MSD WHEN BIASES ARE ALWAYS MADE}}$$

$$\rho = \frac{\sigma_\theta}{\sigma_{\hat{\theta}}} = \frac{\text{STANDARD DEVIATION OF THE VARIATION IN } \theta}{\text{STANDARD DEVIATION IN A } \theta \text{ ESTIMATE}}$$

FIGURE 2. The Disadvantage Coefficient as a Function of the Standard Deviation of the Estimate of a Bias and the Standard Deviation of the Bias as a Variable

The Variation of C with n

The disadvantage ratio is a way of normalizing the mean-square deviation which will occur under procedure II. The values $\rho = \Theta/\sigma_{\hat{\Theta}}$ in the case where the biases are sampled from a $N(0,\sigma_\Theta^2)$ distribution are also normalized values. The advantage to using these normalized results is that it is easy to show general results. The disadvantage is that a casual reading may lead to erroneous conclusions.

As more measurements are made the mean-square deviation under procedure II decreases and the Θ or σ_Θ value at which the mean square deviation's maximum occurs are also both decreased. In the previous generalized presentation, the effect of the number of measurements of the standard is indicated only in an implied manner. In the following, the results will be given as a function of n. It is important to emphasize here, however, that this can only be done if one assumes that the standard is known without error. Figures 1 and 2 indicate quite specifically how MSD_{II} varies as a function of Z and ρ. However both MSD_{II} and ρ are functions of n as well. To illustrate this the value of Z

= 2 is chosen since this is about the absolute value used in two-sided tests at the 95 percent level. Then in Figure 3, MSD_{II} is plotted in units of σ^2 as a function of Θ where Θ is given in units of σ. Similarly in Figure 4, MSD_{II} is given in units of σ^2 and σ_Θ is given in units of σ.

These figures show the dramatic effect of the sample size on MSD_{II}, but they also indicate that a point of diminishing returns sets in. The basic curve for Z = 2 in Figures 1 and 2 are simply transformed in scale as n is increased. MSD_{II} decreases inversely as n, Θ and σ_Θ decrease inversely as the square root of n. In all the curves the asymptotic values of Θ and σ_Θ increase are $MSD_{II} = \sigma^2/n$. The convergence to the asymptotic value is much faster in the case of Θ than in the case of σ_Θ.

As mentioned before the results assume that the value of the reference standard is known without error. If σ', the standard deviation of uncertainty is not zero, the mean-square deviation associated with procedure II is, of course, limited by this standard deviation.

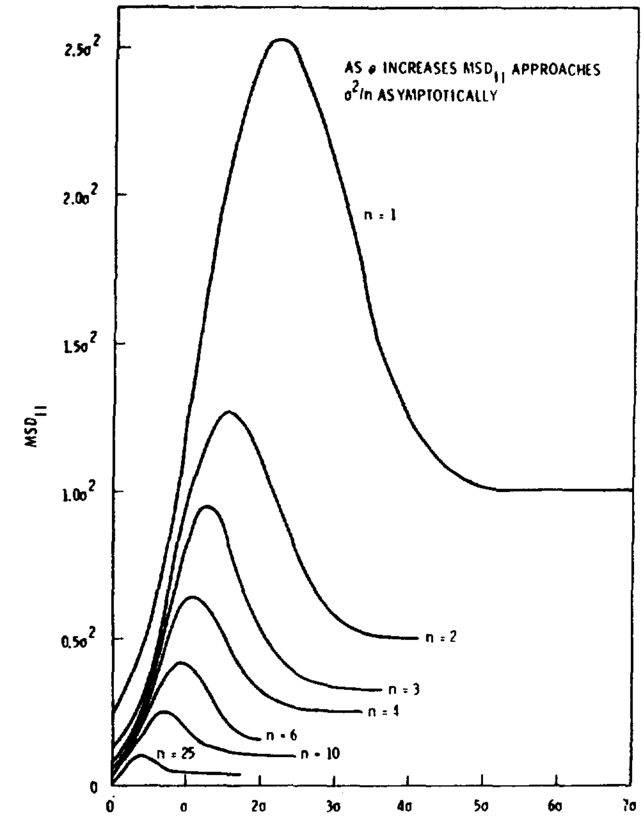
<u>Added Remarks</u>

The study reveals certain performance characteristics of the two bias corrections procedures which are useful in deciding which procedure should be employed. Other considerations also pertain to the choice of procedure which are considered herein in the context of nuclear materials control.

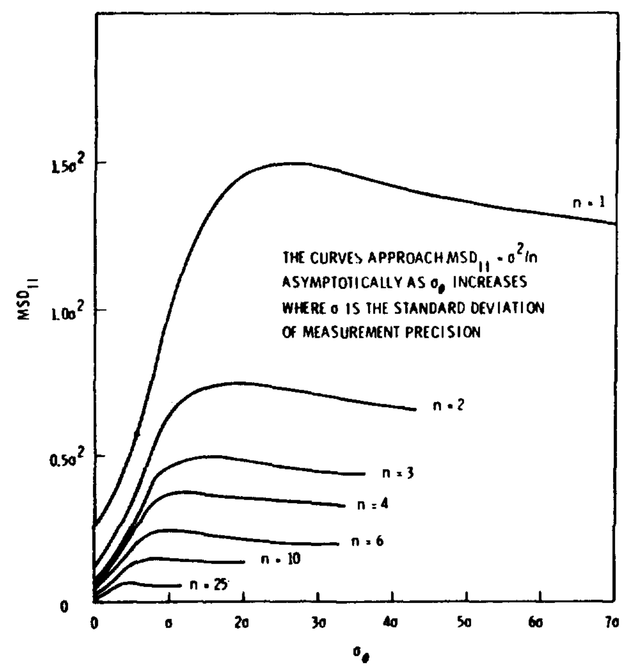
1. The first consideration should be the importance of the particular measurement process to the variance of MUF. If the errors in measurement of a particular process have little effect on the variance of MUF it is not of pressing urgency to improve the systematic error situation encountered.

2. The cost of making operator measurements on the standard in order to improve the bias estimate is also important. Thus, points 1 and 2 jointly indicate an implicit cost-benefit motivation. It is worthwhile to improve an inexpensive but important measurement system. It is not important to improve an unimportant but expensive measurement process. Many cases fall somewhere between the two extremes.

3. The best method of controlling the process aside from the case where adherence to some absolute criteria is required, depends upon a knowledge of the process. This in turn presumes a history of results. If it is satisfactory simply to bound the mean-square deviation because of the particular measurement system is known to have little effect on the results and if the precision is known to be good, the procedure of not making bias corrections unless a significant bias correction is evidenced makes sense. Then one would minimize the administrative cost of the periodic bias checks and their applications to production data. If a measurement is important and



<u>FIGURE 3.</u> MSD_{II} as a Function of Θ and n



<u>FIGURE 4.</u> MSD_{II} as a Function of σ_Θ and n

the history of the measurement process has been a lack of stability, a good case can be made for making routine bias corrections on an accelerated frequency scale. This avoids the situation where the mean-square deviation is large if the bias happens to be in the neighborhood of $\sigma_{\hat{\theta}} Z_{1-\alpha/2}$.

4. The long-term behavior of the process is of importance. Suppose the precision is somewhat poor in the sense that there is a relatively large standard deviation of precision. Then the operator may have difficulty in determining that the particular set of data indicates a bias unless the true bias is large. However as bias measurements accumulate the bias test will have more power and the bias will be estimated more precisely. This will decrease the error in the bias corrections in a percentagewise and probabilistic sense.

5. As a practical matter the procedure of spacing the n measurements out over the accountability period in order to make an estimate of an average bias during the accountability period makes sense. Any change in bias during the period is included as part of the residual error and in this sense a more realistic estimate of residual variance is obtained. If procedure II is used the test would be made at the end of the accountability period. Under procedure I the bias corrections could be applied as they are made or applied to the total at the end of the period. The reader may wish to convince himself that if a bias correction is made for each production measurement, one can apply them on a one-to-one basis to the production measurements or can make a correction to the total amount for the accountability period. The results are algebraically identical. One may object to the use of bias in the sense indicated here since bias is thought of as a constant quantity that persists. However, it is a common experience that repeated values at one time of a standard can have a statistically significant difference from the mean at another time. In addition the overall bias estimate over time may be significantly different from zero. The problems inherent here have to be dealt with no matter what one's preferences are as to terminology.

