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MEASUREMENTS AND STANDARDS FOR NUCLEAR MATERIALS SAFEGUARDS

May 1, 1978 — September 1, 1978

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National Bureau of Standards

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PREFACE

This report was prepared for the U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research under Interagency Agreement No. AT(49-25)-9009.

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ABSTRACT

This report is a review of the period, May 1, 1978 through September 30, 1978, of a long-term NBS program sponsored by NRC to up-grade national measurements and standards capability for nuclear materials safeguards.

The overall approach that NBS is utilizing to provide for development and dissemination of a consistent set of national measurement standards for nuclear materials safeguards is presented. It should be stressed that a great deal of work needs to be done to provide the standardzation base for alternate fuel cycles. Many materials such as thorium, Uranium 233, and plutonium or mixed oxides "spiked" with fission products might well be found in future alternate fuel cycles. The NBS program is aimed at providing both the standards for today's needs and the standards for future fuel cycles.

A summary of the progress for each of the five tasks in the project is given.

OVERVIEW OF NBS PROGRAM

An adequate measurements and accounting system is necessary for the detection of and protection against surreptitious removal of special nuclear material by persons having authorized access to facilities. The sensitivity of this type of detection depends directly on the uncertainties of measurement. The NBS program will assure the availability of the certified reference materials, reference measurement methods, and quality assurance methodology for the adequate control of measurements for safeguards. Domestic and international dissemination is required.

The goal of the proposed NBS program is:

> To assure that measurement standards exist for the timely measurement of special nuclear material both in today's fuel cycles and in future alternate fuel cycles so that the measurements can be performed at reasonable cost with accuracy sufficient for the safeguarding of nuclear material. These measurements of enriched uranium, plutonium, and related materials need to be made by both inspectors and the industry.

The NBS program in measurements and standards for safeguarding of nuclear materials consists of three related parts: (1) calibration standards, reference measurement methods, sampling schemes, statistical treatment of data and data generation; (2) dissemination mechanisms to transfer the standards and reference methods and data to the users; and (3) mechanisms to directly assist inspectors and the nuclear industry to ensure that their measurements are of sufficient accuracy.

In order to carry out the tasks assigned to NBS in a timely manner, NBS must continually assess the advancing needs for national measurement standards. NBS must also provide the broad technical base that is needed to carry out the program. NBS has received substantial guidance and input from NRC as to standards needs. Continued input from all appropriate NRC offices (NRR, NSS, SD, IE) will be extremely helpful and is solicited.

NBS is using a multidisciplinary, matrix management approach to carry out the program. Under the new NBS reorganization, work is being carried out in seven line organizations: Center for Radiation Research, Center for Thermodynamics and Molecular Science, Center for Analytical Chemistry, Center for Materials Science, Center for Applied Mathematics, Center for Absolute Physical Quantities and the Center for Mechanical Engineering and Process Technology. Researchers with backgrounds in analytical chemistry, mass and volume, nuclear and radiation physics, thermodynamics, mechanics, etc. are part of the program team. NBS is also supplying a substantial amount of equipment, both old and new, that is needed to carry out the program.

PROGRESS OF TASKS

Task I: DEVELOPMENT AND IMPLEMENTATION OF MEASUREMENT ASSURANCE PROGRAMS AND STATISTICAL SUPPORT FOR NUCLEAR MATERIALS SAFEGUARD

Volume Calibrations: Discussion between NBS and BNL led to a presentation on accountability tank volume calibration by an NBS staff member to INMM task group 8.2 at the 19th Annual Meeting of INMM in Cincinnati. This presentation was intended to make the group aware of the ongoing work at NBS on new methods of accomplishing tank volume calibrations when the relationship between volume and liquid level is nonlinear. A computer program written at Bell Labs, which will be helpful in this work, has been acquired.

SALE: Members of NBS staff attended the first meeting of the SALE program steering committee on May 23 and the SALE participants meeting on May 24 and 25; discussions there were on format and content of SALE reports, and directions for the programs.

ASTM Committee C-26: A second draft of the proposed ASTM standard on sampling and sample handling of PuO_2 powder was completed jointly by J.A. Lechner of NBS and S. Turel of NRC. This draft was discussed at the ASTM Committee C-26 meeting on July 26-28. Random and systematic errors were discussed at some length; some thoughts on this topic pertinent to the standard under discussion but applicable more broadly will be circulated.

Recruitment: Discussions were held with at least 6 potential candidates for recruitment. The search continues with good prospects of hiring at least 2 of these. An attempt is being made to attract one or more postdoctoral fellows to the Safeguards program in the coming year; these would provide a broader base of expertise at no cost to the program.

Miscellaneous: Discussion with the other Divisions at NBS engaged in the Safeguards work continue. The ANS/NBS Nuclear Safeguards meeting in Williamsburg on May 14 to the 17th, was attended by a staff member. Several documents were reviewed or commented upon, both internal and external.

5-year Plans: Quite a bit of time has been spent developing a 5-year plan for the Safeguards effort, and in integrating it with the 5-year plan for the Center for Applied Mathematics. The benefits of such planning efforts are likely to be substantial, even though not immediately obvious.

Calorimetry: Discussions were held at NBS, regarding the need for traceability of Mound Labs calorimetric measurements. A meeting of the committee consisting of NBS and Mound personnel was held at NBS on September 12. Two items were discussed: Procedures for establishing traceability of calorimetric measurements to be made at Mound Labs or elsewhere, and procedures and measurements necessary to make NBS-SRM's out of the Pu heat sources produced by Mound Labs.

Seminars: The following seminars were held:

1. Dr. Paul deBievre, CBNM, Geel, Belgium, June 2, 1978, "Verification Measurements for Nuclear Safeguards."

2. Dr. Frederick Forscher, Energy Management Consultants Inc., August 24, 1978, "Proliferation Resistant Fuel."

3. Dr. R.E. Perrin, LASL, September 29, 1978, "High Precision Isotopic Analysis of Nanogram Quantities of Uranium and Plutonium."

Investigators for this task are J.A. Lechner, C. Spiegelman, H. Ku and C. Reeve.

