NBSIR 80-2051

NBS/AID/PCSIR Survey on Standardization and Measurement Services in Pakistan

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Office of International Relations
National Bureau of Standards
U.S. Department of Commerce
Washington, D.C. 20234

Held January 12-25, 1979
Issued June 1980

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Chairman, Pakistan Council
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International
Team Members: Mr. Cyril H. Dix, United Kingdom
Mr. Hugh L.K. Goonetilleke, Sri Lanka
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Dr. Chul Koo Kim, Korea
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A Report of a Survey Conducted Jointly by the National Bureau of Standards and the Agency for International Development PASA TA(CE)5-71

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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U.S. DEPARTMENT OF COMMERCE, Philip M. Klutznick, ***Secretary***

Luther H. Hodges, Jr., ***Deputy Secretary***
Jordan J. Baruch, ***Assistant Secretary for Productivity, Technology and Innovation***

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, ***Director***

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I. EXECUTIVE SUMMARY

Following similar projects conducted by the National Bureau of Standards in other countries, the Ministry of Science and Technology of Pakistan and under it the Pakistan Council of Scientific and Industrial Research invited NBS to organize a six-person international team of experts in selected topics of metrology to advise the Government of Pakistan on the adequacy and needs for standards and measurement services. This team was specifically expected to comment upon, elaborate, and fill in details for the existing and fully approved plan to establish a new laboratory in Islamabad which under the PCSIR will be the primary national standards body under the title of National Physical and Standards Laboratory. This Survey was undertaken with shared funding and guidance from the Government of Pakistan and the U.S. Agency for International Development.

The team composed of specialists from Korea, Sri Lanka, the United Kingdom, and three NBS staff members, visited numerous industrial, academic, and governmental establishments in the Islamabad, Peshawar, Lahore, and Karachi areas within a two-week period in January 1979 (Section IV). They were accompanied by a high-level Pakistani counterpart team representing the PCSIR laboratories. The entire Survey was under the continuous personal direction of Dr. Abdul Ghani, the PCSIR Chairman, who saw in it an opportunity to study the problems and opportunities of industry whether privately or publicly controlled. The team strongly endorsed the NPSL plan, having found every indication that a national focal point for good measurements appeared as a critical need for Pakistan's development. A summarizing letter of conclusions and recommendations dated on the last day of the Survey is reproduced with other recommendations and relative remarks by visiting team members (Section III). Throughout their brief stay in Pakistan, the visiting team members discussed freely with their hosts specific problems arising from inadequate availability and use of measurement services. As in most other countries, the team found a widespread failure to understand the full importance of measurement and standards. Some of these detailed observations are noted within this report in the itinerary section (IV).

No country has progressed industrially with success without a well-built and well-kept measurement standards facility staffed with highly trained, well-motivated and well-compensated specialists of highest integrity. Their services are needed to provide a uniform, self-reliant national measurement system traceable to recognized international standards. They must provide calibration services to laboratories throughout the nation for: equity in retail markets; raw material discovery and selection; interchangeability of parts; industrial process control; quality assurance through testing of products for domestic and export trade; protection of home, work, and natural environments; the control and distribution of power; and so forth. Their services are also needed for providing training in measurement methodologies such as in the use of standard reference materials. Metrology today is as important in application of material and chemical sciences as in physical sciences. Despite considerable comprehension by the technical community, Pakistan today suffers losses from lack of standards in its industries, which will become ever more crippling without a major national commitment of effort and funds to standards and measurements based on know-how available internationally and in part already in Pakistan. Equally needed is a widespread understanding by industrial and political leaders, on whose decisions the rapid implementation of the NPSL plan depends. Success of the plan, of course, then depends on the careful selection of staff, good building design and modern instrumentation, good management and technical guidance, international cooperation, and above all, good interlaboratory cooperation and consultation within Pakistan. There is in Pakistan an unlimited scope for standards development work with economic benefit. The visiting team feels strongly that given a fair opportunity and the tools for such a laboratory, NPSL can become a major economic asset to Pakistan.

The visiting Survey Team acknowledges most gratefully the open discussions and friendly receptions throughout their stay in Pakistan.

II. INTRODUCTION:

BACKGROUND OF NBS/AID SUPPORT FOR STANDARDS IN DEVELOPMENT

A. General

Ten years ago, the U.S. State Department and the Agency for International Development requested the National Bureau of Standards to determine whether the expertise at NBS was relevant to development abroad and, if so, by what mechanism the transfer of experience to industrializing economies could be accelerated. At a seminar attended by more than a dozen developing countries and several international agencies, NBS was advised that:

1. An infrastructure in standardization including measurement technology is absolutely essential to development of any sort particularly when industrial projects are included.

2. Even though NBS is not primarily a teaching institution, this agency should give technical standardization support to AID's programs abroad.

During the following 10 years NBS, with partial support from AID and the developing countries themselves, has undertaken several kinds of well-documented experimental projects in standardization for development. For instance, representatives from several developing countries, including Pakistan, have taken part in workshops in which NBS organized an itinerary around the United States to show how standardization programs operate in the United States. Under another of these experimental projects, NBS has offered to put at the disposal of the government of a developing country for 2 full working weeks the knowledge and experience of up to 12 specialists in standardization topics chosen by the host government. These teams were organized by Mr. H. Steffen Peiser, Chief of the NBS Office of International Relations, and included highly qualified experts from third countries as well as from the United States. The Director of each NBS/AID Survey was always a highly placed standards official of the host country, who arranged for domestic counterpart team members and joint team visits to typical agencies, laboratories, industries, and universities for discussions on the availability or additional need for self-reliant standardization and measurement services in that country. In every one of these surveys, these team visits themselves led to a significant dissemination of opportunities and benefits from standardization.

B. Exploration of a Proposal for an NBS/AID Survey of Standardization and Measurement Services in Pakistan

Mr. Peiser took a special interest in a tentative approach from the Government of Pakistan concerning such a survey there. Through previous visits to that country, through management of a "special foreign currency project" at the Pakistan Institute of Nuclear Science and Technology (PINSTECH), and through his service as U.S. delegate to the CENTO Science Board, he had gained an admiration for the abilities, work ethics, discipline, and determination of Pakistani colleagues. He knew of the great needs of Pakistan for higher quality and standards for life. Therefore, Mr. Peiser made a preliminary visit to Pakistan in June 1978 in order to find out whether the Government saw an opportunity for such a survey and, if so, what would be the timing and topics of specialization chosen by the host government. On arrival Mr. Peiser was shown a most helpful working paper, which is here reproduced in full with minor editorial changes to help American readers:

WORKING PAPER FOR DISCUSSION WITH MR. H. STEFFEN PEISER IN CONNECTION WITH THE REQUIREMENTS OF THE NATIONAL PHYSICAL AND STANDARDS LABORATORY (PCSIR), ISLAMABAD

Correspondence initiated by the PCSIR Member for Technology on January 21, 1978, and later on taken up by the Chairman of PCSIR with Mr. H. S. Peiser, Chief, Office of International Relations, NBS, Washington, D.C., United States, has resulted in the visit of Mr. Peiser to Karachi for holding discussions on the above subject. Accordingly, meetings have been fixed at Islamabad, Lahore, and Karachi from June 24-28, 1978, in which relevant PCSIR scientists have been invited to express their views for proper planning of the NPSL.