ACKNOWLEDGEMENT

The reference article suggested the use of the disadvantage coefficient as a method of comparing procedures I and II. The author would also like to acknowledge the very helpful editorial suggestions made by Norman S. Beyer and James A. Merrill.

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1. Mosteller, Frederick, "On Pooling Data," Journal of the American Statistical Association, Vol 43, June 1948, pp. 231-242.

HIGH SPEED LETTERBOMB DETECTOR

San Diego, Calif.—"Letterbomb," a terrifying word that has made countless headlines recently, also has spurred development of a revolutionary high speed letterbomb detector by IRT Corporation of San Diego.

"The IRT high speed letterbomb detector has made it virtually impossible for a terrorist's thin, plastic explosive to sneak through in an envelope," said Dr. Robert L. Mertz, IRT President.

"Nine out of 10 major companies have been threatened with bombings in recent years," Mertz said.

The FBI received 121 reports of U.S. terrorist bombings in December alone. The 1974 total of various types of bombings amounted to 2,225, according to the FBI's National Bomb Data Center report.

"The IRT detector can help fill the security void in a number of domestic and foreign government agencies as well as private industries faced with the threat of terrorist bombings through the mail," Mertz added.

Flexible plastic explosives can be rolled thin to look and feel like an ordinary letter, said Hans Weber, the IRT Program Manager who was responsible for development of the system. "And yet," he said, "this small amount of explosive material is powerful enough to seriously injure or even kill the person who opens it.

"Without slowing down the regular flow of mail," Weber said, "the high speed computerized detector can screen up to 36,000 letters per hour. That's 10 letters per second.

"Every single letter is thoroughly analyzed in only 1/25 of a second by sensors built into the IRT detector," Weber added. "If the letter contains a bomb it is automatically diverted to a safe container."

The second IRT high speed letterbomb detector to be completed under a U.S. government development program has been delivered to a federal agency in Washington, D.C.

The detector's sensor system quickly examines every piece of mail for any explosive element. A computer analyzes the data and automatically rejects any suspicious letter. The high speed detector also represents a breakthrough in simplicity of operation. Any employee can learn to operate it in a matter of minutes.

IRT Corporation is widely recognized for its expertise in the practical application of advanced technologies. The company is actively engaged in the manufacture and marketing of advanced nondestructive testing equipment and instrumentation systems.

NEW SCOPE AND GOALS FOR N15 SUBCOMMITTEE INMM-9 (NONDESTRUCTIVE ASSAY)

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ABSTRACT

The current status of ANSI INMM N15 Standards Committee work in the area of nondestructive assay methods for nuclear materials control is summarized. Related ANSI standards development bases and procedures are described. New and expanded scope and goals for N15 Subcommittee INMM-9 (Nondestructive Assay) are presented, including the formulation of five new task forces to develop standards for the use of nondestructive assay methods for nuclear materials control.

INTRODUCTION

In 1966, the American National Standards Institute (ANSI) asked the Institute of Nuclear Materials Management (INMM) to form Standards Committee N15, entitled: "Methods for Nuclear Materials Control." Since that time, Standards Committee N15, under the initial direction of R. Delnay (Dow) and more recently of J. Jaech (Exxon), has successfully contributed to the ANSI nuclear standards program by actively addressing nuclear materials control standard development needs in eight topical areas. These areas of principal contribution include:

1. Nuclear Materials Control Methods
2. Statistics
3. Records
4. Inventory Techniques
5. Audit Techniques
6. Calibration Techniques
7. Nondestructive Assay
8. Physical Protection in Plant

Standards Committee N15 maintains ongoing standards development efforts in each of the foregoing areas.[1,2] Each topic is addressed by a standing subcommittee consisting of one or more task forces made up of technical experts from related sectors of the nuclear industry. The result is a panel of experts which serves to review and consolidate industrywide scientific inquiry and experience relating to nuclear materials control methods, and express the results of such efforts in terms of general value to the nuclear community.

Since its inception, Standards Committee N15 has successfully generated 13 approved ANSI standards. Many of these standards have been adopted by the Nuclear Regulatory Commission in Regulatory Guides. Several additional proposed ANSI standards are in the final stages of review and approval. Additionally, approximately 24 other standards, dealing with all aspects of nuclear materials control within the nuclear industry, are in varying stages of development by Standards Committee N15. This paper discusses current and future N15 standards development activities relating to nondestructive assay methods for nuclear materials control.

SUMMARY

The status of Institute of Nuclear Materials Management (INMM) N15 Standards Committee (Nuclear Materials Control) work in the area of nondestructive assay measurement methods is summarized. An overview of the status and goals of recent N15 standards in the area of nondestructive assay methods for nuclear materials control is presented and related to second-generation standards requirements. N15 organizational changes aimed at satisfying these needs are presented, including the expansion of Subcommittee INMM-9 (Nondestructive Assay) activities beyond current emphasis on specific measurement methods to include related areas which impact on overall nondestructive assay measurement system performance.

New INMM-9 scope, goals, staff, and milestones are summarized. Efforts to formulate future ANSI standards in the following six topical areas dealing with nondestructive assay methods for nuclear materials control are discussed:

1. Material Classification
2. Container Standardization
3. Physical Standards
4. Measurement Controls
5. Measurement Techniques
6. Automation Methods

Support in attaining current objective and identifying additional needs is solicited from the INMM membership.

ANSI DESCRIPTION

Organization and Goals

The American National Standards Institute (ANSI) is an internationally recognized standards organization which works to establish consensus guides and codes which promote understanding and uniform practice within the industrial community.[3] Areas in which ANSI has successfully developed standards include:[4]

1. Definitions, terminology, symbols, and abbreviations
2. Design, materials, parts, and equipment
3. Performance characteristics of materials, parts, and equipment
4. Procedures for determining performance characteristics and reliability
5. Methods of testing, inspecting, analyzing, and rating

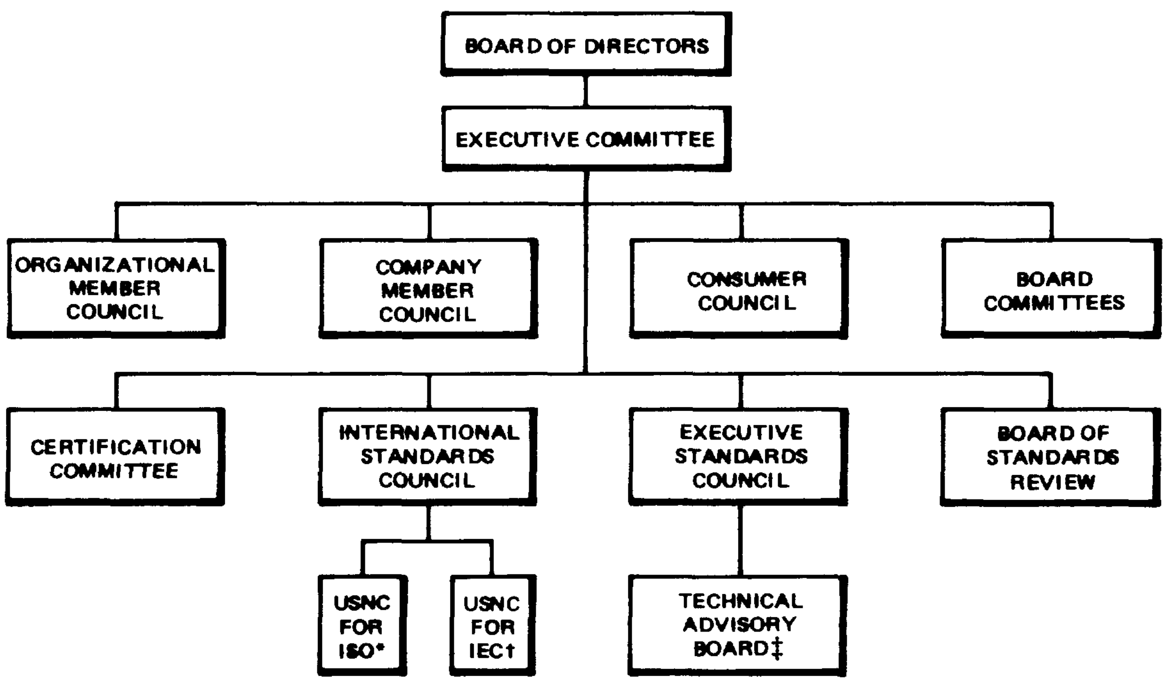
6. Units of size, weight, volume, and rating

7. Practices promoting the safety, health, and welfare of employees and the general public

8. Procedures for operating, processing, handling, storing, and transporting materials, parts, and equipment

9. Selecting, training, and evaluating operators of equipment and processes

The ANSI does not, in itself, develop standards in any of these areas. Rather, ANSI serves a central review, communication, and approval function. Specific technical responsibilities for the development of standards are assigned to Technical Advisory Boards which make specific assignments to technical societies or related groups with specific knowledge and experience in the area where standardization is required. The relationship of these Technical Advisory Boards to the overall ANSI organization is shown in Figure 1. Particular note should be taken of the broad base of ANSI activities, including numerous and diverse standards topics on a national and international level.