Task II: STANDARDIZATION OF DESTRUCTIVE ANALYTICAL CHEMISTRY METHODOLOGY FOR NUCLEAR MATERIALS

A. Chemical Assay

1. Assay of SALE Depleted Uranium by Titrimetric Method

The uranium content of a SALE depleted uranium was determined by the NBL titrimetric method. Samples of SRM 960, uranium metal, were utilized as a standard of known uranium content and were assayed identically to the SALE samples. Prior to cleaning, sample coupons were reduced to a nominal size of approximately 2 g for titration and 1 g for coulometric assay. All samples were cleaned by acid leaching in successive baths of 1:1 HNO_3 and 1:3 HCl. Some difficulty was encountered in obtaining sufficiently clean SALE samples because of the formation of thick oxide layers which were removed by several cycles through the cleaning process.

After cleaning, samples of SRM 960 and SALE uranium were weighed, dissolved in a mixture of $HF-H_3PO_4$ and titrated together in groups of six. Two chemists, one experienced and the other inexperienced with the technique, were utilized. This arrangement was utilized to gauge the experience factor for the NBL modified Davies-Grey procedure. Both analysts took duplicate samples of the six SALE samples and performed the analysis in a

manner such that replicates of the same sample were not made on the same day. A maximum effort was made to mix and randomize analysts and samples during the period devoted to titration.

High precision titrimetric analysis requires both experience and patience. It can be inferred from repetitive measurements and other unreported data that interanalyst and also interlaboratory differences of about 0.01% in assay values and in precision may be observed. It is believed that this condition will be commonplace until the necessary research is conducted to determine the exact nature of secondary reactions in the titrimetric method.

2. Assay of SALE Depleted Uranium by Coulometry

The uranium content of the SALE depleted uranium was also determined by coulometry. The uranium assay is based upon the constant-current coulometric reduction of uranyl ion with electrogenerated titanous ion in a fulfuric acid medium. Seven depleted uranium partial coupons of approximately 1 g were taken for analysis. Six of the samples were analyzed in duplicate and a seventh was included for the purpose of providing additional data on the precision of the method and homogeneity within a sample position. The precision of the coulometric measurements were comparable for the SALE and SRM 960, but were not as precise as the measurements by the modified Davies-Grey method.

B. Isotopic Analysis

1. Mass 238 Background Interference

Mass spectrometric isotopic characterization of Pu samples for the AS-76 measurements revealed a systematic difference of approximately 0.5% for the ^{238}Pu abundance determinations by NBS

and another characterizing laboratory (2nd quarterly report, 1978). The most likely cause of the difference, since there were no trends for the other Pu isotopes, was an incomplete separation of U from Pu by the ion-exchange separation chemistry. It was also probable that there was a background contribution at mass 238 from either U, an inorganic molecular species, or an organic compound. For 238U isotopic abundances of less than 0.1 atom percent, it was also known that inexplicable and significant deviations from the precision of the measurement method occured for high purity samples. It was, therefore, decided to throughly investigate background interference as the cause of the systematic difference while the other characterizing laboratory investigated incomplete separation of U from Pu.

The overall approach was to establish an upper limit for a blank filament system and then to analyze SRM 993, a material highly enriched in ^{235}U (99.8 atom percent) to determine an upper limit for extraneous ions at mass 238. Our research utilizing a conventional faraday cup detection system has provided the following information:

a. There is no evidence of U background from the Re filament system at a detection sensitivity of $1\text{-}2 \times 10^{-16}$A.

b. There is a non-reproducible, unidentified background contribution at mass 238 of less than 5×10^{-16}A.

c. The ionizing filament temperature is the only mass spectrometric parameter which has shown any degree of correlation to the background.

Although the present effort to evaluate mass 238 background contributions have been temporarily suspended until other efforts to improve and upgrade the U and Pu techniques are completed, the following implications for high precision and high accuracy must be considered.

a. A reduction from the nominal operating temperature of 2160°C is prudent until more is known about the spurious background at mass 238. Based upon our existing knowledge of the formation of organic ions at high temperatures, it appears that a temperature between 2100°C will be finally utilized.

b. Although the background interference is not observed for each analysis, it is capable of producing a bias of 0.1% for ^{238}U and ^{238}Pu abundances of 2-3 atom percent.

c. Evaluation of background contributions must be made for ^{238}U, ^{234}U, ^{235}U and ^{236}U.

2. ^{235}U Composition of SRM 950b

Data has been received from the Goodyear Atomic Corporation, the Paducah Gaseous Diffusion Plant and the National Bureau of Standards (Table 1) as part of a cooperative effort to determine the ^{235}U composition of SRM 950b. Each laboratory prepared its own calibration mixes and/or utilized its own in-house natural standard. Laboratory No. 2 represents a thermal ionization measurement with a precision of 0.02% (95% confidence level) while all others are the more precise (< 0.01% at the 95% confidence level) UF_6 measurements. No special significance is attached to the apparent difference between the thermal ionization and UF_6 data, since on an absolute scale, biases of 0.02 to 0.05% are currently possible between different laboratories. These small biases are attributed to the uncertainty in evaluating different calibration standards used at the laboratories and present a clear example of the need for common standards and improvement in chemical assay techniques.

The investigators for this task are L.A. Machlan, H.M. Kingston, J.R. Moody, G. Marinenko, and E.L. Garner.

Table 1. ^{235}U Composition of SRM 950b

	Weight Percent	Atom Percent
Lab #1	0.71067	0.71970
Lab #2	0.71095	0.71998
Lab #3	0.71069	0.71972
Lab #4	0.71064	0.71966

Task III: STANDARDIZATION OF NDA METHODOLOGY FOR NUCLEAR MATERIALS.

A. Gamma-Ray Spectrometry Portion of the Nuclear Safeguard Program

The work during this last quarter of FY78 has progressed slowly in the primary areas of interest.

1. The preparation for certification of the joint set of NBS-Euratom NDA Standard Reference Materials has been given to the Euratom Laboratory at Geel, Belgium to supervise. The first group of samples for analysis by both destructive and nondestructive techniques are expected to arrive sometime during the first quarter of FY79. In order to facilitate the shipment of the samples between the two Euratom Laboratories, BCMN-Geel and IRC-Ispra, and NBS, U.S. SNM export and import licenses have been obtained from NRC.

2. Data reduction techniques and methods for determining the atom percent of ^{235}U on low enriched materials ($\leq$ 10% ^{235}U) have been applied to the archival gamma-ray spectrum library of known ^{235}U enrichment levels. The archival gamma-ray spectrum library had been collected from the Uranium Isotopic SRM's which were prepared earlier this year as counting standards. The result of this work has been to establish calibration curves for the determination of the ^{235}U atom percent, as seen in Figures 1 and 2.