In this connection, a draft working paper has been prepared for discussions. The broad methodology of setting up the NPSL, as suggested by various scientists, is outlined below:

1. Recruitment and training of the scientific staff in various fields, as provided in the PC-1. (Proforma and Feasibility Report Rev. January 1974, PCSIR copy available on request from NBS. An extract is reproduced in Appendix I.)

2. Possibilities of collaboration with similar international agencies, particulary with NBS.

3. Planning and setting up the Standards and Measurements Division and the Materials Division of the NPSL.

4. Building design with technical details for fittings and fixtures of various types of equipment.

5. Planning and ordering equipment for the workshop.

6. Apart from the building requirements previously spelled out, some of the rooms shall have to be made free from electromagnetic and electrical disturbances.

7. It would be valuable if Mr. Peiser could provide us the data on annual expenditure and income for such laboratories in the United States, United Kingdom, and a few developing countries.

8. Phased program for the years 1978-79 and 1979-80, equipment already available, and what has so far been achieved are summarized below:

First year 1977-78

i) Land has been procured; tenders for the construction of the boundary wall and for the architectural design of the NPSL building have been floated. The tenders would be awarded before June 30, 1978. Two Senior Research Officers and 4 Research Officers will also be recruited soon. The staff positions for the years 1977-78 and 1978-79 are shown below:

	Standards and Measurements Division		Materials Division	
	1977-78	1978-79	1977-78	1978-79
Director		1		1
C.S.O	-	-	-	1
P.S.O.	+1	1	+1	1
S.R.O.	1+1	2	2+1	4
R.O.	1+2	8	1+2	9
J.T.O.	-	3	-	2

+Means likely to join before June 30, 1978.

Program of Work

i) 1977-78

The equipment already available consists of two universal measuring machines for engineering products, two 20 kg secondary standard balances, a couple of top loading and one Sartorius balance for working/secondary standard weights. One working standard meter, a set of uncertified secondary standard French weights, one set of certified secondary standard weights manufactured by the Pakistan Mint, and some equipment for measurement of electrical parameters, e.g., resistance, inductance, and capacitance are also available.

Some reference standard weights, balances, volume measures, electrical equipment and slip gages have been ordered which are expected to arrive sometime in the middle of the financial year 1978-79.

1978-79

1. A comprehensive list of users and requirements of the country would be prepared after an international symposium on metrology with participation from developing countries in which experiences of the developing countries would be collected and used for forward planning of the NPSL.

2. Setting up of the Standards Division to meet the above requirements.

3. Planning and setting up of the Materials and Analytical Laboratory.

4. Starting construction of the NPSL building.

1979-80

1. Completing construction of the building, including fittings and fixtures.

2. Equipping of length and electrical laboratory.

3. Equipping of the Materials Division.

4. Equipping of the Workshop.

5. Production of working standard weights.

Research and Development (R&D)

In the PC-1 Proforma, the pattern of R&D in the Standards and Materials Division is of the order of 20 percent and 35 percent respectively, which would be followed in the NPSL.

Equipment and Training

Possibility of complete equipping of Standards or Materials Division and maximum training facilities may be discussed.

I. Training

The following training facilities are essential and help in this regard would be most welcome.

a) Physical Standards and Measurements Division

Six training facilities, one in each of the basic fundamental physical units with top priority on mass, length, and electrical standards and all related quantities, including instrument use, repair, design, and development would also be addressed.

b) Materials Division

1. Analytical methods.

2. Electroanalytical chemistry, including modern methods of instrumental analysis.

3. Chemical thermodynamics.

4. X-ray analysis.

II. Equipment

Approximately 40 percent and 20 percent of the equipment listed for the Standards and the Materials Divisions in the PC-1 shall be procured in the year 1978-79, keeping in view the following preliminary program of work which would be undertaken in the NPSL in the year 1978-79:

a) Physical Standards and Measurements Division

i) Maintenance of basic and primary physical standards and calibration of secondary standards.

ii) Advice on the standard practices for measurement.

iii) Development and production of secondary standards using facilities available in the country.

b) Materials Division

i) Determination and compilation of the physical, physico-chemical, and thermodynamic properties of materials, and providing information service on materials.

ii) Physical and physico-chemical studies of the surface properties of constructional materials.

iii) Research on the physical and molecular structure of the materials and development of special materials having specific properties for use in science and industry.

iv) Providing, after thorough research, authenticated and standard analytical methods for determining chemical composition of materials.

Dr. S.M.A. Hai, formerly of Yale University, now at the Pakistan Council of Scientific and Industrial Research, reported Mr. Peiser's visit fully. His text, with very minor editorial changes to conform with NBS style, is reproduced in full:

Mr. H. S. Peiser, Chief of the Office of International Relations, National Bureau of Standards, United States, arrived in Pakistan on June 24, 1978, at 1:45 a.m. He was received at the Karachi Airport by Dr. S.M.A. Hai.

Mr. Peiser and Dr. Hai left for Islamabad on the same morning by the 7:30 a.m. flight. From the airport, they went straight to NPSL to enable Mr. Peiser to take a look at the existing facilities in temporary quarters of the National Physical and Standards Laboratory at the Quide-e-Azam University.

After that, two sessions of discussions (one in the morning and one in the afternoon) were held at the Guest House of NPSL. The following were present:

Dr. A. Ghani, Chairman, PCSIR

Mr. H. Steffen Peiser, NBS

Dr. R. A. Shah, Director, PCSIR Laboratories, Peshawar

Dr. S.S.H. Zaidi, Controller of Weights and Measures, Government of Pakistan, Islamabad

Dr. M. Aslam Chaudri, Officer In-Charge, NPSL, Islamabad

Dr. Zafar Ahmed, Senior Research Officer, NPSL, Islamabad

Dr. Tayab M. Qurashi, Senior Research Officer, NPSL, Islamabad

Mrs. M. S. Khan, Research Officer, NPSL, Islamabad

Dr. S.M.A. Hai, Senior Research Officer (Officer In-Charge, Planning), PCSIR, Karachi

Mr. Peiser described the role of NBS as a national focal point for the science of measurement. As such, it has developed into the prime civilian "in-house" physical science laboratory of the U.S. Government and now also encompasses such areas as building technology, computer and engineering science, work on engineering and product standards, etc. The equivalence of the self-reliant missions of NPSL and NBS in their respective countries was discussed as were the international organizational links between such national standards bodies. NBS, for example, has cooperative activities with many other countries. A consensus was reached on the priorities for NPSL based on a previous survey of industry and government needs in Pakistan. Undoubtedly, NPSL, to start with, should ask for help with the realization of internationally agreed measurements for mass, length, time, temperature, and electrical and radiometric quantities.

Mr. Peiser advocated voluntary standardization for products and services, except where the safety and health of people were concerned. Even if Pakistan at this time has to enforce compliance with physical, engineering, or other standards, he felt that NPSL should not have a direct role in such regulatory surveillance, but should rather provide all interested parties with reliable technical services, including practical test methodologies. In many measurement processes, such as in the assurance of equity in the marketplace, mass, length, area, and volume are mostly concerned at a level of accuracy well below that to be achieved at NPSL. The accuracy inherent in the national standards can then be disseminated through several calibration levels in which some accuracy is lost. The Weights and Measures Department of the Ministry of Industry should play the key role based on top level calibration by NPSL. Occasionally, however, at some working levels in some industrial plants, highest accuracy will be needed, and NPSL must be well prepared to identify and serve directly such vital needs. This situation will be met more and more frequently as the industrial advancement of Pakistan continues.