*U.S. National Committee for the International Organization for Standardization (ISO)
†U.S. National Committee for the International Electrotechnical Commission (IEC)
‡NTAB is one of the ANSI technical advisory boards

Figure 1. American National Standards Institute (ANSI) Organization

Both by charter and emphasis, ANSI's primary goal is ensuring that its standards represent the consensus in a particular area. This is accomplished through active participation at the writing group level by individuals from related sectors of industry, and by extensive review of proposed standards by the peer groups to ultimately use the standard. An overview of this development process is presented in Figure 2, showing the progression of a standard from writing group, to subcommittee, to committee, to public review, and ultimately to national consensus standard.

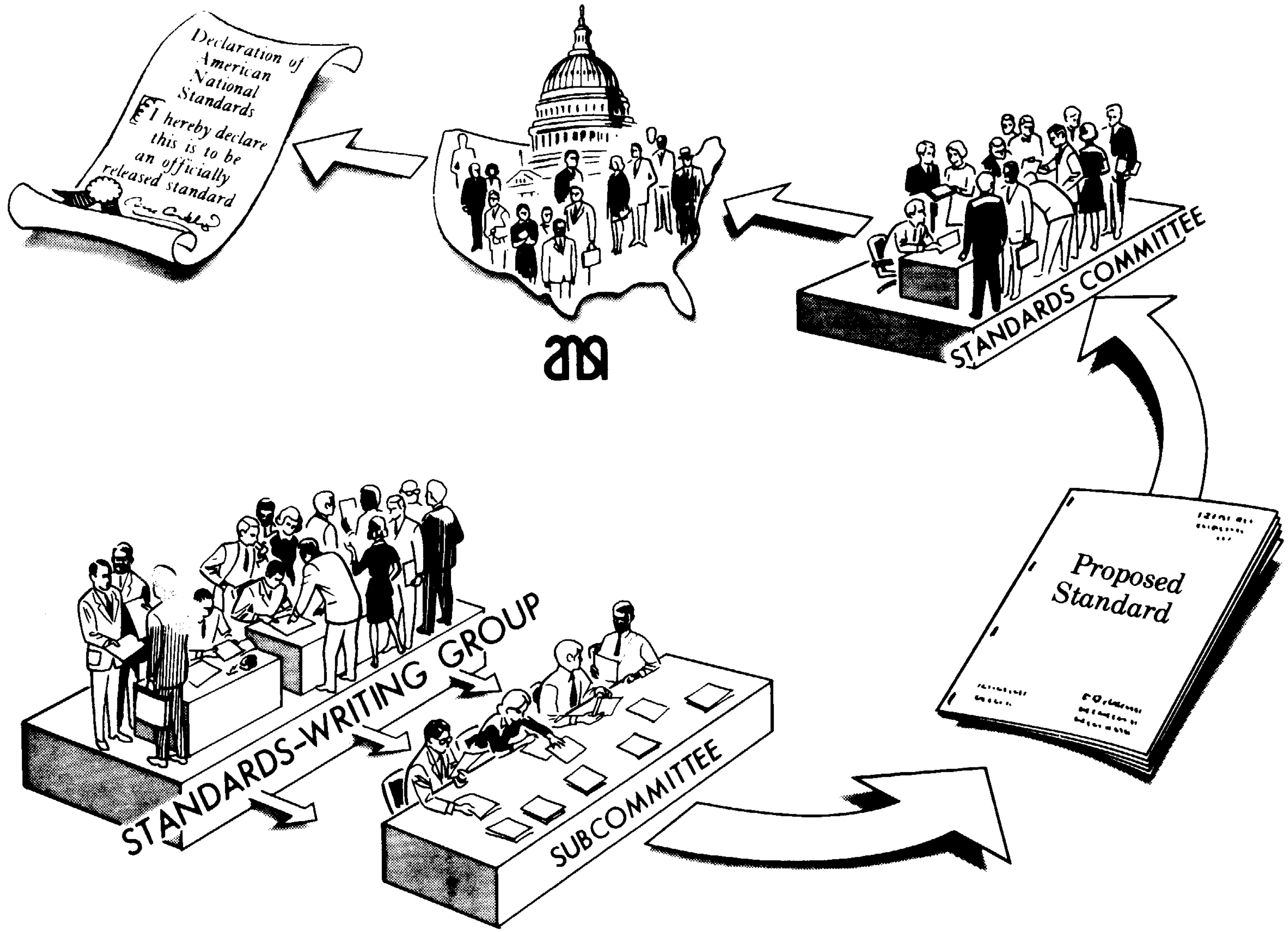


Figure 2. Development of a Standard

Standards issued by ANSI are intended to provide information in the form of recommendations for a particular operation, which are based on established practice. If properly developed and used, ANSI standards are beneficial because they[4]

- Establish recognized levels of acceptable quality, performance, reliability, and safety.
- Reduce misunderstandings between producers and users.
- Provide a rational basis for contracts.
- Increase opportunities for trade.
- Provide guidance for design, construction, operation, surveillance, maintenance, and inspection.
- Provide economy through uniformity and interchangeability.
- Form the bases for regulations, and provide guidance for the application and implementation of such regulations.
- Provide ease of communication through standardization of definitions, sizes, and symbols.
- Provide logical alternatives to slow and costly trial-and-error methods.

More specifically, the development of ANSI nuclear standards[4]

- Assists in the standardization of nuclear facilities.
- Ensures a high level of public health and safety and environmental protection in the design, construction, and operation of nuclear facilities.
- Assists industry in complying with government regulations.
- Provides bases for more expeditious accomplishment of reviews for permits and licenses.
- Provides assurance that nuclear facilities will operate reliably.

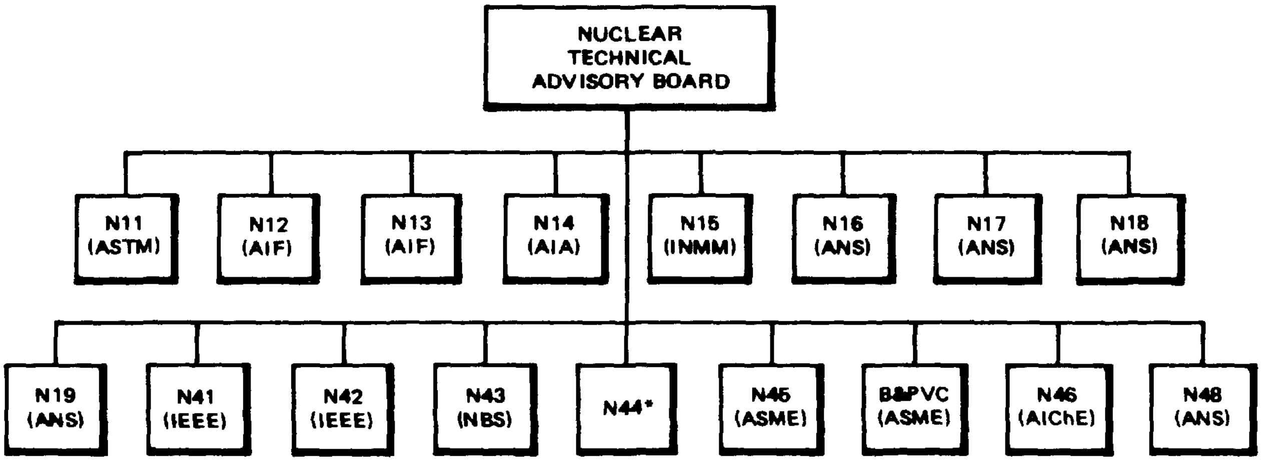
Methods

Within ANSI, the Nuclear Technical Advisory Board (NTAB) is assigned responsibility for developing standards relating to design, construction, and safe and reliable operation of nuclear facilities. Under this broad charter, NTAB invites various technical societies to coordinate standards development activities on specific "nuclear" topics within their principal area of expertise. Sixteen such standards committees currently exist under NTAB (see Figure 3). The INMM is responsible for Standards Committee N15 dealing with methods for nuclear materials control. Standards Committee N15 operates under the following charter:

> "Standards for the protection, control, and accounting of special materials in all phases of the nuclear fuel cycle, including analytical procedures where necessary and special to this purpose, except the physical protection of special nuclear material within nuclear power plants."