3. Work on the assembly of the segmented gamma scan unit has progressed slowly this quarter, however, completion of the unit is expected during mid FY79.

4. The draft of the proposed ANSI Standard, Guide to Preparing Calibration Material for Non-Destructive Assay by Passive Gamma-Ray Counting, has been completed by the INMM-9.3, Non-Destructive Assay, Subcommittee of Standards Committee N15 and is undergoing peer review.

The investigator for the gamma-ray spectrometry portion of this task is S. Carpenter.

B. Calorimetry

This period was devoted to installing the Mound heat-flow calorimeter in a large, temperature - regulated water bath. Also, the calorimeter was instrumented to investigate the effect of calorimeter position in the bath on the calorimeter output fluctuations. Failure of the large bath motor has delayed testing. A smaller water bath designed to contain a single calorimeter is now being constructed. Calibration of the standard resistors for current and potential measurement in the calorimeter has been completed. An

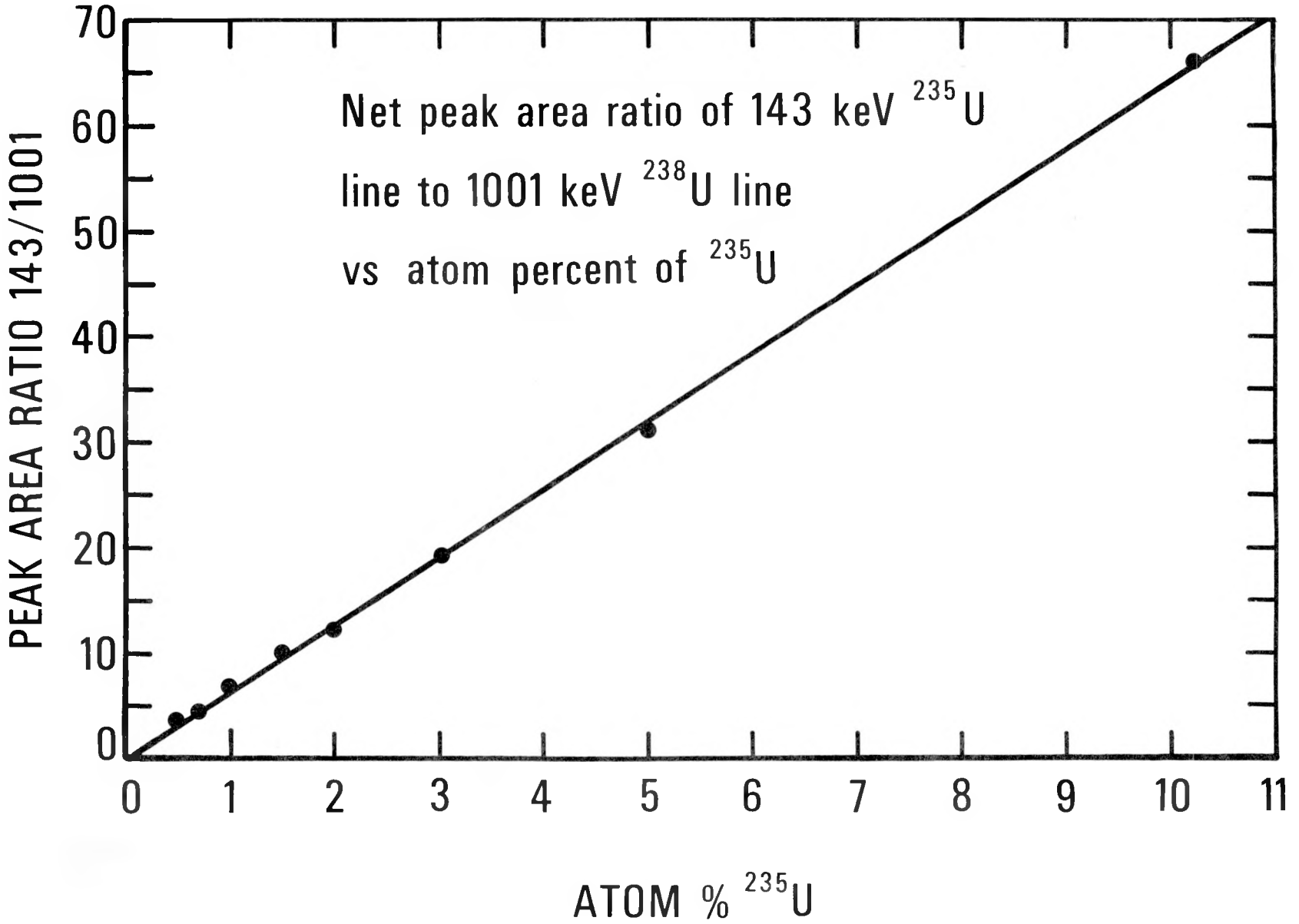
Net peak area ratio of 143 keV ^{235}U
line to 1001 keV ^{238}U line
vs atom percent of ^{235}U
PEAK AREA RATIO 143/1001
ATOM % ^{235}U
0
10
20
30
40
50
60
70
0
1
2
3
4
5
6
7
8
9
10
11