Cooperation with NPSL and assistance from NBS was decided in the following areas, subject to concurrence by USAID/Islamabad:

1) Publication exchanges would include literature from NBS, the Journal of Research, "Dimensions," the basic metrology papers collected in SP 300, the U.S. national measurement system, the annual abstract booklet of NBS publications, model laws, the list of NBS standard reference materials, NBS publication list of volumes with standard reference data, etc.*

2) Invitation to the PCSIR to nominate one participant in the regional seminar organized with NBS at the new Korea Standards Research Institute (K-SRI) on the topic of "Metrology in Industry and Government--How to Find Out Who Needs What Services." This seminar will be followed by a tour of research and industrial facilities. Costs will be borne by K-SRI and NBS.*

3) Invitation to the Director of NPSL to participate in the NBS/AID Workshop on Standardization and Measurement Services as practiced in the United States to be held in the United States from October 8-21, 1978. The cost of travel and

*Implemented since.

subsistence in the United States will be borne by AID and NBS. International travel should, if possible, be provided by the guests.*

4) On receipt of an invitation, NBS will send an international team of experts, in subjects to be specified by NPSL, to survey the needs and delivery of metrological services to Pakistan industry and other governmental agencies from December 2-14, 1978. The program will include lectures, discussions, and visits to government agencies, universities, industries, and laboratories in the Karachi, Lahore and Islamabad areas. Costs will be shared between NBS, AID, and NPSL, the international travel being provided by NBS/AID.**

5) NBS can and will receive well-grounded and motivated NPSL staff members for research orientation at NBS in the field of physical standards in which they are to have leadership in Pakistan. Periods of training will vary from four to eight months with NBS providing guidance and facilities; cost of travel and subsistence being either borne by NPSL or by an international agency or by AID whose Mission in Islamabad will consider such an application by the PCSIR through the Government of Pakistan if a strong benefit to small-scale industry can be anticipated.***

6) Under the PL-480 program, NBS is prepared to consider research grants for cooperation in metrology which would satisfy the following criteria:

   a) Interest to NBS.

   b) Interest to NPSL.

   c) Competence of the scientists engaged in the project.

   d) A definite research result to be anticipated that would be in the interests of Pakistan.***

The Chairman thanked Mr. Peiser for his visit and discussed with him the challenges faced by the scientific community in Pakistan. Recognition of the need for science as a vital and indispensable element in development was not widely appreciated in practice. Funds and other support were sometimes very hard to get.

Mr. Peiser was of the opinion that these problems are not unique to Pakistan, even if there they are present to a high degree. Nevertheless, it was agreed that we must go forward with confidence. The rational order was to hire the right technical staff,

*Implemented since.
**Implemented and the subject of this report.
***Not yet implemented.

to choose the instrumentation, and then to finalize the construction plans. Mr. Peiser visited the U.S. Embassy and USAID in Islamabad to give a brief summary report on the plans for NPSL and possible NBS cooperation. The attitude in both places demonstrated an interest and seemed generally favorable and supportive.

Mr. Peiser informed PCSIR that Mr. Frank Trippett, the Science Officer at the U.S. Embassy, is the best contact for PL-480 projects and that Mr. Walter Stettner, the Senior Officer In-Charge of the Economic Section of USAID/Islamabad, would guide any AID support for NBS/NPSL cooperation.

A luncheon was hosted by the Chairman of PCSIR at which Dr. Nisar Ahmad, Additional Secretary of the Ministry for Science and Technology, was also present. Before departure from Islamabad, informal discussion with Drs. M. A. Chaudri, Z. A. Khan, and M. M. Qurashi helped to reemphasize the desirability for assistance in ordering equipment. Mr. Peiser thought Dr. R. C. Sangster might be available for a consultation visit to Pakistan in August or early September 1978. Moreover, attention was given to desirable lecture topics to be presented during the NBS/AID/PCSIR Survey of Metrology Services in Pakistan as follows:

1) Realization and calibration against fundamental (reference/prototype) standards of measurement, viz., for mass, length, temperature, electrical standards, luminosity, time, and derived units.

2) Electrochemical studies/techniques as applied to:

   (a) Corrosion studies and its remedy.
   (b) Production of pure metals.

3) General talk on production, maintenance, and tests involved for standard reference materials (SRM's).

4) Calibration of the instruments involved in instrumental analysis, viz., IR, UV, visible light spectrophotometers, emission spectrophotometers, etc.

5) Ultrasonic and far infrared studies.

Mr. Peiser referred back to a previous discussion with Dr. S.S.H. Zaidi, Controller of the Ministry of Industries, at which the priority subjects for the Survey were agreed, namely:

1) Mass
2) Length and Interferometry
3) Electrical Standards
4) Time and Frequency Standards

5) H.V. (High Voltage) Measurements
6) Radiofrequency and Microwave Measurements
7) Thermometry
8) Optical Radiometry
9) Optical Instrumentation
10) Solid State Physics

This list would be shortened by those topics in which the responsible NPSL officers could not be appointed before the end of October. Even so, Mr. Peiser was very doubtful whether these topics could all be effectively included in the survey program.

At Lahore, Dr. Hai and Mr. Peiser were received by Dr. M. Hanif and taken to the PCSIR Laboratories, where the Director, Dr. M. K. Bhutty, personally summarized the work of all seven divisions which Mr. Peiser was able to visit briefly three and a half years after a similar previous laboratory tour. He expressed admiration for the variety of significant projects of economic, social, and technological potential on which work was proceeding at these laboratories with most creditable results in some fields. In more informal conversation, Mr. Peiser felt that the inspirational scientific leadership in this institution was a significant factor in its remarkable success. Mr. Peiser insisted it be recorded that he thought Pakistan's development depended on continued improvement in facilities and status recognition and rewards for scientists in PCSIR Laboratories.

PCSIR Headquarters Meeting, June 27 & 28, 1978,
on Programs for NPSL; Tentative Agenda

June 27, 1978

1) Report of Visits to Islamabad and Lahore.

2) General Impressions.

3) The Mission of NPSL and the Survey of Needs for Physical Standards Services.

4) The Role of NBS in the United States.

5) NBS Programs Relevant to NPSL.

   a) Surveys
   b) Workshops
   c) Regional Seminars
   d) Guest Workers
   e) PL-480

6) Construction for NPSL.

7) Staffing of NPSL at Home and Abroad.

8) Equipment

   a) Ordering
   b) Maintenance
   c) Spare Parts
   d) Calibration

9) UNCSTD

10) International Organization for Legal Metrology - BIPM - UNESCO - CENTO - ADB

11) SRM - SRD; Important Functions at NPSL

12) The Role of Enforcement

   a) Traceability to National Physical Standards

   b) Compliance with Standards (for products, exports, imports, safety, test methods, etc.)