In accordance with these foregoing objectives, Standards Committee N15 has established eight standing subcommittees to address the topics described in the Introduction. Subcommittee INMM-9 (Nondestructive Assay) is one of these subcommittees and operates under the following charter:

> "Establish standards for the use of nondestructive assay methods for special nuclear materials control and accountability."



Standards Committee Secretariats

ASTM	– American Society for Testing and Materials
AIF	– Atomic Industrial Forum
AIA	– American Insurance Association
INMM	– Institute of Nuclear Materials Management
ANS	– American Nuclear Society
IEEE	– Institute of Electrical and Electronics Engineers
NBS	– National Bureau of Standards
ASME	– The American Society of Mechanical Engineers
B&PVC	– Boiler and Pressure Vessel Code
AIChE	– American Institute of Chemical Engineers

*Secretariat to be assigned

Figure 3. ANSI Nuclear Standards Program

Details of N15 Subcommittee INMM-9 (Nondestructive Assay) activities are provided in the section on INMM-9 expansion.

The actual mechanism for developing an ANSI standard is shown schematically in Figure 4. First, the need must be determined, based either on a request from an interested party or based on identification by a standing writing group. Next, the project needs must be defined and assigned to a particular writing group. Current N15 INMM-9 efforts on a standard for the nondestructive assay of low-enriched light water reactor UO_2 fuel rods are an example of one such outside request — in this case, made by the Nuclear Regulatory Commission (NRC) to Standards Committee N15. Next, initial and revised drafts of the needed standard must be developed, reviewed, and revised. Following the resolution of internal comments, ANSI-Board of Standards Review (BSR) and public comment reviews must be initiated. All negative comments resulting from these reviews must be reconciled in writing or incorporated in the standard prior to submittal of the final standard to ANSI for approval and issuance. Finally, after initial development and approval stages are complete, and throughout its life at a minimum of every 5 years, each ANSI standard is reviewed, reaffirmed, and if necessary, revised or withdrawn. The result is a dynamic set of guidelines or recommended practices for the industry, which are established and maintained by a panel of experts to assure timeliness and technical accuracy.

NONDESTRUCTIVE ASSAY STANDARDS

Needs

Although intensive development efforts have successfully demonstrated exciting measurement capability for the use of nondestructive assay methods on many nuclear fuel cycle applications, this experience has also uncovered certain shortcomings. The principal shortcoming in the present nondestructive assay approach is difficulty in evaluating and comparing measurements. These difficulties occur because of the diversity of applications, equipment, data reduction methods, and sample configurations used within the nuclear industry.[5,6] As a result, nondestructive assay measurement

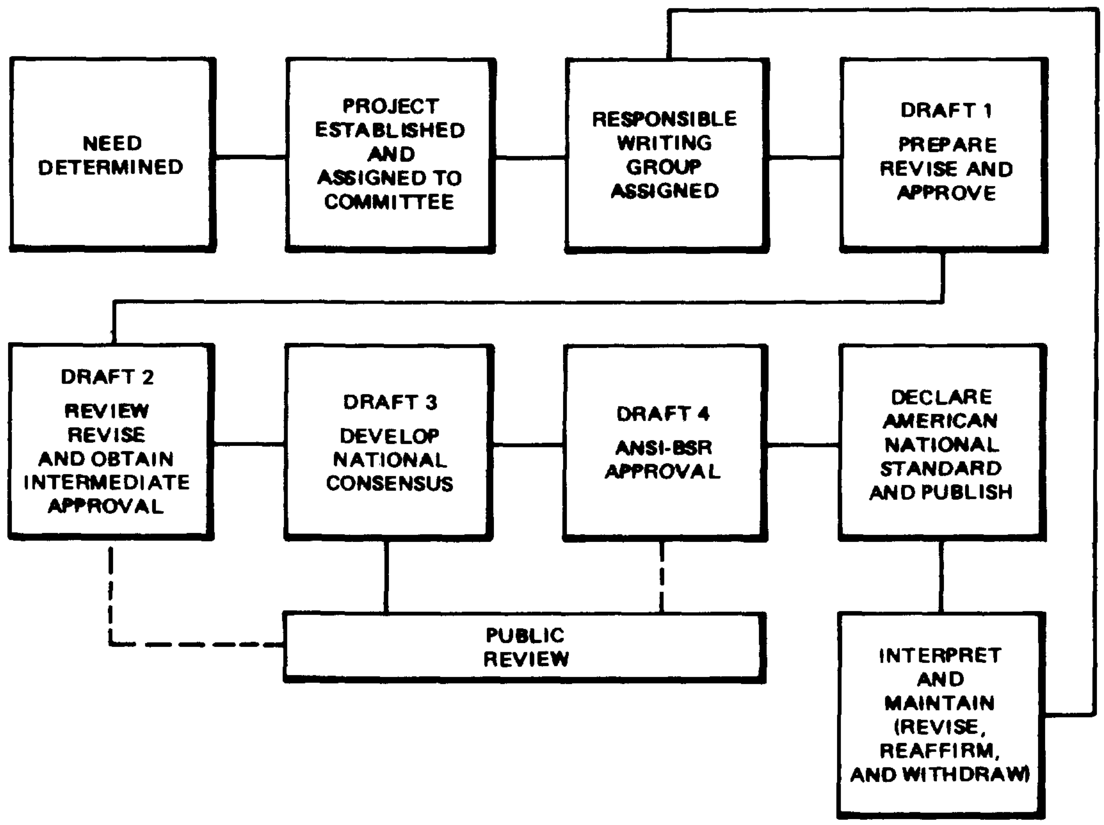


Figure 4. Life of an ANSI Standard

methods in use today have tended to be directed toward the solution of specialized measurement problems without considering the "big picture." Clearly, a major contribution to this lack of generalization ties into the current rush to develop and implement new systems to respond to recent safeguards regulations. However, this approach (or more correctly, lack of approach) must not be allowed to continue. If nondestructive assay methods are ever to obtain their fullest capabilities on nuclear fuel cycle measurement applications, leadership must be provided to establish uniform methods for making and comparing such measurements.

Toward this goal, the development of standards of uniform practices is one essential component of the solution to the current nondestructive assay measurement dilemma. Further, it could be the single most important contribution to the continued maturity of viable nondestructive assay measurement alternatives. Of necessity, such standards must consider the diversity of current nuclear fuel cycle measurement applications. However, the product of these considerations must be measurement uniformity and compatibility. Measurement uniformity is the real problem facing the implementation of nondestructive assay methods in the current industrial safeguards arena, and should be considered a priority goal for future development efforts. It is also a problem which the ANSI, through INMM Standards Committee N15, is working to solve.

Status

The development of consensus standards dealing with nondestructive assay methods for nuclear materials control was initiated by the INMM Standards Committee N15 in mid-1972. Initial activities were directed in two areas:

1. Subcommittee INMM-8 (Calibration Techniques) which is responsible for establishing standards for calibrating nuclear material control measurement methods. INMM-8 is chaired by Mr. Lou Doher (Dow Chemical Company, Rocky Flats).

2. Subcommittee INMM-9 (Nondestructive Assay) which was originally established with the goal of establishing standards for the nondestructive assay of low-enriched LWR UO_2 fuel rods. INMM-9 was originally chaired by Mr. Lynn Hurst (Nuclear Audit & Testing). The revised activities of this subcommittee are the principal subject of this paper.