Figure 1

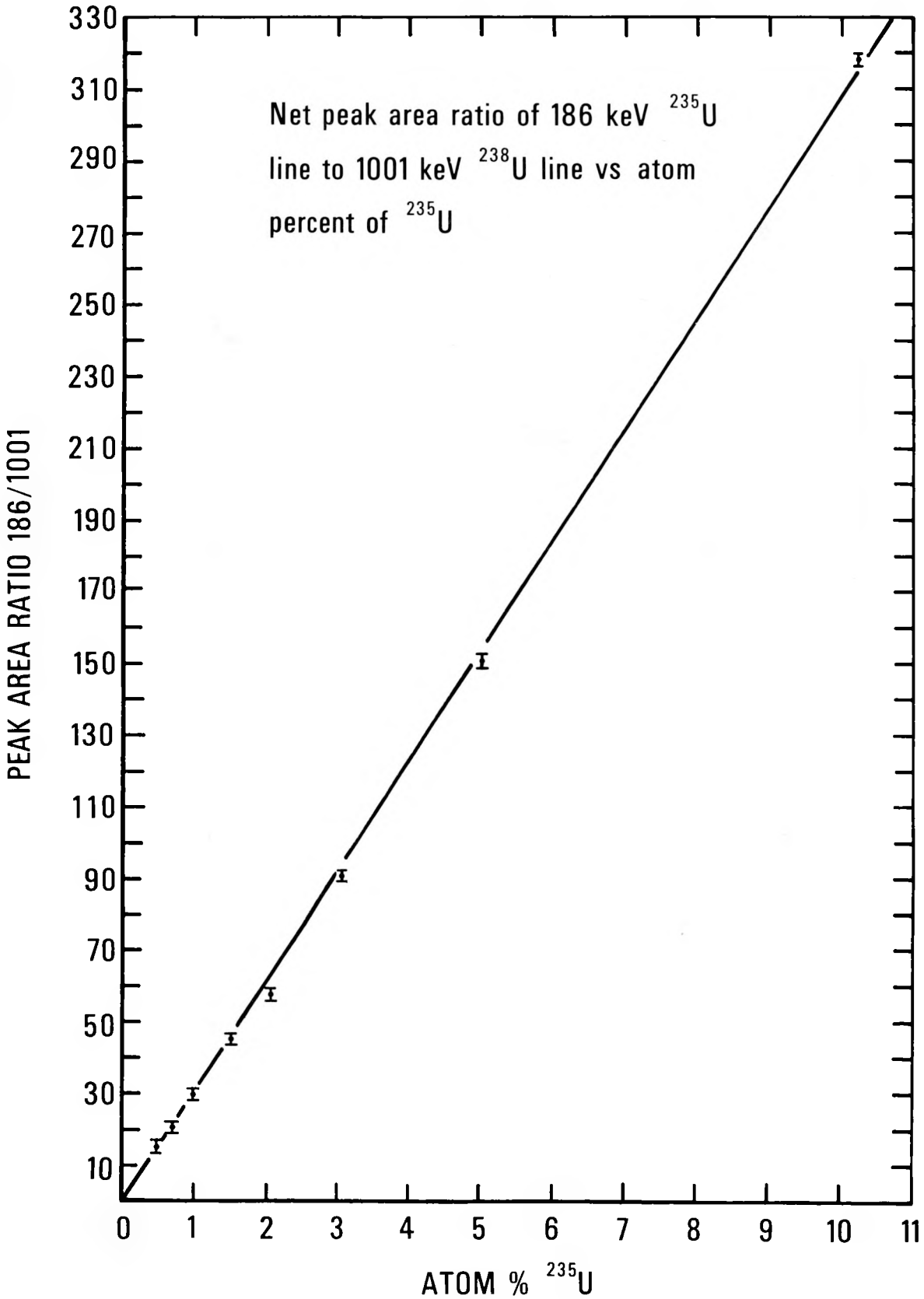
Net peak area ratio of 186 keV ^{235}U line to 1001 keV ^{238}U line vs atom percent of ^{235}U
PEAK AREA RATIO 186/1001
330
310
290
270
250
230
210
190
170
150
130
110
90
70
50
30
10
0
1
2
3
4
5
6
7
8
9
10
11
ATOM % ^{235}U

Figure 2

automatic inductive ratio-arm bridge has been received and is being checked out. This apparatus will be used in the calibration of secondary thermometers, for monitoring calorimeter temperatures during testing and for measuring temperatures within the ice calorimeter during operation.

The investigators for the calorimetry portion of this task are D. Ditmars and J. Colwell.

C. Resonance Neutron Radiography - Linac Produced Neutrons

All components of the computer for resonance neutron radiography have been received. The staff involved with this program have finished special software courses necessary for the implementation of these computers. We presently also are seeking outside software development service for the systems portion of the computer facility. The full development of software will require at least six months. However, the system will be partially useful earlier.

The other instrumentation for the resonance neutron radiography has been installed including remotely operable scanning table, collimators, detectors, etc. Detector development is underway with the objective of improving resolution. For large samples our objective is 2 - 3 mm; for smaller samples $\sim$1mm. Much needs to be done here since our present resolution is at the 4 - 5 mm level.

The following papers have been presented at the International Conference on Neutron Physics and Nuclear Data for Reactors and other Applied Purposes, at Harwell, September 25-29, 1978 and will be published in the Proceedings of the Conference:

1. Chemical and Temperature Effects on Thermal ^{235}U Fission, by R. A. Schrack and C. D. Bowman.

2. The Influence of Molecular Vibrations on Neutron Reactions, by C. D. Bowman and R.A. Schrack.

During the next quarter we hope to complete the software for data acquisition and to improve the resolution. Demonstration tests can then follow. We also will complete the experiment designed to test for sensitivity of neutron radiography to chemical form of the nuclear material.

Investigators for the resonance neutron radiography with linac-produced neutrons portion of the task are C. D. Bowman, R.A. Schrack and J. Behrens.

D. Resonance Neutron Tomography - Reactor Produced Neutrons

During this reporting period, the design of the standard waste container scanning system and neutron beam collimator has been frozen. The vertical collimator design will permit variations in neutron beam diameter ranging from 6 to 25mm. The components necessary for fabrication of these systems have been ordered. Partial shipments have been received of the scanning power supplies and translator electronics.

As this is regarded as a research/feasibility project, the scanner system is designed to accept a waste container the size of a one-gallon paint can. The problem of performing resonance neutron tomography on 114- and 208-liter (30- and 50-gallon) containers will be addressed once the feasibility data have been obtained utilizing the small container and the Los Alamos computer simulation and extrapolation exercises have been completed.

The delivery of the data handling equipment has been delayed due to a malfunctioning disc. The company representative has assured delivery of the system in approximately two weeks; however, this is purely conjecture.

The shield design to house the scanning system and the collimator change fixture is in progress. Weight and space constraints are presenting serious design problems.

Personnel of the Neutron Standards Group are cooperating in this project by providing NBS Standard Fission Detectors for the final system and foil sources with which the preliminary experiments will be performed.

The investigator for the resonance neutron tomography using reactor produced neutrons portion of this task is D. Garrett.

Task IV: FEASIBILITY STUDY ON THE USE OF ACCURATE INFRARED THERMOGRAPHY TECHNIQUES FOR NUCLEAR MATERIALS

The goal of this task was to determine whether infrared thermography techniques could be used as an analytical tool to locate and determine the quantity of plutonium holdup in nuclear fuel cycle plants. Work on this task in now complete and this a report of the results.

The approach was in three phases: (1) the gathering and evaluation of information about commercially available infrared thermographic equipment, (2) a detailed facility analysis, and (3) calculational studies based on the physics of the situation.

