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Establishing a **MASTER** Favorable Safeguards Climate Within a Nuclear Facility

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June 8, 1971

Atlantic Richfield Hanford Company
Richland, Washington 99352

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ESTABLISHING A FAVORABLE SAFEGUARDS CLIMATE
WITHIN A NUCLEAR FACILITY

By

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and
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June 8, 1971

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ABSTRACT

Efforts toward developing an effective safeguards program involve not only research and development, but also the effective application of known technology by resourceful humans. The following areas of attention are presented with humanistic as well as procedural aspects being discussed. Practical experience is cited when applicable.

- *Gaining the understanding and concern of those involved as to the importance and worth of safeguards efforts.*
- *The role and qualifications of a statistician responsible for practical application of statistics to safeguards.*
- *Elements involved in the acquisition of data through laboratory standards and referee programs in order to achieve normality and constancy of variance.*

ESTABLISHING A FAVORABLE SAFEGUARDS CLIMATE WITHIN A NUCLEAR FACILITY

INTRODUCTION

Safeguards is a collective term that comprises those measures designed to guard against the diversion of source and special nuclear material from uses permitted by law or treaty, and to give timely indication of possible diversion or credible assurance that no diversion has occurred.

Efforts toward developing an effective safeguards program involve not only research and development, but also the effective application of known technology by resourceful humans. Since physical security alone is insufficient protection against diversion in a complex nuclear facility, surveillance and material accounting techniques must be employed. Measurements for such techniques are obtained through the efforts of the personnel who operate the facility: management, operating, laboratory, or maintenance personnel. The accuracy and precision of the measurements, above what are required for process control, are to a significant extent dependent upon *need* as understood by these people.

This paper discusses some means which may be utilized to gain the understanding and concern of those involved as to the importance and worth of safeguards efforts; the role which statistical programs can play; and the qualifications of such programs as related to achieving normality and constancy of variance.

AUTHOR EXPERIENCE

C. A. Colvin is currently a senior chemist assigned to the Atlantic Richfield Hanford Company (ARHCO) Research and

Development Department where he is concerned with separations processes and waste management. He was directly associated with Hanford analytical control laboratories for six years, with an additional fourteen years in process chemistry research and development. The fourteen years have included considerable liaison work with operations, process engineering, and control laboratories as well as analytical methods development and materials accountability. He has participated in the Argonne Safeguards Training Program.

D. F. Shepard is a statistician assigned to the ARHCO Research and Development Department where he is responsible for statistical consulting, specifying theoretical techniques for statistical evaluation, and for providing statistically designed programs for specific applications. This function of the past five years followed nine years as a statistician in operations research. Previous to that, he managed an analytical control laboratory for one year; was a group leader of a nuclear process control laboratory for ten years; and performed as a chemist and supervisor for seven years. He has completed considerable graduate work in statistics, chemistry, and computer programming. He participated in the Statistical Methods for Safeguards course at Argonne National Laboratory.

SELLING SAFEGUARDS

Industrial facilities exist to produce products. The means used to produce the products are generally accepted by personnel at all levels as being essential. Measures such as safeguards, having little to do with production, have to be sold by convincing people of their significance and need. Surveillance and materials accounting are particular aspects of safeguards which need the support and dedication of a variety of people within a nuclear facility.

One means which has been used at Atlantic Richfield Hanford Company to sell safeguards was the preparation of a summary of the Safeguards Program.¹ The summary was short enough to encourage reading, and long enough to be comprehensive. The Table of Contents for the summary is included as Appendix A. An attention-getting title, *Opportunity for Survival--A Look at Nuclear Materials Safeguards*, was given in order to attract interest. It was given wide distribution within the company; and the response was generally good. Many employees expressed appreciation for such background information as the description of the Nonproliferation Treaty, its relationship to International Safeguards, and the role of domestic nuclear accountability. Such tie-ins are not always evident when reported in the news media.

AREAS OF SPECIFIC IMPORTANCE

SAMPLING

Representative sampling is a major problem especially when dealing with radioactive materials. It is essential that operating personnel be alert to sampling equipment malfunction, solids in process solutions, two or more liquid phases, and perhaps inadequate design for accountability sampling. A continuing alertness for solids in process solutions is essential since they are a result of a broad spectrum of conditions and may contain accountable materials, interfere with analyses, or bias tank measurements.