At the outset, INMM-8 standards development efforts dealing with nondestructive assay were divided into three categories: (a) active radiometric, (b) passive radiometric, and (c) calorimetric methods. However, after initial discussions on the subject of developing a standard for calibrating specific nondestructive assay techniques, it became apparent that nondestructive assay technology was not sufficiently stable or advanced in its status at that time (circa 1972) to justify development of specific calibration standards. Rather, because of the rapid state of development and advancement, which has occurred as a result of industrywide concern in the safeguards area, what was needed was a "general" guide to catalog common nondestructive assay methods and measurement problems and provide criteria for selecting and using available technology for particular nuclear material control measurement applications. Therefore, as a result of initial INMM-8 efforts, it was concluded that the industry was not yet ready for a number of "specific" standards dealing with newly developed nondestructive assay methods. Nondestructive assay technology, for the majority of measurement applications at that time, was changing too rapidly to allow development of a meaningful standard. However, notable exceptions to this general rule were determined to exist in the areas of calorimetric assay of plutonium and LWR low-enriched UO_2 rod scanning for U-235.

In response to these initial findings, the scope of N15 Task Force INMM 8.3 (Radiometric Calibration Techniques) was revised in 1973 by Chairman Darryl Smith (LASL) to provide for the development of a "general" guide to calibrating nondestructive (radiometric) assay methods used for nuclear materials control. Concurrently, INMM-9 Task Force activities on the development of a LWR low-enriched UO_2 fuel rod standard, and INMM-8.4 (Calorimetric Techniques) Task Force activities on the development of a calorimetry calibration standard, were continued as originally defined.

As a result of these efforts, three N15 standards dealing with nondestructive assay standards have been developed:

1. ANSI N15.20, entitled "Guide to Calibrating Nondestructive Assay Systems," by N15 Task Force INMM-8.3 (Radiometric Calibration Techniques).

2. ANSI N15.22, entitled "Calibration Techniques for the Calorimetric Assay of Plutonium Bearing Solids Applied to Nuclear Materials Control," by N15 Task Force INMM-8.4 (Calorimetric Techniques).

3. ANSI N15.23, entitled "Nondestructive Assay of the Fissile Content of Low Enriched Uranium Fuel Rods," by N15 Task Force INMM-9 (Nondestructive Assay).

Proposed ANSI Standards N15.20 and N15.22 have completed public comment and have been submitted for ANSI approval. Proposed ANSI Standard N15.23 has been drafted and submitted for public comment.

Although each of these three standards developed by N15 is significant on its own, perhaps the most important result of initial N15 efforts in developing "general" standards for using nondestructive assay methods for nuclear materials control was the identification of additional topics where "specific" standards could be written, and were needed to supplement current nuclear materials control methods within the nuclear industry. The remainder of this paper addresses these needs and N15 Standards Committee actions aimed at resolving them.

INMM-9 EXPANSION

To be responsive to the standards development needs defined during previous N15 Standards Committee activities, Subcommittee INMM-9 (Nondestructive Assay) has recently reorganized. This reorganization has been conducted in two phases. First, previous INMM-9 rod scan standard development efforts are continuing under a new INMM-9 Task Force designated as INMM-9.5 (Techniques). Second, in order to provide a capability to address a broad range of nuclear materials control measurement problems, five additional task forces dealing with nondestructive assay techniques have been established. As a result, six INMM-9 Task Forces are currently involved in standards development efforts in the area of nondestructive assay techniques. Areas of principal interest include:

Task Force	Title
INMM-9.1	Material Categorization
INMM-9.2	Container Standardization
INMM-9.3	Physical Standards
INMM-9.4	Measurement Controls
INMM-9.5	Techniques
INMM-9.6	Automation

In addition to the six standing task forces described above, support has been solicited from prominent experts in the field to act as consultants to INMM-9 in the areas of scope and policy formulation.

The new Subcommittee INMM-9 (Nondestructive Assay) organization structure is summarized in Figure 5. INMM-9 is privileged to have received the support of excellent chairmen for each of the six task forces. They include:

Task Force	Chairman	Affiliation
INMM-9.1 (Material Categorization)	Dr. Richard N. Chanda	Dow, Rocky Flats
INMM-9.2 (Container Standardization)	Dr. Thomas L. Atwell	Los Alamos Scientific Laboratory
INMM-9.3 (Physical Standards)	Dr. John T. Glancy	General Atomic
INMM-9.4 (Measurement Controls)	Dr. Darryl B. Smith	Los Alamos Scientific Laboratory
INMM-9.5 (Techniques)	Mr. Lynn K. Hurst	Nuclear Audit and Testing
INMM-9.6 (Automation)	Dr. Walter W. Strohm	Mound Laboratory

Further, Drs. G. R. Keepin (LASL) and W. A. Higinbotham (BNL) have agreed to serve as consultants to INMM-9.

The scope of standards development work for each of the six INMM-9 Task Forces described above is shown in Figure 6. Subjects range from material segregation and preparation methods, to measurement control and assurance methods, to data acquisition and diagnostic techniques. Clearly, it will take more than one subcommittee chairman, six Task Force chairmen, and two consultants to accomplish, in a timely manner, the number of goals INMM-9 has addressed. Again, the INMM is privileged to have received the support of numerous individuals from related sections of the nuclear community. For example, in response to these needs and as a result of recent expansion efforts, Subcommittee INMM-9 (Nondestructive Assay) has assembled a staff of 61 highly qualified individuals with expert knowledge in various aspects of nondestructive assay methods used for nuclear materials control. As shown in Figure 7, a total of 29 different organizations are represented: 12 licensees, 2 instrument vendors, 11 license exempt (contractor), and 4 government agencies.

Clearly, this level of support, and broad-based participation, will work toward the achievement of needed standards development goals in a timely and technically sound manner. However, in order to assure that N15 standards represent the consensus opinion, Subcommittee INMM-9 (Nondestructive Assay) staff was selected from all available sectors of the nuclear community. For example, of the six Task Force chairmen, two are from the private sector and four are from contractors. INMM-9 Task Force staff membership is made up of 44% private, 41% contractor, and 15% government personnel. Details for each task force are shown in Figure 8.