13) Any Other Business

14) Summary of Agreed Program Elements

At the Karachi headquarters of PCSIR, in the NPSL Meeting the following were present:

Mr. H. S. Peiser
Mr. M. Aslam
Dr. M. M. Qurashi
Dr. R. A. Shah
Dr. S.S.H. Rizvi
Dr. M. Hanif
Dr. M. Aslam Chaudri
Dr. B. Farooqi
Dr. S.M.A. Hai

After a brief diversion on calorific gas generation from biowastes, the tentative agenda were adopted. The summary of the visits to Islamabad and Lahore was followed by Mr. Peiser's general impressions, which centered around the conviction that a focal point for physical measurement standards was absolutely essential though, of course, not the sole element for industrial development. How else can one hope to select consistent raw materials, control production processes and assure oneself of quality of products? Mr. Peiser founded his confidence that Pakistan was capable of rapid development for the betterment of all its people on the vast natural and human resources, the work ethics, the scientific leadership, and other factors.

The meeting continued to discuss the mission for NPSL and the history of the plans which originally included two more divisions. All agreed that regulatory authority and enforcement of engineering standards, however important, should not be a direct responsibility for NPSL.

The experience with the role of NBS was described by Mr. Peiser, and then the meeting reaffirmed the approbation of PCSIR of the above-mentioned projects, namely the survey, workshop, regional seminar, and guest assignment to NBS and other national institutions. Well-qualified staff would be sent for four to eight months as trainees for their intended responsibilities at NPSL. Mr. Peiser would assist in referring PCSIR to the best institutions in Australia, Czechoslovakia, Italy, and Yugoslavia.* The meeting questioned the attraction of PL-480 grants, but Mr. Peiser felt that NPSL might receive benefits not readily provided otherwise.

It was readily decided to postpone construction in favor of the sequence preferred by the Chairman, but considerable discussion ensued on the desirability of east-west orientation of the building and other devices to avoid uneven heating by the sun.

Staffing for NPSL would now proceed with great rapidity. Mr. Peiser advised high standards and selectivity but also felt that Pakistanis abroad should be given attractive opportunities to return at least for a trial period to work for the NPSL, possibly on fellowships from the U.N. or other international agencies. It was made quite clear that in the modified plan for NPSL, the prime national responsibility for instrument maintenance and repair would not be placed in that organization, but nevertheless, the problems of choice, etc., of the equipment for NPSL were of major importance to be considered immediately by the staff after recruitment. There followed a discussion on expression of interest in cooperation, possibly under the PL-480 grants in standard reference material programs, which were to be an important feature of NPSL programs.

Fund estimates for NPSL may have to be revised upwards, especially by comparison with the Korean expenditures for an analogous program, but U.N. agencies (such as UNESCO) or USAID or the Asian Development Bank might be expected to be interested in supporting NPSL if the plans are further elaborated with foresight.

On June 28, the meeting started on the agenda, item 8, concerned with equipment. The following were present:

*In which countries some funding had been offered to Pakistan.

Mr. H. S. Peiser
Mr. M. Aslam
Dr. M. M. Qurashi
Dr. R. A. Shah
Dr. S.S.H. Rizvi
Dr. M. Hanif
Dr. M. Aslam Chaudri
Dr. B. Farooqi
Dr. S.M.A. Hai

The list of items to be ordered immediately was scrutinized in full realization that the majority of equipment purchases are deferred till later fiscal years, that is, after the responsible officers of NPSL have given detailed consideration of their carefully considered requirements. The items to be ordered now include only general purpose equipment which will prove necessary without question. A lively debate centered on the question of weight sets needed for NPSL. Mr. Peiser's original idea of ordering only a few mass standards seemed not practical because of emergency and limited capacity of calibrating intermediate weights. In general, Dr. M. M. Qurashi favored duplicate sets, at least one of which should be with certified values.

The meeting was well aware that one-piece weights were preferable but might be more expensive.

Turning to maintenance and spare parts of the PC-1 plan,* it was generally agreed that we may not have made adequate provisions, especially for the hard currency components. It was the consensus of opinion that in the future we will have to increase this allocation by at least a factor of 2.5.

The internal calibration procedures should be left to the carefully considered discretion of the scientists in charge, since it was impractical to lay down a standard calibration interval.

Mr. Aslam described his contribution in the Pakistani planning for the U.N. Conference for Science and Technology for Development. His own article was concerned with transfer of technology. A similar paper was written by Dr. M. M. Qurashi on appropriate technology. The draft paper of Pakistan, prepared by the Ministry of Science and Technology, would not make a specific recommendation of a National Capability in Metrology, but made several strong points on this type of infrastructure, e.g., for quality control of products. Mr. Peiser described briefly the serious concern of the United States to make a meaningful and constructive contribution to that Conference. Mr. Peiser assured us that the United States would propose to recommend measures to support the development aims of the less industrialized regions of the world.

*See Appendix 1.

On the topic of OIML (International Organization for Legal Metrology), Mr. Peiser described the increasing significance of that organization's intent to establish internationally recognized measurement procedures for all commercial transactions, including international trade. From the almost 200 committees and subcommittees of this organization, much could be learned by NPSL. Besides, that organization was making a special effort at this time to become more relevant to third world countries. The meeting recommended that consideration be given to the possibility of Pakistan through NPSL joining that organization. Their address will be sent to us by Mr. Peiser.

Item 11

Mr. Peiser described the critically evaluated commercial data collected by NBS and associated by other national organizations under the SRD program. There was a likelihood of NPSL being able to benefit from these programs and eventually contribute to them, possibly under the PL-480 program. The discussion then turned to other sources of information of possible interest to NPSL, such as ISONET (International Organization for Standardization Information Network), NTIS (the U.S. National Technical Information Service), and systems such as MEDLINE (Medical Information by Title and Abstract).

Item 12

Further mention was made of the advice NPSL would be expected to provide to organizations such as the Pakistan Standards Institute and the Central Testing Laboratory on test methodology by which compliance with product standards could be established.

The meeting came to an end by a note of thanks to Mr. Peiser from Mr. Aslam on behalf of PCSIR. Mr. Peiser expressed similar sentiments. There was a commitment for continued collaboration and understanding.

There was also a general consensus that Mr. Peiser's visit to Pakistan has been quite useful in streamlining the future line of action for implementing the scheme for NPSL.

Mr. Peiser flew back to the United States on June 29, 1978, at 3:40 a.m. by Pan Am. He was seen off at the airport by Dr. Hai on behalf of PCSIR.

C. The Survey and Its Teams

Implementation of item 3 (p. 9) brought Dr. M. M. Qurashi, Director General for Appropriate Technology Development Organization, to NBS in October. His return to PCSIR as NPSL Director was the aim but not yet approved (c.f., Section IV.B). He attended the NBS/AID Workshop on U.S. standards and measurement practices. He also contributed to an NBS Seminar preparatory to UNCSTD on the Technological Knowledge Base for Industrializing Countries and met with persons responsible at NBS for laboratory construction and maintenance in preparation for the design and construction of new NPSL facilities to be constructed in Islamabad. Most importantly, Dr. Qurashi informed us that plans for the NBS/AID Survey of Standardization and Measurement Services were going forward. We should aim for two weeks in January 1979 and plan to include a slightly smaller survey team than had been involved in similar surveys of other countries. The official invitation from the Government of Pakistan could be expected shortly. Thus, Mr. Peiser initiated corresponding U.S. clearances and chose the following team in conformity with the topics which were chosen in further correspondence by Dr. Abdul Ghani, PCSIR Chairman.