In the information gathering and evaluation phase, a search was made of the literature on the theory of the performance and applications of thermal imaging systems, and manufacturers of thermal imaging systems were contacted to acquire literature on the performance and technical applications of the available systems. The facility analysis consisted of visits to facilities and analysis of facility models. Visits were made to the DOE/ Rockwell Rocky Flats Plant and to Argonne (personnel of both of these facilities have had field experience in holdup measurements), to LASL where the application of other NDA techniques to holdup measurements was discussed, and to Mound Laboratory to discuss the possibility of applying infrared thermography for determining plutonium holdup in dismantled process lines. Three facility models were analyzed: the Westinghouse-Anderson mixed oxide recycle fuel fabrication plant; the proposed nitrate-to-oxide conversion facility designed by the Savannah River Laboratory; and the AGNS chemical separations plant.

The heat which develops in plutonium due to self absorbtion of the spontaneous alpha decay will produce slightly higher temperatures in the regions immediately surrounding a localized concentration of plutonium. If all the heat can be measured and if the isotopic composition is known, it is possible to accurately determine the amount of plutonium present. In the case of holdup measurements in processing facilities, it is not possible to measure all the heat evolved by the plutonium because the measurement is unbounded. For example, a typical processing facility will in general have a system of interconnected enclosures which contain the process equipment. For safely reasons, air is continuously circulated through these enclosures at a pressure slightly below ambient by a totally self contained air handling system. As a consequence of the flowing air, an unknown amount of the heat evolved by plutonium at one point is dissipated elsewhere in the enclosures and associate ductwork.

Thermographic instrumentation seems to offer an attractive means of rapidly sensing surface temperature distributions. Instruments are available on the commercial market which can resolve a temperature difference as small as 0.1 K under the appropriate measurement conditions. The field of view is large, the spatial resolution quite good and the thermal image obtained can indicate temperatures accurate to 0.1 K after proper calibration. Unfortunately, the conditions for measurements in the processing plant are such that this level of performance can never be realized. The reduction in accuracy is caused by the uncertainty in the proper values of emissivity of the surfaces viewed and the unknown contribution of the background thermal radiation.

Calculations show that these two effects can easily produce uncertainties in the estimated temperature difference of 10 to 20 percent. In addition, such common things as a fingerprint, dust, an oily film or variations in surface texture and orientation are likely to produce false indications of temperature differences which may be larger than those to be measured.

Another and perhaps more serious limitation on the use of these instruments in the processing plant is that window materials, through which the instrument might "see" into a glovebox for example, severely attenuate thermal radiation in the wavelength range of 2 to 14 micrometers, the interval in which thermographic instrumentation functions. This effectively restricts the use of these instruments to the survey of the exterior of the enclosures when the more important need is for measurements on the process equipment contained within.

For these and other more technical reasons, it is concluded that infrared thermographic techniques cannot contribute significantly toward improved accuracy in holdup measurements at plutonium processing plants. Although it is not possible in a processing plant to utilize the heat generated by the plutonium to obtain a quantitative measure of its amount, the temperature gradients associated with the disseipation of that heat may be useful in fixing its location.

To the extent that these surface temperature gradients may provide spatial information which could be useful in the interpretation of conventional gamma-ray or neutron counting data, it is recommended that an inexpensive, hand-hold, contact temperature probe be used. Measurement with such probes can yield temperature differences which are accurate to 0.1 K or better after careful calibration.

The investigators for this task were M. Reilly and H. Marshak.

Task V: STANDARDIZATION OF BULK MEASUREMENT METHODOLOGY IN NUCLEAR FUEL CYCLE PLANTS

A. Field Calibration of In-Plant Accountability Tanks

A second series of process tank calibration runs was made at the Allied-General Nuclear Services Barnwell Plant. The analysis of the data was initiated.

A seminar on volume calibration of nuclear process tanks was conducted at the Rockwell Hanford Operations, Richland, Washington on July 6, 1978.

The preparation of the paper, "The Application of an Improved Calibration System to the Calibration of Accountability Tanks," for presentation at the IAEA International Symposium on Nuclear Materials Safeguards, Vienna, Austria, October 2-6, 1978 and for inclusion in the Symposium proceedings has been completed.

A proposed calibration of a second tank at the Savannah River Plant was discussed with DuPont and DOE personnel. The tank is a right circular cylinder 3.05m (10 ft) in diameter and 3.35m (11 ft) high. The calibration is tentatively scheduled for January, 1979.

This calibration effort will provide an opportunity 1) to determine the jet heel (residual solution) by spiking with lithium, 2) to plan with personnel of the NBS Statistical Engineering Division to facilitate development of a definitive uncertainty statement for tank Calibration, and 3) to conduct a joint NBS-DOE workshop during the calibration for the instruction of personnel of other facilities.

The development of an algorithm to permit the transformation of calibration equations developed for water calibration to equations for process solutions at appropriate temperature has been initiated using two different approaches.

The investigators for this portion of the task are J. Whetstone, J. Houser, F.E. Jones, and B. Robertson.

B. Simulated Process Tank Study:

A detailed task plan was designed to examine the processes of the bubbler tube liquid level measurement system. Central in the planned tasks was critical analysis of the pressure signals recorded by the transducers monitoring the air bubbler tube. Typical traces of these pressure signals (third quarterly report) have now been decomposed into two regimes each of which has been the focus of a separate study.

It is felt that if the different factors contributing to the salient features in each of these regimes are well understood then a repeatable complete trace can be reliably produced so that the transducer system can give a credible average pressure value to determine accurately the liquid level. The decomposition of the pressure trace (see Figure 3) is done so that the gradual rise to the peak designated "A" in the figure is referred to as the "slow response" regime. The rapidly varying pressure signal that follows the sharp decrease in pressure after bubble breakoff is called the "fast response" regime.