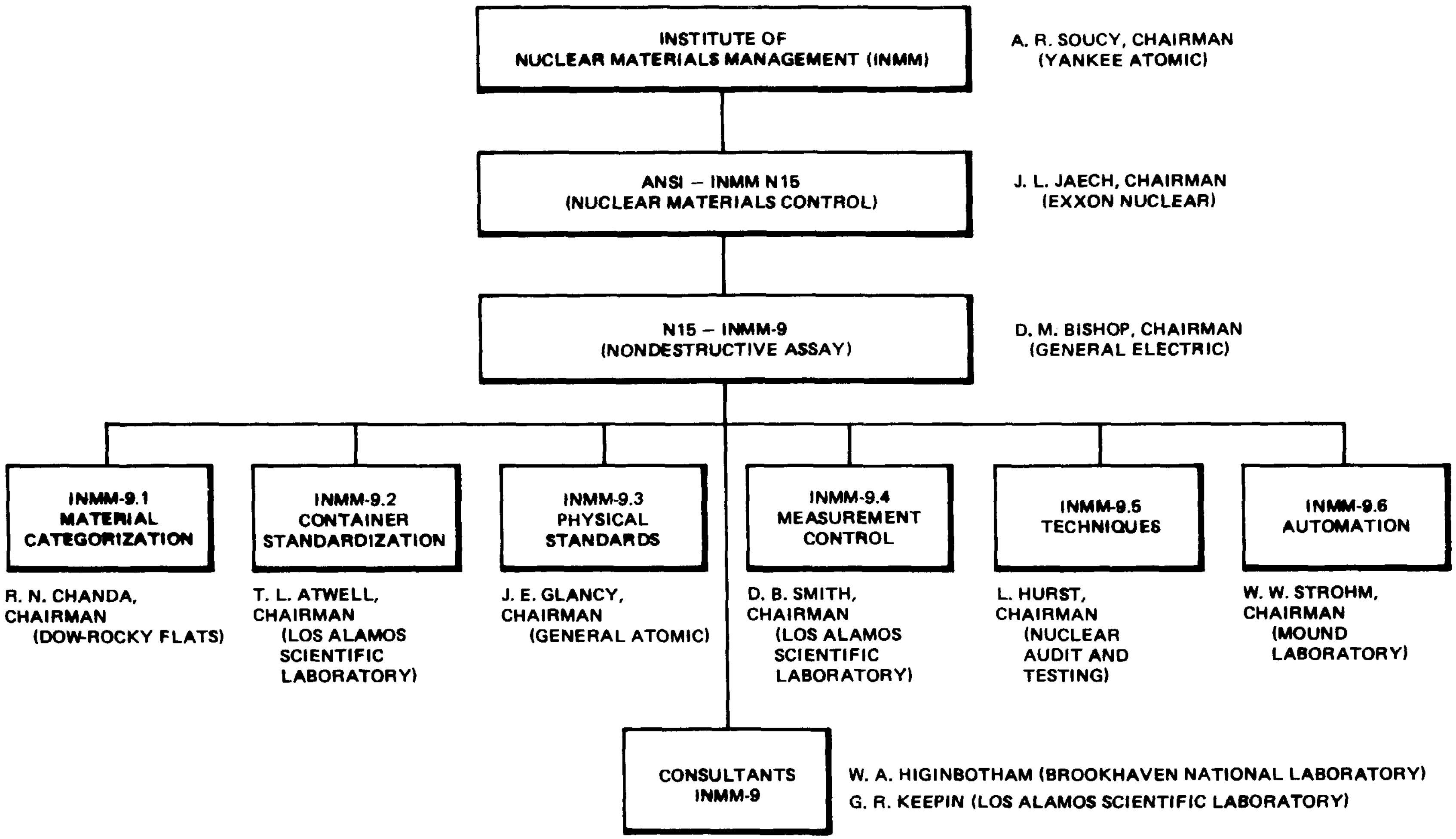


Figure 5. N15 Subcommittee INMM-9 Organization

INMM-9 – NONDESTRUCTIVE ASSAY

ESTABLISH STANDARDS FOR THE USE OF NONDESTRUCTIVE ASSAY METHODS FOR SPECIAL NUCLEAR MATERIALS CONTROL AND ACCOUNTABILITY.

INMM-9.1 – MATERIAL CATEGORIZATION

ESTABLISH STANDARDS FOR THE SELECTIVE CLASSIFICATION, SEGREGATION AND PREPARATION OF MATERIALS SUBJECT TO NONDESTRUCTIVE ASSAY.

INMM-9.2 – CONTAINER STANDARDIZATION

ESTABLISH STANDARDS FOR THE SELECTION AND SPECIFICATION OF STANDARDIZED CONTAINERS FOR MATERIALS SUBJECT TO NONDESTRUCTIVE ASSAY.

INMM-9.3 – PHYSICAL STANDARDS

ESTABLISH STANDARDS FOR THE SPECIFICATION, FABRICATION, QUALIFICATION AND PERIODIC VERIFICATION OF PHYSICAL CALIBRATION AND CONTROL STANDARDS FOR NONDESTRUCTIVE ASSAY.

INMM-9.4 – MEASUREMENT CONTROL

ESTABLISH STANDARDS FOR NONDESTRUCTIVE ASSAY MEASUREMENT CONTROL AND ASSURANCE.

INMM-9.5 – TECHNIQUES

ESTABLISH STANDARDS FOR THE SELECTION, SPECIFICATION AND USE OF NONDESTRUCTIVE ASSAY METHODS.

INMM-9.6 – AUTOMATION

ESTABLISH STANDARDS FOR AUTOMATED NONDESTRUCTIVE ASSAY DATA ACQUISITION, ANALYSIS, DIAGNOSTIC TESTING AND REPORTING.

Figure 6. Work Scope — N15 Subcommittee INMM-9

Licensee	Participants
1. Allied Gulf (AGNES)	2
2. Babcock & Wilcox (B&W)	2
3. Exxon Nuclear (Exxon)	2
4. Nuclear Audit and Testing (NA&T)	1
5. Kerr McGee (K-M)	2
6. General Atomic (GA)	2
7. General Electric (GE)	5
8. Nuclear Fuel Services (NFS)	1
9. Nuclear Material and Equipment Company (NUMEC)	2
10. United Nuclear (UN)	2
11. Westinghouse Electric (W)	2
12. Other	1
TOTAL	24

Instrument Vendors	Participants
1. Intelcom Rad Tech (IRT)	2
2. National Nuclear Corporation (NNC)	2
TOTAL	4

License Exempt	Participants
1. Argonne National Laboratory (ANL)	1
2. Atlantic Richfield (ARHCO)	2
3. Brookhaven National Laboratory (BNL)	1
4. Dow-Rocky Flats (DRF)	4
5. Lawrence Livermore Laboratory (LLL)	1
6. Los Alamos Scientific Laboratory (LASL)	6
7. Mound Laboratory (MOUND)	3
8. Oak Ridge National Laboratory (ORNL)	2
9. Pacific Northwest Laboratory (PNL)	2
10. Sandia Corporation (Sandia)	1
11. Westinghouse (HEDL)	2
TOTAL	25

Government	Participants
1. Energy Research and Development Admin. (ERDA)	2
2. National Bureau of Standards (NBS)	1
3. New Brunswick Laboratory (NBL)	1
4. Nuclear Regulatory Commission (NRC)	5
TOTAL	9

Figure 7. N15 Subcommittee INMM-9 Staff Representation

TASK FORCE	AFFILIATION Private	Contractor	Government	TOTAL
9.1 — Material Categorization	2	5	2	9
9.2 — Container Standardization	4	4	2	10
9.3 — Physical Standards	5	4	1	10
9.4 — Measurement Control	5	3	2	10
9.5 — Techniques	8	4	1	13
9.6 — Automation	3	5	1	9
	27	25	9	61
	(44%)	(41%)	(15%)	(100%)

Figure 8. N15 Subcommittee INMM-9 Sector Affiliation

This staff of experts has established rigorous and important goals. For example, Figure 9 shows preliminary titles for the six standards INMM-9 has committed to publish. Each of these goals was formulated with the intent of strengthening current technology, and providing a basis for maintaining and assuring measurement system performance. Task Force INMM-9.5 (Techniques) has already submitted its standard on UO_2 rod scanning for public comment. This standard should be available by the end of 1975. The remaining five INMM-9 Task Forces have met in conjunction with the 16th Annual Meeting of the Institute and established a rigorous schedule which includes completion of first draft standards in each area by mid-1976 and publication in late 1976.

CONCLUSION

The continued success of the nuclear industry's standards development program depends on the individual participation of technical experts and the support of their management.

Strong management support and recognition are needed for the individuals who are involved in the development of nuclear standards. It is imperative that government and industry management appreciate the importance of the national nuclear standards activity, and that qualified people are made available by management to help write and review the standards. Management should recognize its obligation to support travel and attendance at standards committee meetings. The individual expert is the cornerstone of the nuclear standards effort. As a participant in the development of nuclear standards, experts can contribute skill and technical knowledge to the writing and review of standards. Their training, knowledge, and experience will help to maintain high-quality standards that are relevant to industry's needs.

As a member of the nuclear community in general, and the INMM in particular, your participation and support is the key to the successful development of nuclear standards. Subcommittee INMM-9 (Nondestructive Assay) stands ready to accept additional personnel to help complete current standards development activities, and is more than willing to consider additional requests for future standards.

TASK FORCE	STANDARD
INMM-9.1 (Material Categorization)	"Categorization of Special Nuclear Material for Nondestructive Assay"
INMM-9.2 (Container Standardization)	"Standardized Containers for Nondestructive Assay"
INMM-9.3 (Physical Standards)	"Nondestructive Assay Physical Standards"
INMM-9.4 (Measurement Controls)	"Nondestructive Assay Measurement Control and Assurance"
INMM-9.5 (Techniques)	"Nondestructive Assay of Low Enriched Light Water Reactor UO_2 Fuel Rods for Fissile (U-235) Content"*
INMM-9.6 (Automation)	"Automated Nondestructive Assay Data Acquisition and Analysis"

*Currently in the final stages of development

Figure 9. Proposed ANSI Nondestructive Assay Standards

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SOME THOUGHTS ON BIAS CORRECTIONS

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INTRODUCTION

The problems associated with making bias corrections to SNM accountability data have received considerable attention recently. In particular, two key questions are: (1) when should bias corrections be made, and (2) whether or not bias corrections are made, how may the uncertainty associated with the resulting data be expressed?