1. Mr. Cyril H. Dix
   Head, DC/LF Measurement Group
   Division of Electrical Science
   National Physical Laboratory
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2. Mr. Hugh Lionel Kingsley Goonetilleke
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6. Dr. John K. Taylor
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   Voluntary Standardization Activities
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For the record, it should be said, because their titles do not indicate the following distinctions: Mr. Dix, besides heading one of the world's best-known low frequency electrical measurement groups, has professional experience in electronics and radiofrequency measurements. Mr. Goonetilleke has been a leader in OIML committees concerned with development and is a coordinator of the U.K. Commonwealth Science Council's S.E. Asia Metrology Program. Dr. Heydemann was formerly head of the NBS work on pressure and vacuum measurements and then the Program Office. Dr. Kim brings with him the experience of the establishment of a national measurement system with a central metrology facility in another developing country. Mr. Peiser has observed industrial growth in several countries. After 40 years of service, Dr. Taylor is the dean of scientists at NBS and unexcelled in experience in analytical chemical methodologies. Biographical sketches of these team members are given in Appendix 3. The Pakistan counterpart host team which toured with the visiting team was twice as numerous, and at each center, it was further reinforced by regional team members. Dr. Abdul Ghani, PCSIR Chairman, was Survey Director and personally led the team, encouraging all programmed, as well as several additional improvised, activities.

SURVEY TEAM MEMBERS FROM PAKISTAN

Dr. Khurshid Ahmad, PCSIR, Karachi
Dr. M. Aslam, PCSIR Member, Technology
Dr. M. Khurshid Bhatty, Director, PCSIR, Lahore
Dr. A. B. Chaudhary, PCSIR, Lahore
Dr. M. Aslam Chaudhari, NPSL, Islamabad
Dr. Abdul Ghani, Chairman, PCSIR, and NBS/AID Survey Director
Dr. M. Hanif, PCSIR, Lahore
Dr. S. M. Abdul Hai, PCSIR, Karachi
Mrs. M. S. Khan, NPSL, Islamabad
Dr. A. A. Khan, NPSL, Islamabad
Mr. Niaz Mohammed, PCSIR, Peshawar
Dr. M. M. Qurashi, Chairman, Appropriate Technology Development Organization, Islamabad
Dr. S. A. Qureshi, PCSIR, Lahore
Dr. Tayyeb M. Qureshi, NPSL, Islamabad

Dr. S. Sadrul Hasan Rizvi, PCSIR, Karachi
Dr. R. A. Shah, Director, PCSIR, Peshawar
Dr. S.S.H. Zaidi, Controller of the Department of Weights and Measures, Islamabad

In briefing the team members from abroad and explaining their terms of reference, Mr. Peiser wrote in part:

> From January 12 (latest arrival in Islamabad) to departure from Pakistan on or after January 25, we agree to place ourselves, our technical experience, and our efforts at the disposal of the Pakistan Council of Scientific and Industrial Research . . . .
>
> Our assignment is not necessarily confined to NPSL, and I like to feel that the Government of Pakistan generally and other institutions in particular, including PCSIR laboratories, will want to make contact with us. Also included may be the Pakistan Science Foundation, the National Science Council, the Pakistan Industrial Technical Assistance Center, and others. Dr. Ghani will no doubt explain to all officials we meet that we are simply persons with some technical knowledge in some of the fields he and his colleagues have indicated to us are of special priority. We have no political, financial, or economic function. Technology and specifically standardization are, in our opinion, a necessary ingredient for development, but there are other factors that are equally relevant. We do not claim to address them. One of these is the cultural base in Pakistan of which I for one am unfortunately rather ignorant. Now, I do not believe this is a serious handicap because development, in my opinion, depends on choices being resolutely made from within a culture. I know enough about Pakistan to be deeply impressed by its natural and human resources. I believe there are strong indications of self-discipline, a good work ethic, and a sense of combined purpose and idealism, both religious and secular, all of which gives the opportunity for the Pakistan leadership to move that country forward in a self-reliant way.
>
> Do not please believe that our task is an easy one. I know we will be deeply moved or even shocked by the poverty we will see, by primitiveness of some of the industry, by the lack of resources in some of the few existing laboratories, by lack of knowledge in some places, and--almost worst--by belief that we come with specific detailed solutions when our answers will only point the way to how our Pakistan friends can themselves start to acquire a stand-alone capability.
>
> I believe we will be met with respect and personal friendship everywhere, but should, in one place or another, some hard feelings erupt against us as representatives of "rich" nations, let us be understanding and listen. The recent history of Pakistan has been sadly frustrating. We share the hope for happier days ahead. . . .

. . . Each of us will have a Pakistani technical counterpart officer to whom we try to transfer as many of our thoughts and ideas as is practical. Dr. Ghani will also introduce us to high Pakistan Government officials. This is not just a formality. It is difficult in all our countries for our political and administrative leaders to comprehend fully the need for a self-based infrastructure in science and technology, including standardization. How often have I heard, "Standardization is a key element in advanced technology and for a competitive consumer market, but standardization surely does not pertain to small-scale industry in a less developed country (LDC)." As long as this widespread false picture persists among political and industrial leaders of LDC's, all development plans will end in ruinous failure. We know that, but that does not help Pakistan, unless by patient rational argument we can convince our hosts and those determining Government science policy.

The same applies at the small industrial plants and village-level manufacturing groups, a few typical ones of which we hope to visit as the Survey Team splits up into its subgroups . . . his (Dr. C. K. Kim) special advice is needed from his knowledge of technology in a highly industrialized country and of a standards institution in a rapidly industrializing country. I hope he will attach himself from time to time to several of the other groups and write a note at the end on what opportunities he sees for NPSL to effectively cater for the near-term needs of industry and the Government. In this and in all our report, which I hope we will write within four to six months after completion of the Survey, we will aim to be constructive, but when we have to be critical to be helpful, we will not evade our responsibilities of being entirely honest with understanding. By that, I mean particularly that we never conclude, "The Government must do this or that," but rather, "If the Government were to choose to do so and so, the following benefit would be expected."

Visits should almost certainly be included to the PCSIR Laboratories at Karachi, at Lahore, and at Peshawar; the Atomic Energy Research group working on trace element analysis; and the universities. As program manager for the "Special Foreign Currency Program" of the National Bureau of Standards, I will incidentally be looking out for possible opportunities for research grants of interest to NBS technical projects which can be assisted by Pakistani scientists working in their own institutions and for carefully evaluated interests of Pakistan. . . .

Each of us is likely to be asked to give at least one technical lecture to a slightly wider technical audience. Please indicate the title at your early convenience. . . My title will be "The NBS U.S. Infrastructure Laboratory in the Physical Sciences." My spare optional title will be "Symmetry in Art and Science."

I do not believe there are any extraordinary health hazards to which we will be exposed. However, you may wish to consult your medical officer before departure also to help with any required or recommended injections, vaccinations, or medications. . . .

Pakistan is a beautiful country, rich in history and historic sights. The people have a great loyalty and an ability to accept scientific education to the highest academic levels of distinction. I know many will be our friends before we leave. So it is my New Year wish to you that this Survey will start 1979 for you with an enjoyable and fruitful work assignment.