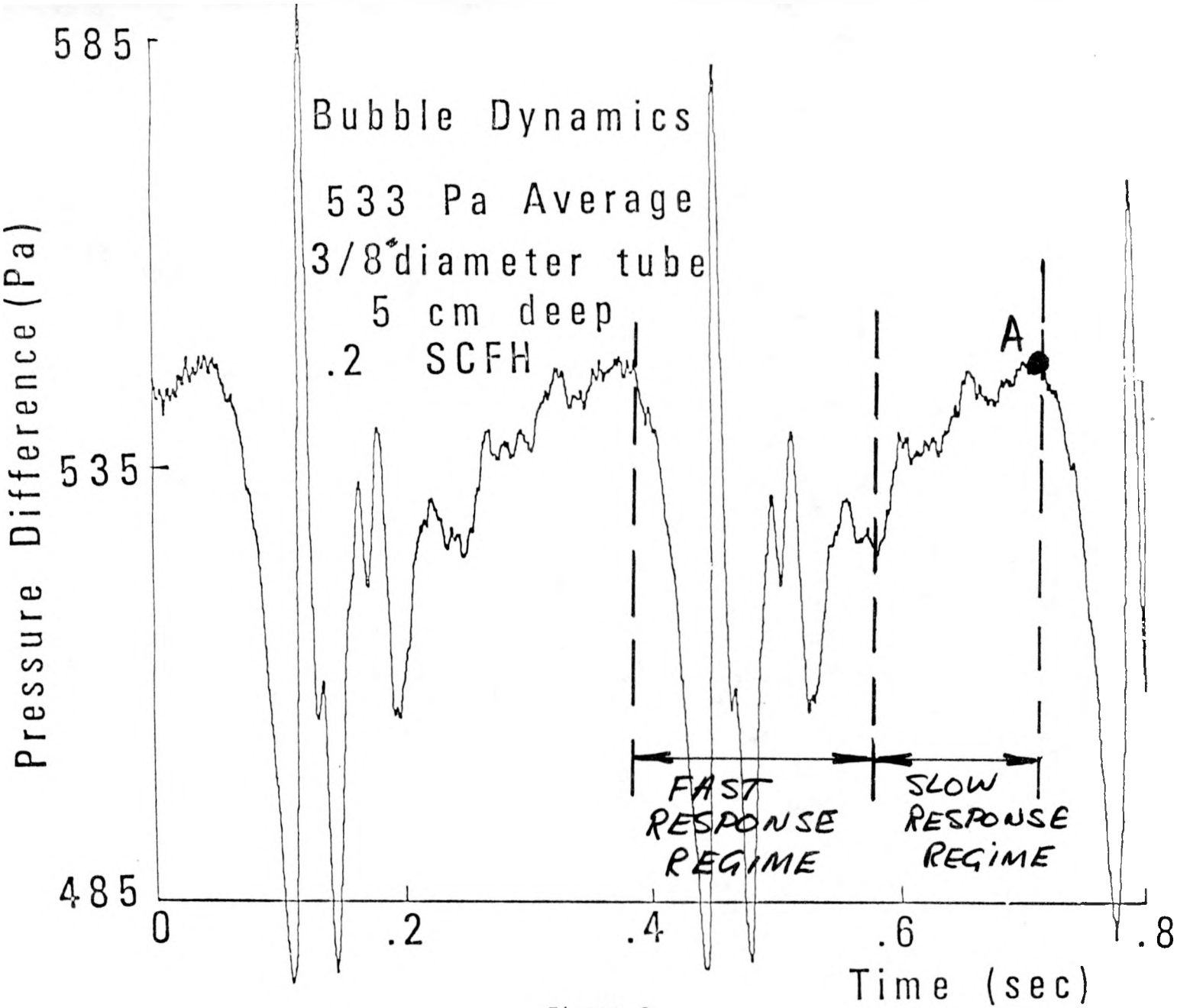

Figure 3.

Observed Pressure as a Function of Time in a 3/8" Diameter Tube.

In the slow response regime, the rise rate has been conclusively shown to be due to the size and shape of the bubbler tip. A series of photographs showing the different stages of bubble development during a bubble cycle are shown in Figure 4. Here the tip is cut off perpendicularly to the tube axis and the bubble developed is axisymmetric. Because of the axisymmetric bubble shape the latter stages of bubble development occur via a horizontal growth which produces a relatively flat pressure trace. Figure 5 shows similar photographs for a tube with an angled cutoff tip. The bubble growth here is more vertical owing to the fact that the tube constrains horizontal expansion around about half the bubble's equator. This growth pattern produces a more sharply rising trace in the slow response regime.

The differences in pressure rise rates in the slow response regime that are attributable to bubbler tip geometry are shown in Figure 6. Here, for the same air flow rate the top trace indicates a very smooth and flat pressure signature before breakoff while the angled tip shows a sharper rise with a more irregular signal.

In the fast response regime, it is presently found that the characteristics of the pressure signal are produced not just by compression and rarefaction waves in the air column of the bubbler tube but by the entire system namely liquid and air oscillations, and the nature of the bubbler tip. This can be seen in Figure 4 in the nature of the respective oscillations following the bubble breakoff.

Preparations are now underway to initiate the thermal and uranyl hitrate portions of the study. A system has been designed and built which will handle this solution and the required heat transfer in the appropriate manner.

The investigators for this portion of the task are B. Robertson and A. Gaigalas (visiting professor).

C. Test Air Served Weigh Beam

The awaited Electro-Hydraulic Mass Comparator unit has been received. Initial checkout showed that several components were missing and others required modifications. These have been designed and built or ordered. Several high precision load cell readout units have been ordered for use in the laboratory testing of the Mass Comparator. Checkout and testing continues on the system sub-assemblies completed.

The investigators for this portion of the task are P. Pontius and R. Mitchell.