There is no simple answer to question (1). The problem is complicated by the fact that as standards, procedures, and regulations are developed, the administrative problems associated with making bias corrections cannot be ignored. These problems occur because of time lags in standards data such that when bias corrections are required, this may mean that a substantial body of past data needs revision. A common action is to make such corrections on subsequent data also, and here the assumption is implicitly made that the bias estimated for one period of time will also apply to the next time period. Such an assumption is not necessarily valid because of changing conditions in the laboratory.

It is the purpose of this paper to present some discussion and results that are hopefully of value in finding answers to the questions given in the first paragraph.

Experimental Situation and Mathematical Model

A number of measurements are made under a given set of conditions on a standard having known reference value μ_o. The value observed for the i^{th} observation on the standard is x_i. The model is

$$x_i = \mu_o + \theta_1 + \varepsilon_i; \quad i = 1, 2, \ldots, n \qquad (1)$$

where ε_i is randomly selected from some probability distribution with mean zero and unknown variance σ_ε^2, and where any two ε values, ε_i and ε_k, have zero covariance. Defer discussion on θ_1 for the moment. The reference value, μ_o, is assumed to be known exactly.

Using the same measurement technique, an unknown sample is then measured to produce observation y_j.

$$y_j = T_j + \theta_2 + \varepsilon_j \qquad (2)$$

where T_j is the true value for item j for the characteristic in question.

The values θ_1 and θ_2 describe how the measurement system produces results that are offset on the average from the reference value μ_o. Consider the following cases:

Case (1): $\theta_1 = \theta_2$. This occurs when the conditions under which the standard is run and when the unknown sample is run are the same. In this case, if a bias correction is to be made, the observed y_j value is corrected by an amount $\hat{\theta}_1$, where $\hat{\theta}_1$ is an estimate of θ_1 (and hence of θ_2) derived from the standards data, $x_1, x_2, \ldots x_n$. The question of when the bias correction should be made under the Case (1) model is not considered in detail here; other authors have dealt with it.(3)

Case (2): $\theta_1 \neq \theta_2$, with probability one, but both values are randomly selected from the same probability distribution having zero mean and variance denoted by σ_θ^2. This occurs when the conditions under which the standard and unknown sample are run are different. Under the Case (2) model, it is clearly inappropriate to make a bias correction on y_j.

It is helpful to consider an example to clarify the distinction in the two cases. Consider a laboratory that provides measured values for, say, percent uranium in a type of scrap over a given period of time. Over this time period, the laboratory measures a standard n times by the same analytical method to provide assurance that the measurement system is functioning properly. The mean of the results of these measurements of the scrap are similarly offset in the same direction and by this same amount. In this case, this offset amount (positive or negative) is $\theta_1 = \theta_2 = \theta$, and θ may be regarded as an unknown constant. The critical assumption here is that the production data are offset by the same amount and in the same direction as are the standards data.

From the second viewpoint, assume that the mean of the results of the laboratory is offset in some direction and by a given amount over one time period (or under one set of conditions), and in a succeeding time period, the amount and possibly the direction will change. This "shifting bias" is not uncommon. For example, even in carefully controlled experiments that extend over some period of time, the "time" effect can be quite a dominant effect for reasons which are often unexplainable. Because of the relatively small size of the bias in any one period of time, coupled with the administrative difficulties in adjusting data after the fact, the data consisting of measurements on the standard are not used to correct production data generated at the same time as the standards data, but rather to make inferences about uncertainties in unknown sample data generated by the same measurement process. In this situation, θ_1 and θ_2 may be regarded as having been randomly selected from some probability distribution.

In application, there may be some question as to how θ in a given framework should be treated in a given instance. However, the mathematical distinction is quite clear, and it is the mathematical distinction between the two concepts that is treated in the remainder of the paper.

Case 1: $\theta_1 = \theta_2 = \theta$

The bias, θ, is estimated by the average of the $(x_i - \mu_0)$ values

$$\hat{\theta} = \bar{x} - \mu_0 = \sum_{i=1}^{n} x_i / n - \mu_0 \qquad (3)$$

The model for the uncorrected production data point y_j is given by equation (2).

If the bias correction is made, then the adjusted y_j value is

$$y_j' = y_j - \hat{\theta} = T_j + \theta - \hat{\theta} + \varepsilon_j \qquad (4)$$

Then, whereas y_j has expected value $T_j + \theta$, y_j' has expected value T_j, i.e., the bias has been removed in a mathematical sense since $E(\hat{\theta}) = \theta$, or $E(\theta - \hat{\theta}) = 0$. ($E(\phi)$ denotes the mathematical expectation of ϕ).

However, we must proceed further because in actual fact, the effect of the bias has not been wholly accounted for. Although $(\theta - \theta)$ has expected value zero, it does not equal zero. It has a variance equal to $\sigma^2_{\bar{x}}$, i.e., its variance is σ^2_ε/n. Therefore, from (4) it is seen that

$$\text{variance } y_j' = \frac{\sigma^2_\varepsilon}{n} + \sigma^2_\varepsilon \qquad (5)$$

where σ^2_ε/n represents a systematic component and σ^2_ε a random component. To clarify, if additional production data were corrected for the same estimated bias, all data points would exhibit the same average offset from T_j, viz., $(\theta - \hat{\theta})$. Any two such values would have covariance σ^2_ε/n. The scatter among the observed production data values would be described by σ^2_ε, whether or not the bias corrections were made. The component, σ^2_ε/n, describes how far from T_j the average of the corrected y_j' values would be offset.

Suppose now that the bias correction is not made. The model (2) applies, and y_j has expected value θ, an unknown but estimated quantity. One can then describe the uncertainty in y_j by the mean square error (MSE) concept, where the MSE is the expected value of the square of the difference between the random variable and the true value. If the expected value equals the true value, then the MSE is the same as a variance.

$$\text{MSE } (y_j) = E\,(y_j - T_j)^2$$

$$= E\,(\theta^2 + 2\theta\varepsilon_j + \varepsilon_j^2)$$

$$= \theta^2 + \theta^2_\varepsilon \qquad (6)$$

Since θ^2 is not known, it may be replaced by its maximum likelihood estimate, $(\bar{x} - \mu_0)^2$. Presumably, in practice and under a Case (1) structure, one would feel comfortable in not making the bias correction only if $(\bar{x} - \mu_0)$ were quite small relative to the random error variance, or if the measurement of the item involved has little effect on MUF or LE(MUF).

Case (2): $\theta_1 \neq \theta_2$

The model is written as before except that θ_1 and θ_2 are now randomly selected from the same population with mean zero and variance σ^2_θ. The problem then is to use the standards data to estimate σ^2_θ. In reference (1), the estimator E_1 was suggested.

$$E_1 = (\bar{x} - u_0)^2 \qquad (7)$$

It has been pointed out by several critics that E_1 results in a biased (in a statistical sense) estimate of σ^2_θ, but that E_2 gives an unbiased estimate.

$$E_2 = (\bar{x} - u_0)^2 - s^2/n \qquad (8)$$

where s^2 is the usual sample variance, and is the estimate of σ^2_ε.

It would appear that E_2 is the preferred estimator because it provides an unbiased estimate of the parameter. However, a closer examination of the two estimators reveals that perhaps E_1 should not be discredited.

First, with respect to the fact that E_2 is unbiased while E_1 is not, this is not necessarily the case. It is noted that E_2 is unbiased only if the estimate given in (8) is actually used in each application. However, for small sample sizes and small values of σ_θ^2 relative to σ_ε^2, it is quite likely that a given estimate will be negative. In practice a negative value for a variance component is not used, but rather, the variance is taken to be zero. The net effect is that E_2 is also a biased estimator under these circumstances. The extent of bias is quantified later in this report, and is compared with the bias in E_1, σ_ε^2/n.

Even if E_2 were not in fact biased, i.e., if negative estimates of σ_θ^2 were used when encountered, it would still not follow that E_2 were preferred over E_1. This is because statistical bias is only one property of an estimator, and in fact, is not necessarily too important when compared with other properties of estimators. In particular, given two possible estimators one might tend to prefer the one that provides an estimate within a given distance of the parameter being estimated with the higher probability.