In preparation for the Survey, Mr. Peiser distributed to the Survey Team members diverse background literature including, for example, Dr. M. Aslam's paper on a "Technology Delivery System."

III. Conclusions, Recommendations, and Some Notes from Lectures By Visiting Team Members

A. The Visiting Team's Letter at the End of the Survey to the PCSIR Chairman

Dr. Abdul Ghani, the Survey Director, pointed out that the benefits from the Survey lay not only in the many individual visits and discussions, but equally in the report that could be widely circulated. He was concerned with the long estimated delay in publication and requested an immediate summarizing letter to be delivered to him at the conclusion of the Survey. In it the team members tried to give a clear indication of their impressions of standardization and measurement technologies in Pakistan. The letter addresses the present state of development in these fields, the relevant needs and opportunities, and the mechanisms for achieving the most important objectives for the economic, industrial, or social development in Pakistan. This letter is here reproduced in full:

24 January, 1979

Dear Dr. Ghani,

The visiting team of technical specialists from abroad has spent two weeks in discussion under your guidance with Pakistan counterpart experts visiting governmental and industrial institutions on the subject of physical, chemical, and engineering measurement standards. We, the visiting team members, hereby report initial, tentative conclusions to be followed in about three months by a full report. As you are aware, this Survey of the needs for measurements in Pakistan was organized by the U.S. National Bureau of Standards, jointly sponsored by the U.S. Agency for International Development and your Pakistan Council for Scientific and Industrial Research under the Ministry of Science and Technology Research of Pakistan. The team is deeply appreciative of the Minister's personal encouragement, the interest also shown by the Additional Secretary, Dr. Nisar Ahmad, the support of the USAID Mission Director, and the enthusiastic cooperation of a very large number of leaders in Pakistan. Above all we admire your personal involvement throughout the Survey. Special acknowledgment must also go to the governmental organizations of Great Britain, Korea, and Sri Lanka who made expert team members freely available to this Survey.

A central national technical capability in measurement science and technology exists in all industrialized and many less developed countries of the world. In recognition of an urgent, important, and now widely accepted need, the team strongly concurs with the Pakistan Government's decision to inaugurate, fund, and give on-going support to the National Physical Standards Laboratory of the PCSIR.

Measurement capability is needed equally for raw material discovery, evaluation and selection; for industrial process control; for quality assurance of products; for the rule of equity in domestic and international markets; for protection of the work and home environment; for the enforcement and demonstration of compliance with regulations; for the delivery of health services; the evaluation of soils; the control of power sources; the operation of transportation and communication systems; etc. Measurement capability is indispensable for higher technologies, such as a significant domestic instruments industry and the reception of modern technologies. A study in the United States has assembled convincing evidence that, there at least, measurement-intensive industries outpace others in growth. Similarly, some rapidly advancing third world countries are the ones with strong measurement programs.

A national center for measurement science and technology can serve its nation in the following ways:

1. It is equipped and staffed to maintain national measurement standards and to disseminate the accuracies inherent in them to provide uniform, compatible, internationally recognized measurements.

2. It develops, implements, and consults on test methodologies in conformity with engineering, product, safety, and process standards.

3. It advises and acts as technical referee to maintain order in domestic and international markets; for instance, to verify compliance with standards, specifications, codes, or contracts.

4. It acts as national focus for knowhow, training, and international contact in quantitative measurements at or near the highest attainable accuracy.

5. Through professional societies and seminars, it introduces a nationwide awareness of the discipline of measurement control so essential in modern science and technology.

It is the unanimous opinion of the visiting team that development of Pakistan would benefit significantly from the availability of the following:

1. One effective focal point for self-reliant measurement science and technology in contact, abroad, with other national and international metrology centers, and at home, with all institutions and companies where good measurements are needed.

2. Extension, information, coordination, and training services to disseminate a widespread awareness of the need for good measurement controls. The aim would be to develop an appreciation for good "housekeeping" and reliable records of test, for the limited constancy of standards and instruments calibrations, and for the dangers from buildup of small errors to damaging, unforeseen departures from planned operations.

3. Analysis of the savings that could be achieved by avoiding ineffective calibrations using some instruments badly or relying on instruments with unjustified confidence. They have the result of escalating costs of non-interchangeability of parts, industrial rejections, and waste. The cost to Pakistan of NPSL probably would be far less besides enabling the country to export more goods and produce higher technology products.

To perform the relevant functions adequately in Pakistan, NPSL will need excellent facilities and outstanding staff. In the opinion of the visiting team, the choice of a modest building site located in Islamabad is endorsed provided continuing contacts, advice, and consultation are sought from industrial regions of Pakistan and also from institutions such as the PCSIR Instruments Center, the Pakistan Standards Institution, and the Central Testing Laboratories, all of which have missions closely related but different from NPSL. The move from the temporary quarters at the Quaid-e-Azam University in Islamabad can proceed as construction permits. This work should be started urgently.

The selection and training of staff presents greater problems. The work of NPSL could become effective more rapidly if carefully selected staff members could be given assignments to other national centers abroad such as NBS. NPSL management should develop a comprehensive training plan possibly with the help of the U.N., the World Bank, or other assistance organizations such as AID. The success of NPSL would also be accelerated by attracting highly qualified Pakistanis abroad, temporarily or permanently, to participate in the institution building task. The team believes that competitive remuneration is a necessary but not even sufficient condition. What Pakistanis need to be shown is a national commitment to the scientific method and technological advancement that will make their specialist knowledge relevant to the developing society. In general, most of the staff at NPSL must feel attracted by the employment conditions for a successful standards measurement laboratory.

Adoption of a particular program structure for NPSL may facilitate planning and budgeting. NBS has found a procedure useful which is presented here as one of several alternatives:

1. All work is divided into tasks of suitable size. The output from all work within one task should be closely related. For example, all temperature measurement work could form one task.

2. To form a task:

    (a) A problem area is selected.

    (b) The contribution that NPSL can make towards the solution of the problem is defined.

    (c) A plan of action with milestones for the next several years is developed, the needed resources estimated, and the available manpower assessed.

    (d) The probability of success, services delivered to industry, relation to other activities at NPSL or elsewhere, and the enhancement of staff expertise is evaluated.

All tasks are arranged in priority order. The currently available funds are assigned to the tasks of highest priority. New funds are requested, at the Director's discretion, for tasks not currently funded but found to be important.

In addition to the continuous supervision by the line management, all established tasks are reviewed annually by the Director, his senior staff and are conveyed to an advisory board of experts from industry and the universities. Progress towards the accomplishment of previously agreed milestones is checked and future objectives are adjusted accordingly. Judicious changes are made in the priority ordering of currently funded tasks.

All accounting, including the personnel cost, is by task. This allows the Director at any time to display the expenses incurred towards the accomplishment of the various tasks and to compare this with the expected benefits or with the level of services currently provided to the Nation's industry, universities, and Government agencies.

In summary, the team therefore suggests that some desirable functions of NPSL are:

1. Provision of internationally traceable national primary standards maintained under excellent and fully documented conditions.

2. Dissemination of their accuracy through a calibration service.

3. Accreditation of lower-level laboratories for calibration.

4. Spreading education and awareness of metrological practice through contacts with industry, seminars, attachment of industrial personnel, etc.

5. Provision of guidance publications.

6. Maintaining liaison with other national laboratories, both directly and through the International Bureau of Weights and Measures (BIPM), and other international organizations.