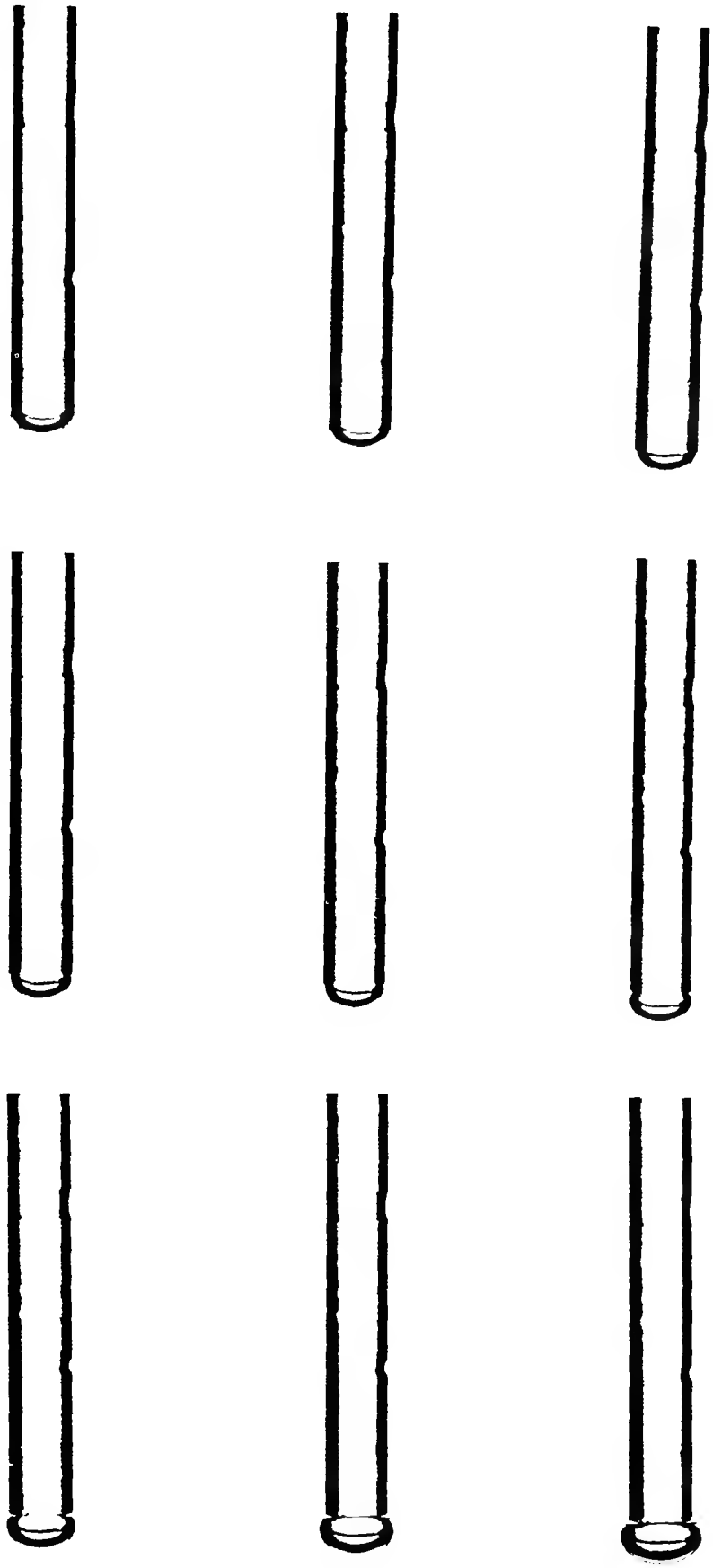

Figure 4. Shape of Bubbles at Various Stages of Development in the Tube with a Flat End.

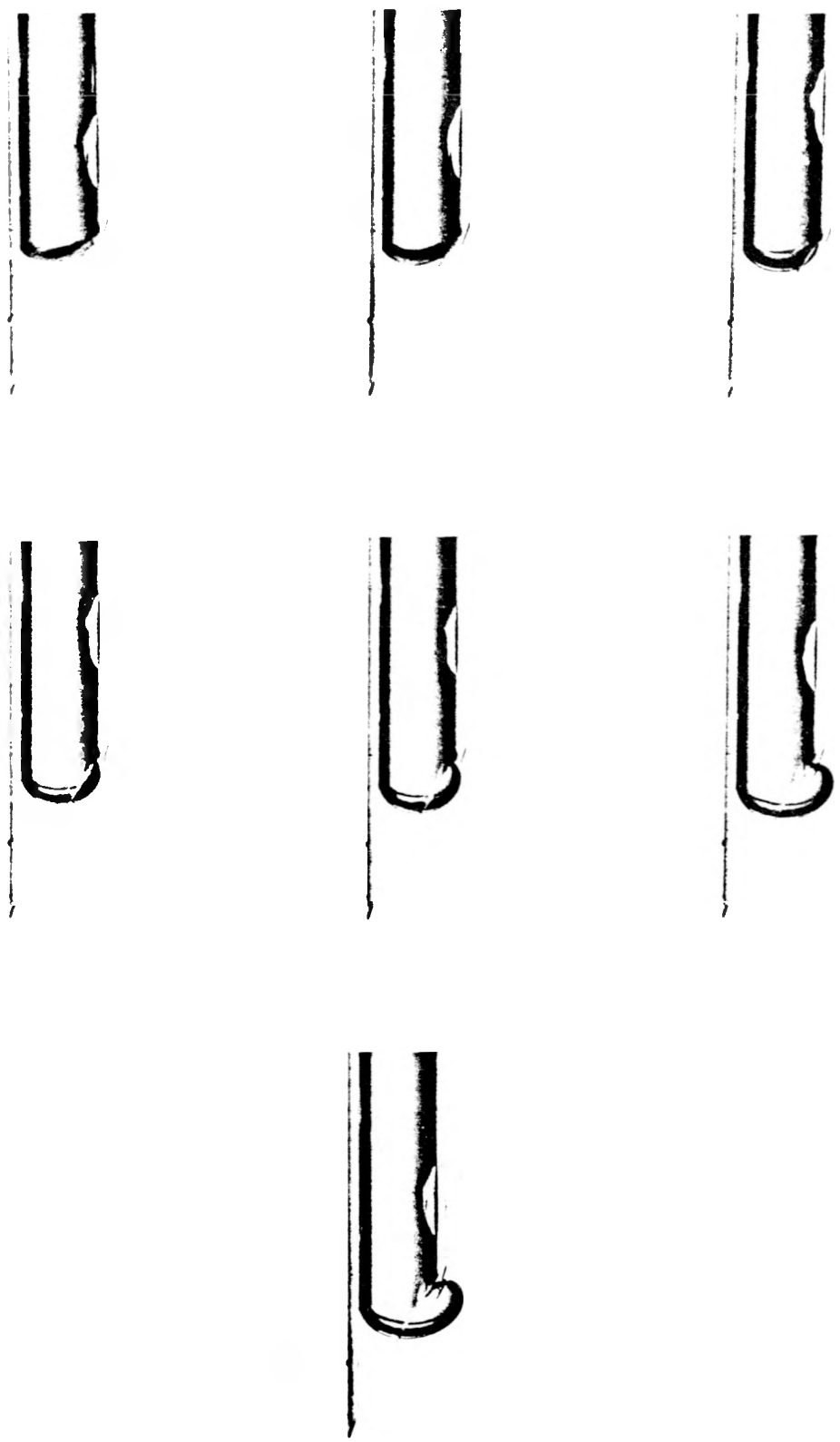

Figure 5. Shape of Bubbles at Various Stages of Development in the Tube with an Angled End.