Examine how E_1 and E_2 compare using this criterion. First, consider E_1. For given (σ_θ, σ_ε, n) with $\mu_0 = 0$ for simplicity, find the probability that $\bar{x}^2/\sigma_\theta^2$ lies between 1/k and k, i.e. that $\bar{x}^2$ is within a factor k of σ_θ^2 the parameter to be estimated. This may be written

$$Pr\ (\sigma_\theta^2/k < \bar{x}^2 < k\ \sigma_\theta^2) \qquad (9)$$

This probability can be evaluated using the fact that $\bar{x}^2$ divided by $(\sigma_\theta^2 + \sigma_\varepsilon^2/n)$ is distributed as chi-square with one degree of freedom. This probability has been calculated for selected values of σ_θ, σ_ε, n, and k, and the results are shown in Table I. Corresponding probabilities for the second estimator, E_2, are also shown in Table I. These were calculated using a computer Monte Carlo simulation assuming that the probability distributions are normal. Although only 200 trials were run at each set of parameter values, the results for E_2 are considered to be determined with sufficient precision for comparison purposes.

The general picture portrayed in Table I is quite clear. It is seen that based on the criterion of "closeness" to the true parameter value, where closeness is measured on a relative basis, the estimator E_1 is generally preferred to E_2. They tend to give comparable results when n gets large, or when σ_θ gets large relative to σ_ε. Elsewhere, E_1's superiority occurs because of the large probability that E_2 will produce a negative estimate.

TABLE I

Probability that Estimate is Within a Factor k of σ_θ^2. ($\sigma_\varepsilon^2 = 1$ in Table)

		$\sigma_\theta = .25$		$\sigma_\theta = .50$		$\sigma_\theta = 1.0$		$\sigma_\theta = 2.0$	
n	k	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2
5	2	.240*	.075	.308	.175	.322	.305	.323	.325
	4	.478	.195	.571	.320	.581	.550	.575	.515
	9	.727	.340	.779	.445	.755	.660	.742	.660
	16	.852	.390	.851	.490	.819	.690	.807	.720
10	2	.280	.150	.381	.200	.322	.290	.322	.295
	4	.542	.255	.581	.380	.577	.530	.573	.550
	9	.773	.355	.767	.540	.746	.625	.739	.685
	16	.864	.385	.832	.610	.812	.665	.805	.745
20	2	.308	.220	.322	.230	.323	.285	.322	.330
	4	.571	.390	.581	.475	.575	.495	.572	.605
	9	.779	.500	.755	.615	.742	.605	.738	.730
	16	.851	.525	.819	.630	.807	.650	.804	.795
40	2	.318	.205	.323	.320	.322	.345	.322	.315
	4	.581	.400	.577	.540	.573	.575	.571	.560
	9	.767	.515	.746	.685	.739	.725	.737	.740
	16	.832	.575	.812	.710	.805	.770	.803	.810

*Three place accuracy in the E_1 values is not warranted.

Table II provides a further summary of the simulation data. The column headings have the following interpretations.

- E_1: Expected value for the estimator $(\bar{x} - \mu_o)^2$
- E_2: Expected value for the estimator $(\bar{x} - \mu_o)^2 - s^2/n$ (unbiased)
- E_{2p}: Mean value of $(\bar{x} - \mu_o)^2 - s^2/n$ based on simulation, but setting negative values equal to zero.
- P: Probability that E_2 will provide a negative estimate of σ_θ^2, based on simulation.

Note that even with respect to statistical bias, E_1 does not fare badly when compared with E_{2p} rather than with E_2. This is because of the high probability that E_2 will provide a negative estimate when σ_θ^2 is small relative to σ_ε^2, as is often the case in practice. Of course, when n is reasonably large, it doesn't make any difference whether one uses E_1 or E_2 since s^2/n will be expected to be very small relative to $(\bar{x} - \mu_o)^2$.

TABLE II

Statistical Biases of E_1, E_2, E_{2p} ($\sigma_\varepsilon^2 = 1$)

n	σ_θ^2	E_1	E_2	E_{2p}	P
5	0	0.2	0	0.1036	0.600
	0.0625	0.2625	0.0625	0.1909	0.540
	0.25	0.45	0.25	0.3539	0.490
	1	1.2	1	1.1690	0.260
	4	4.2	4	3.9969	0.195
10	0	0.1	0	0.0506	0.670
	0.0625	0.1625	0.0625	0.0892	0.590
	0.25	0.35	0.25	0.2946	0.365
	1	1.1	1	1.0980	0.250
	4	4.1	4	3.7351	0.145
20	0	0.05	0	0.0191	0.670
	0.0625	0.1125	0.0625	0.0776	0.460
	0.25	0.30	0.25	0.2625	0.340
	1	1.05	1	0.9106	0.230
	4	4.05	4	3.9510	0.075
40	0	0.025	0	0.0100	0.640
	0.0625	0.0875	0.0625	0.0866	0.380
	0.25	0.275	0.25	0.2415	0.270
	1	1.025	1	1.0718	0.125
	4	4.025	4	4.6162	0.055

SUMMARY

The following summarizing points are made:

1) One should keep clear the distinction between when θ is some unknown constant (Case 1) and when it is randomly selected from a population with mean zero and variance σ_θ^2 (Case 2).

2) It is only reasonable to make a bias correction when the data to be corrected are offset in the same direction and to the same degree as are the standards data used to estimate the bias (Case 1).

3) Even when one is in a Case 1 situation, it does not necessarily follow that a bias correction should be made. The necessity for doing this depends on the relative size of the bias. Ground rules for when such corrections should be made are not covered in this paper, but other authors have dealt with the problem(3).

4) When a bias correction is made, there remains a residual systematic error because the bias cannot be known but only estimated. The systematic component of variance is σ_ε^2/n where σ_ε^2 is the random error variance of a given measurement on the standard, and n is the number of measurements made on the standard.

5) In the bias situation, when a bias correction is not made (usually because the estimated bias is small in a relative sense), the mean square error may be estimated by the square of the estimated bias plus the random error variance, where the square of the estimated bias is regarded as the systematic component.

6) When θ is selected at random from a population with zero mean and variance σ_θ^2, the standards data are used to estimate σ_θ^2 rather than to make a possible bias correction. There are alternate estimators that might be used. Some suggested ones are

$E_1 = (\bar{x} - \mu_0)^2$, where μ_0 is the standard value

$E_2 = (\bar{x} - \mu_0)^2 - s^2/n$

$E_{2p} = \max.\ (E_2, 0)$

Although E_1 is biased in a mathematical sense, it has certain advantages over E_2, particularly from the view of "closeness" to the parameter value.

7) As a simple rule, the following given in reference (2) has merit.

Rule: When a bias correction is made, the systematic variance component is estimated by s^2/n. When the bias correction is not made, it is $(\bar{x} - \mu_0)^2$.

FURTHER COMMENTS

1) We have dealt with the situation in which standards data are collected at only one point in time, or under one set of conditions. Without prior knowledge, it is difficult to know whether the Case (1) or Case (2) situation applies. However, when standards data are collected under several sets of conditions, this determination can be made. Then, under the Case (2) model, estimation of σ_θ^2 is accomplished by analysis of variance techniques.

2) In the Case (1) situation, $(\bar{x} - \mu_0)^2$ was used as the estimate of θ^2. Although this is the maximum likelihood estimate, it is a biased estimate, and subtraction of s^2/n will remove the statistical bias. As with the Case (2) model, however, it would appear that $(\bar{x} - \mu_0)^2$ is the preferred estimator, keeping in mind that the bias correction will normally not be made only if $(\bar{x} - \mu_0)^2$ is small relative to s^2/n. Thus, $(\bar{x} - \mu_0)^2 - s^2/n$ will virtually always be negative in this situation.

ACKNOWLEDGMENTS

As with an earlier paper in this subject area(1), I submitted a first draft of this paper to a number of associates for critical review and comment. Once again, I was heartened by the response and greatly appreciate the helpful and thoughtful comments that were forthcoming. It is hoped that those who kindly submitted their comments to me will note their influence on this revised presentation.

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AFTER NEW ORLEANS

(Continued from inside front cover)

Does it? My experience in the past has been that often it does not. Parallel laboratories tend not to refer to each other, which might be forgivable, but they also tend not to reference their own work adequately. References to "private communications" are almost unheard of.

In my opinion, the safeguards field is underpublished, under-referenced, and under-read. (It may also be underpaid, but that is a separate question.) The Journal of the INMM can help with the publication part, but only all of us working together can solve the concurrent problems of under-referenced and under-read.