7. Provision of an advisory service on measurement problems to industry, universities, and Government.

The team conveys to you, Dr. Ghani, the sincere hope that this Administration in Pakistan will come to the equivalent conclusion reached by the U.S. Congress when it was faced with an unprecedented expansion of industry. It was then stated that no more important need for national development existed than the creation of NBS. When you search, probably in vain, for the factory, the office, the defense, or regulatory agency in the United States that does not acknowledge or defer to NBS for some vital service, you must conclude that the U.S. Congress showed wisdom and foresight.

With profound gratitude and good wishes to you, NPSL, PCSIR and Pakistan,

Sincerely,

(signed)

Cyril Dix, Hugh Goonetilleke, Peter Heydemann, Chul Koo Kim, Steffen Peiser, and John K. Taylor

B. Mr. Cyril H. Dix's Contribution

In addition to this joint letter, each team member made a brief closing statement which, for the purpose of this report, he was encouraged to expand using material from the lecture he had given during one of the special evening sessions.

First by alphabetic order was Mr. Cyril H. Dix, who talked on "Electrical Standards--the Need in Pakistan."

Electrical Standards--the Need in Pakistan

The needs in Pakistan are of three types. First, there is a need for a wider and better appreciation of the need for standards. The conclusion reached from very many of the visits made was that not only were there no adequate standards and that the personnel concerned did not know how to make the best use of the facilities they had, but also that they did not appreciate that they had any need for standards at all or how these would improve the quality or value of their output. The first and most important need in this respect in Pakistan, therefore, is to spread an awareness of the need for good measurement and the benefits it will bring to quality control, acceptance of the product, amelioration of manufacturing difficulties, etc.

The second need is again an educational one: to provide the knowledge of how to make the best use of whatever facilities may exist and to appreciate what other facilities are necessary and how they in turn should be used. In many cases, it had been observed that the confidence in measurement could have been greatly improved by the designation of particular roles to particular items of equipment and by systematic cross-checking, linearity checking, etc.

These two needs for education are two areas in which the new National Physical and Standards Laboratory should and could play a major role. This could be done by publications, holding of courses, and arranging lectures throughout Pakistan.

The third need, of course, is for material standards. At the present time, the need in Pakistan is not for the highest accuracy that could be achieved, but for the provision and dissemination through a calibration service of standards which would be identified as the national reference. However, there is not much to be saved by setting up standards which are substantially lower than the state of the art, and in any case, it is to be expected that advancing technology will in the not too distant future require a measurement capability as good as can be realistically achieved.

The national standards must have international traceability so that measurement derived from them will be accepted in any part of the world. This is achieved by having certain primary standards of resistance, voltage, capacitance, and inductance which are related by intercomparisons to those of other countries. In addition, a large quantity of measuring equipment to provide derived standards is needed to cover all the practical calibration needs. A series of lists of equipment, which has been found suitable for this and which is suggested as a nucleus, has been supplied to the Chairman. (Copies of these lists follow.) To define the needs in much more detail would need a considerable study, but as an approximate indication, the capital cost of this equipment is approximately £100,000; the laboratory space required would be approximately 200 square meters; and the staff needed to maintain it and operate a calibration service would be 5/6 scientists or engineers of varying grades.

TABLE 1 D.C. VOLTAGE

Ref V	Item	Manufacturer	Model	Qty	Price in U.K. Currency	
V.1	Primary Reference Groups of 12 Standard Cells	GUILDLINE	9152T/12	2	1,700	C but can be calibrated from V.2
V.2	4-cell Transportable standard	ELMEASCO	700A-04	1	1,100	C
V.3	Vernier Potentiometer	H Tinsley	5590C	1	1,500	B
V.4	Null detectors	Keithley	150B	2	2,500	
V.5	Volt ratio box	H W Sullivan	T2100	1	2,500	B
V.6	D.C. Voltage Calibrator	John Fluke	335A	1	3,700	
V.7	Digital Voltmeter	Solartron	7075	1	1,800	B
V.8	High voltage divider	Mann components	Special	1	1,500	C
V.9	High voltage generator	Hunting Hivolt		1	3,000	
			TOTAL		£19,300	

TABLE 2 RESISTANCE

Ref R	Instrument	Manufacturer	Model	Qty	Price in £	Notes
R.1	Primary reference group 100 Ω STANDARD RESISTOR	H Tinsley	NPL Design	5	£1,500	C Also used as A.C. resistance standards
R.2	10 Ω STANDARD RESISTOR	"	"	2	500	C Subsequently calibrated in-house from R.1
R.3	1 Ω " "	"	"	2	500	C
R.4	0.1 Ω " "	"	Class S	2	300	C
R.5	1kΩ " "	"	NPL Design	2	500	C
R.6	10kΩ " "	E.S.I.	SR 104	2	2,500	C
R.7	100kΩ " "	Welwyn Elec. Co.	498500	1	300	C
R.8	10 x 100kΩ Divided megohm	Mann Components		1	500	C
R.9	10 x 1MΩ Divided 10MΩ	" "		1	500	C
R.10	10 x 10MΩ " 100MΩ	" "		1	500	C
R.11	Oilbath	Grant	As supplied to NPL	1	7,000	
R.12	25 Ω Standard Resistor	H Tinsley	NPL Design	2	500	C
R.13	Resistance measurement bridge	E.S.I.	242D	1	8,400	
R.14	Multi-function digital meter	Solartron	7075	1	-	Used for low level calibration. Identical with V.7
R.15	Secondary (Precision grade) Resistors	various available	-	12	600	For use in calibration
R.16	Decade resistance boxes		-	4	200	
				TOTAL	£24,300	

TABLE 3 REACTANCE

Ref X	Item	Manufacturer	Model	Price	Qty	Notes
X.1	Air-bath Capacitance Standards 10pF	General Radio	1408	£5,100	1	C
X.2	" " " " 100pF	" "	1408		1	C
X.3	1nF Capacitance Std	" "	1404/97C1	600	1	C
X.4	1pF " "	" "	1403	300	1	C
X.5	10pF " "	" "	1404/97C3	600	1	C
X.6	100pF " "	" "	1404/97C2	600	1	C
X.7	Capacitance Measuring System	" "	1621	9,000	1	
X.8	1µH Inductance Std	E W Sullivan	R190/1		1	C
X.9	10µH	"	R1901		1	C
X.10	100µH	"	R1910		1	C
X.11	1mH	"	R1920	2,000	1	C
X.12	10mH	"	R1930		1	C
X.13	100mH	"	R1940		1	C
X.14	1H	"	R1950		1	C
X.25	Measurement Bridge	Wilmot Breeden (Wayne Kerr)	B331	3,200	1	C
X.16	0.1µF Capacitance Std	General Radio	1409T	300	1	C
X.17	1µF " "	" "	1409Y	300	1	C
			TOTAL	£22,000		