An analytical laboratory can provide analyses only on the sample received. Successfully relating those analyses to

¹C. A. Colvin. *Opportunity for Survival--A Look at Nuclear Materials Safeguards*, ARH-1709, Atlantic Richfield Hanford Company, Richland, Washington, May 19, 1970.

process material depends on good weight and/or volume measurements and controlled process conditions.

THE ANALYTICAL LABORATORY

An analytical laboratory is the key between the physical material in various forms, and material accountability. Two specific items are vital: (1) results must be provided with known, valid uncertainties; and (2) speed of performing analyses without sacrifice of quality is essential. It is obvious that the more precise an analytical result the better; however from a safeguards standpoint this concern is secondary to knowing what the measurement uncertainty is and the magnitude of the analytical bias.

The following factors relate directly to the capability of the analytical laboratory to satisfactorily meet the above goals:

- A process control-oriented laboratory may not give the necessary emphasis to material balance samples (*i.e.*, there is pressure to place process control samples first even though a particular sample may not be vital at the time).
- Technical personnel should be expected to learn the business by performing routine analyses on a routine basis. A potential supervisor or lead chemist may never in any other way learn the intricacies and problems involved. Lack of this experience leads to unmerited reliance on non-technical personnel.
- Technical manpower should be utilized to assure quality and timely results where needed. There may be tendencies for control chemists to place emphasis on more interesting development work rather than accept and adapt proven methods.

- Establish the attitude that laboratory standards and referee programs are means of determining valid uncertainty information and that they are not designed to determine the worth of the individual or the reputation of the laboratory. Reducing the tendency to take *extra* care when running standards should increase the validity of uncertainty values.

ROLE, QUALIFICATIONS, AND TOOLS OF A STATISTICIAN

Since the use of statistical methods and procedures undoubtedly play a central part in any safeguards system, the role and qualifications of the person responsible for recommending the statistical procedures and implementing their application to specific operations should be carefully considered.

The primary responsibility of the statistician is to provide an unbiased, quantitative understanding of the safeguards system as applied to a specific operation. Some of the general areas of responsibility would be the design of experiments and process tests, analysis of experimental and production data, design and review of measurement control programs, and general statistical consulting.

While the specific nature of the operation will to a major degree determine the role and qualifications of the statistician, there are six general qualifications and conditions that need to be met:

1. Ability to communicate with all levels of operating and staff groups responsible for the operation.
2. Ready access to all data and procedures.
3. A general knowledge as to the feasibility of specific procedures and major sources of measurement errors.

4. Familiarity with laboratory, engineering, and processing capabilities.
5. Adequate computational facilities.
6. Familiarity with general statistical procedures, a ready access to a good library and to consultants in the field.

ABILITY TO COMMUNICATE WITH ALL LEVELS OF OPERATING AND STAFF GROUPS

In recent publications, much has been said about the desirability of improving communications between groups. It is not only desirable, but is a necessity when using statistics for safeguards. Unless the accountant, engineer, chemist, production supervisor, manager, or whoever needs the information is able to clearly convey his needs to the statistician, there is little likelihood of the statistician developing the desired information. Likewise, unless the statistician is able to clearly convey his needs for specific data obtained under well-controlled procedures or methods, there is little likelihood of his being able to provide the required information. Irrespective of the type of technique used (*e.g.*, analysis of variance, regression analysis, covariance analysis, etc.) the statistician will develop a mathematical model using the data obtained to estimate the parameters of this model. Unless the model is adequate to represent the particular problem at hand, even the best data and estimation procedure will be of no avail.

It is also essential that this communication take place at all levels. Whoever is obtaining the primary data must understand what is required. A random sample must be truly random, independent measurements must be independent, and all data must be reported, with an explanation of unusual circumstances if they occur. If the experiment requires a control

or "blind" standard, this standard must receive exactly the same treatment as a normal sample.

Above all, both the statistician and client must be honest with the people with whom they are working. If blind standards are used, the personnel should know that blind standards are being used and why.