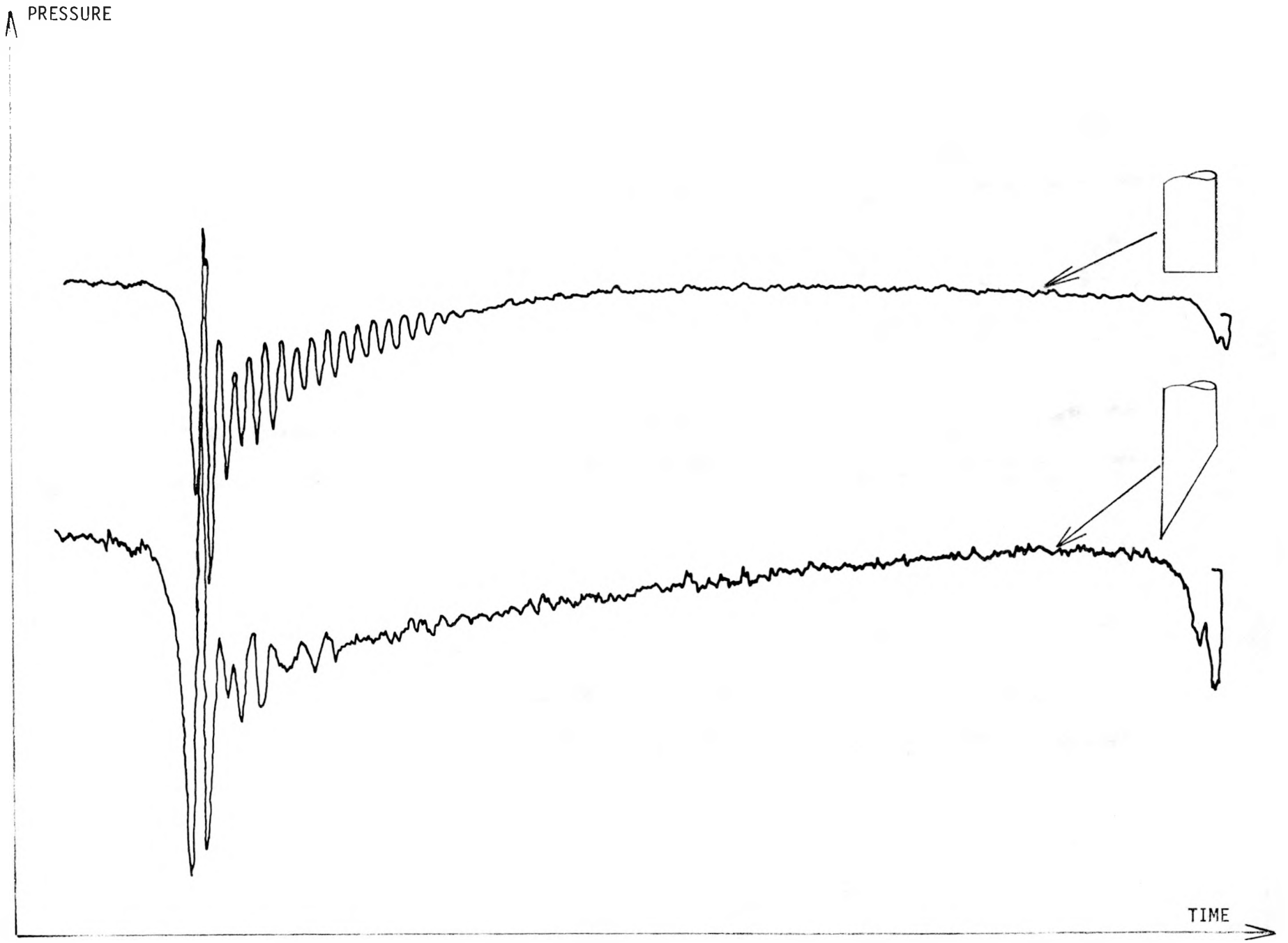

Figure 6. Pressure as a Function of Time for a Flat End Tube and an Angled End Tube.

D. Prototype Dynamic Volume Calibrator

The system to transmit the calibration fluid for the tankem turbine meters into the volumetric standard was designed and built. With this system the respective modes of operation of the dynamic calibrator can be accurately evaluated.

In the preferred mode of operation the dynamic calibrator would continuously transmit calibration fluid to the tankage being calibrated. Concurrently, the liquid level measurement system would continuously monitor the accumulated quantity of liquid in the tank. Alternatively, the calibration fluid could be transmitted for short intervals of time after which the liquid level could be allowed to come to rest and determined via the liquid level measurement system. After this is determined the computerized unit then resumes transmission of calibration fluid, etc.

Efforts to produce the required circuitry for the basic calibrator have continued. Unforeseen problems have lengthened the originally estimated design and construction period.

The investigators for this portion of the task are B. Robertson, P. Baumgarten and D. Cooper.

E. Mobile Flow Standard

The bidding period for the fabrication contract closed July 17. The time required is estimated to be 12 weeks - producing the unit for NBS calibration by mid-October.

The investigator for this portion of the task is J. Whetstone.

F. Pressure Transducer Calibration

The testing of the three pressure transducers submitted by the Rocky Flats Plant has been completed and the units have been returned for installation. The data analysis is about one-third complete.

A visit will be made to the Rocky Flats Plant at the end of September to discuss the evaluation and reports. A fruitful discussion of the needs concerning pressure transducers and of NBS capabilities to meet those needs is anticipated.

The investigators for this portion of the task are V. Bean and S. Wood.

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This report is a review of the period, May 1, 1978 through September 30, 1978, of a long-term NBS program sponsored by NRC to up-grade national measurements and standards capability for nuclear materials safeguards.

The overall approach that NBS is utilizing to provide for development and dissemination of a consistent set of national measurement standards for nuclear materials safeguards is presented. It should be stressed that a great deal of work needs to be done to provide the standardization base for alternate fuel cycles. Many materials such as thorium, Uranium 233, and plutonium or mixed oxides "spiked" with fission products might well be found in future alternate fuel cycles. The NBS program is aimed at providing both the standards for today's needs and the standards for future fuel cycles.

A summary of the progress for each of the five tasks in the project is given.

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