Under no circumstance should data from these tests be used to appraise the ability of the operators or analysts. Experience has shown that including the analyst's name in the data is objectionable. Since it is desirable to investigate the data when unusual circumstances are suspected, the use of a payroll number may be a convenient compromise.

READY ACCESS TO ALL DATA AND PROCEDURES

It is, of course, impossible for the statistician to know all the details about the operation or process being investigated. It is, however, essential for him to be able to contact someone who does have intimate knowledge as to the details of the operation. Also it is essential that any bit of data that might shed some light on the problem be made available--no matter how organizationally private the information is. A statistician probably does not finally use more than about 10 percent of the information that he obtains about a specific problem, but there must not be any limitations upon his ability to obtain the information. He must be trusted implicitly.

The importance of having access to all data and procedures outweighs the advantages of the statistician being in a group that specializes in applied mathematics or statistics if this group is administratively removed from the operating groups.

GENERAL KNOWLEDGE AS TO THE FEASIBILITY OF SPECIFIC PROCEDURES AND MAJOR SOURCES OF MEASUREMENT ERRORS

The statistician must know what physical or chemical events may be taking place to explain the variations observed in the data. Means must also be provided to be sure that the observed variations are due to the process or equipment and are not the result of measurement errors.

FAMILIARITY WITH LABORATORY, ENGINEERING, AND PROCESSING CAPABILITIES

The capabilities of the laboratories, engineering, and processing groups have an important bearing upon the types of programs that may be undertaken. For example, consider the necessity of having independent measurements. This may be accomplished, depending upon the parameter being estimated, by using different analysts on the same shift, using analysts from different shifts, or requiring the measurements to be made in separate laboratories--possibly by different methods.

This qualification and the previous three have indicated the vital need for the statistician to be technically strong in his knowledge of the operation. Such ability should take precedence over advanced statistical ability if a choice has to be made.

ADEQUATE COMPUTATIONAL FACILITIES

One of the obvious but sometimes overlooked requirements for good statistical programs for safeguards is the availability of adequate computational facilities. Those used at ARHCO will be described with the understanding that these *particular* facilities are in use because they are available.

The day-to-day basic computational equipment is a Wang 700 programmable desk top electronic calculator with a 701 output printer (Wang Laboratories, Inc.). The immediately

available (on tape) programs include the standard statistical basic operation of calculating means and standard deviation of sample data, linear regression, Chi Square and t test, analysis of variance, and the generation of random numbers.

For programs requiring either large amounts of data storage or more complex programs, a time share terminal connected with Computer Sciences Corporation's (CSC) Univac 1108 is used. The language generally used is BASIC and the system is CSC's INFONET. This system is also used wherever a program of some length must be stored for immediate day-to-day use.

For somewhat larger problems which require extensive programs but not excessive amounts of data, the same terminal is used but the language is changed to Fortran V and the INFONET CRJE system. This system is also used whenever the program requires either a moderate amount of computer time or has a large amount of output.

For programs requiring a large amount of data input, the data are keypunched on cards which are transported to the computer center for batch processing.

FAMILIARITY WITH GENERAL STATISTICAL PROCEDURES WITH A READY ACCESS TO A GOOD LIBRARY AND TO CONSULTANTS IN THE FIELD

The statistician responsible for application of statistical techniques and methods for safeguards is somewhat analogous to a general practitioner in medicine. He is expected to know something about most of the available statistical techniques and treat any problem that arises. For his immediate use, a personal, assigned library of from 5 to 15 general references would probably suffice--depending largely on the nature of the process or operation for which he is responsible. For specific problems, access to a fairly large library will be advantageous; and in some cases a necessity. Unfortunately many of the highly effective statistical methods still reside in the

literature and are not available in textbooks, although there has been considerable improvement in the past few years in this regard.

Also there is the difficulty that many of the good "modern" techniques are not adequately described in the most recent literature but must be obtained from publications prior to about 1955.

Appendix B contains a list of some of the references that have been of value in the solution of day-to-day problems. The list should not be considered a recommendation for the specific books, but rather to include examples of the types of useful references.

Since in many cases the statistician is the only member of the group engaged in this particular activity, it is highly desirable that some provision be made to permit him to consult or meet with the other general practitioners in his field. Most of the good statistical programs now in use at ARHCO have been developed over the years by using the combined ideas and suggestions of several people. For safeguards, a general meeting or workshop at least once a year would appear to be quite valuable.

A prerequisite for the statistician engaged in day-to-day safeguards applications is the ability to consult when necessary with a specialist in an explicit field.

THE LABORATORY STANDARDS AND REFEREE PROGRAM

The Laboratory Standards and Referee Program (LSR) used at ARHCO is briefly described as an example of the application of statistical procedures.

The primary motivation behind the introduction of the program was the desire to obtain better estimates of the analytical measurement error (precision of the method or *random*

error) and an estimate of the analytical bias (reliability of the method or *fixed* error). Prior to adoption of the LSR program, most analytical measurements were made in duplicate, and control limits were used to reject measurements where the duplicates failed to agree. Some of the more critical measurements were made in quadruplicate; in some cases two measurements being made by one analyst and the other two by another. Unfortunately, the disagreements observed between the answers reported by this system on a sample and those reported at a later date or time by resampling the same tank failed to agree within the expected range. It was realized that better estimates of both the analytical measurement error and the sampling variability should be obtained. Since the analytical measurement error must be known to determine the sampling error, major emphasis was placed on the estimation of the analytical measurement error.

The LSR program consists of two parts. In the *Referee* portion of the program, a random sample of the process samples previously analyzed on a preceding shift are resubmitted to the laboratory for re-analysis by the same method, but by personnel of a different shift. In the *Standards* portion of the program, samples are submitted of known composition and the percent recovery of the material measured is reported.

It was vitally essential to the successful operation of the program to obtain the cooperation of the laboratory analysts. Although this program was clearly designed to test analytical methods and equipment, there was at times a tendency on the part of the analysts to discard standard results that were within the expected variability but outside the analysts' own conceptions as to the capability of the measurement method. At one time the feasibility of eliminating possible personal implication by removing the analyst's pay number from the data cards was considered. This unfortunately makes the tracing back of problems somewhat difficult. The

better the individual analysts understand the needs of the program, the more smoothly it operates.

One effective means which has been used to fit the program to the needs of the process engineers and to the process itself is by "task force assignments." A process engineer will usually head the group and its membership will include an analytical chemist from the operating laboratory, an analytical development chemist, a representative from the accountability group, and a statistician. This group is usually assigned a specific problem or goal and is disbanded when the project is completed.

While it is essential for the statistician to be intimately involved in the development of a program such as the LSR, the actual operation of the program is best conducted by personnel having a routine operating relationship with the laboratories. The statistician, of course, should be available for assistance whenever any unusual problem concerning interpretation of the data arises.

CONCLUSION

There is no substitute for the conscientious efforts of human beings in the application of technology for safeguards purposes. People have to know the needs, reasons, and consequences, as well as have the ability to practically apply technology. Safeguards is not an impossible or economically prohibitive task--it needs only to be sold.

APPENDICES

APPENDIX A

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*Opportunity for Survival--
A Look at Nuclear Materials Safeguards*

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SAFEGUARDS DEFINITION

INTERNATIONAL NUCLEAR SAFEGUARDS

UNITED STATES SAFEGUARDS PROGRAM

RESEARCH, DEVELOPMENT, AND SPECIAL STUDIES

SYSTEMS STUDIES

MEASUREMENT TECHNIQUES

TRANSPORTATION

PHYSICAL SECURITY

INSPECTORS

ACCOUNTABILITY PROCEDURES

COMPUTERIZED DATA PROCESSING

MATERIAL ACCOUNTING AND STATISTICS

POSSIBLE CONTRIBUTIONS BY ATLANTIC RICHFIELD HANFORD COMPANY

LOCAL RESEARCH AND DEVELOPMENT

WASTE MINIMIZATION

LOCAL ACCOUNTABILITY

LABORATORIES

Analytical Laboratories
Standards Laboratory

CONCLUSIONS

ACKNOWLEDGMENTS

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