TABLE 4 ALTERNATING VOLTAGE CURRENT and POWER

Ref A	Item	Manufacturer	Model	Qty	Price	Notes
A.1	Thermal Transfer Instrument and Current Shunts 10mA to 10A	John Fluke (U.K: Fluke International)	540B	1	1,900	C
A.2	A.C. Calibration Source and Amplifier	"	5200/5205	1	7,600	
A.3	True r.m.s. Digital Voltmeter	DATRON	1041 Option 0.1			Calibrated from A1 and A2
A.4	RF Voltage/Power	Rohde & Schwarz	NRS	1	2,000	Calibrated from A1 and A2
A.5	8-decade inductive voltage divider	H W Sullivan	F9200	2	3,000	B
A.6	Non-reactive decade resistance box	H W Sullivan	AC 1049	2	800	B
A.7	Electronic Null detector	General Radio	1232A	2	1,400	
A.8	Watt convertor	YOKOGAWA			2,000	C
A.9	Non-reactive load resistor (100V/2A)	TINSLEY			500	B
A.10	Power Amplifiers	To be advised at time of purchase			1,000	
				TOTAL	£21,400	

TABLE 5 R.F. PARAMETERS

Ref F	Item	Manufacturer	Model	Qty	Price	Notes
F.1	Frequency Counter	Hewlett Packard	5342	1	2,500	DC to 18 GHz
F.2	Frequency Receiver or Atomic Standard			1	10,000	
F.3	Signal Generator	Marconi Instruments	TF2006	1	500	4MHz to 1 GHz
F.4	Swept Source	Hewlett Packard	8620	1	10,000	2GHz to 18 GHz plug-in
F.5	SWR Auto-tester	Wiltron	97A50	1	500	10MHz to 18 GHz
A4	Power Meter	Ronde-Schwarz	NRS	1	-	Included in Table 4
F.6	Power Meter	Hewlett-Packard	436	1	1,500	With diode mount, used for attenuator calibration
	Fixed Attenuators 1, 3, 3, 6, 10, 20db				3,000	
	Cables and Connectors					
				TOTAL	18,000	

TABLE 6 TEMPERATURE MEASUREMENT (for electrical standards)

Ref T	Instrument	Manufacturer	Model	Qty	Price	Notes
T.1	Resistance Thermometry Bridge	H Tinsley	5840	1	2,500	NPL design. Use R.12 as standard
T.2	Platinum Resistance elements	H Tinsley		4	200	C
T.3	Mercury-in-glass Thermometers	Zeal		6	200	C
T.4	Recording Thermographs/ Hydrographs	Negretti & Zambra		4	400	
T.5	Triple point cell (water)	NPL		1	200	C
T.6	Triple point cell (diphenyl ether)	NPL		1	200	C
				TOTAL	£3,700	

NOTES

1. It should not be generally inferred that any equipment listed is uniquely adequate for its task, although in some cases we believe this to be true. This is only a list of items which we at NPL in the United Kingdom have found from our own (and sometimes other people's) experience to be adequate.
2. The letters B and C in the Notes column indicate that these items could appropriately be purchased with BCS(B) or NPL(C) Certification, and we would recommend that this be done.
3. Items X1, X2, V2 and R1 (two out of five) should be recalibrated by BIPM or an established national laboratory periodically. It would be desirable that this should also be done with X3, X17, and that inter-comparisons should be made with other national laboratories when possible.
4. There will also be needed a quantity of minor materials and instruments for general support, e.g., multi-range meters, an oscilloscope, terminals, switches, etc., which are not included in the list.

Table 7 Measurement Capability

QUANTITY AND RANGE	FREQUENCY	REQUIRED UNCERTAINTY	EXPECTED UNCERTAINTY	NOTES
Voltages				
0.1μV to 1V	dc	0.5μV + 50ppm	100nV + 10ppm	Using potentiometer
1V	dc	20ppm	5ppm	Standard cells
1V to 2kV	dc	20ppm	5ppm to 15ppm	Using V.R.B.
2kV to 50kV	dc	not specified	.05%	
Resistance				
1mΩ to 1Ω	dc	0.01% to 20ppm	0.01% to 5ppm	Using standards with E51 Bridges
1Ω to 1MΩ	dc	20ppm	5ppm	
1MΩ to 10MΩ	dc	20ppm	10ppm	
10MΩ to 100MΩ	dc	.01%	.01%	
Specific Values				
0.1Ω	dc	not specified	5ppm	For calibration of standard resistors by substilation.
1Ω	dc		3ppm	
10Ω	dc			
25Ω	dc			
100Ω	dc		2ppm	
1kΩ	dc		3ppm	
10kΩ	dc			
100kΩ	dc		4ppm	
1MΩ	dc		5ppm	
10mΩ	dc		20ppm	
100MΩ	dc		.01%	
Capacitance				
1pF to 1nF	1kHz	.02%	10ppm	Using GR Bridges and 3-terminal capacitors. Other frequencies in the a.f. range could be used.
1nF to 1μF	1kHz	.01%	.005%	
Inductance				
1μH to 50μH	1kHz	1%	1% to .02%	
50μH to 1 H	1kHz	0.1%	0.02%	
Voltage				
1V to 100V	20Hz to 1kHz	0.01%	0.01%	Using Fluke 540B Lower voltage can be obtained with out loss of accuracy from use of I.V.D.
1V to 100V	1kHz to 20kHz	0.01%	0.02%	
1V to 100V	20kHz to 100kHz	1%	0.05%	
1V to 100V	100kHz to 1MHz	1%	0.2%	Using NRS, into coaxial load.
1V to 100V	1MHz to 100MHz	2%	0.5%	
1V to 100V	100MHz to 1GHz	4%	2%	
100V to 500V	20Hz to 1kHz	.03%	0.02%	Higher voltages can be measured at power frequencies by use of transformers
100V to 500V	1kHz to 50kHz		0.04%	
100V to 500V	50kHz to 100kHz		0.2%	

Table 7 continued

QUANTITY AND RANGE	FREQUENCY	REQUIRED UNCERTAINTY	EXPECTED UNCERTAINTY	NOTES
Current				
10mA to 20A	Audio frequencies	.05%	0.02% to 0.1%	Using Fluke thermal transfer unit
Power	50Hz to 1kHz	not specified	.03%	For calibration of wattmeters
	dc to 16Hz	2% to 4%	1%	Dependent on knowledge of impedance.
Frequency	10Hz to 18GHz		1 in 10^9	Better accuracy could readily be achieved if needs arise.
VSWR				
R.F. Match in 50Ω coaxial line	300MHz to 10GHz		0.02	Using r.f. sources Wiltron Autotest.
Attenuation				
	10KHz to 10GHz	0.1dB	0.02dB + 0.001dB per dB	Using NRS meter or HP 436 to measure insertion loss.

The noted r.f. needs were particularly in the RF, UHF and X Bands. However the equipment proposed is capable of use over the whole frequency spectrum within the limits shown.

C. Mr. Hugh L.K. Goonetilleke's Contribution

Mr. Goonetilleke's statement followed the major points of his lecture which is here reproduced in its entirety because of its great relevance to this report.

The Importance of Metrology for Pakistan and How Metrication Can Be Made Use of to Foster Its Development

I must at the outset thank the Government of Pakistan, Dr. Abdul Ghani of the PCSIR, Mr. Peiser, and the NBS of the United States of America for inviting me to form a part of this Survey Team. It is an opportunity which gives me much satisfaction in many ways. The first is that the organization and the country that I come from, small though they may be, have been asked to contribute to a dialogue of this nature; secondly, because of the very good relationship that exists between our two countries--a considerable volume of trade passes between them; thirdly, because our countries form part of the same geographical and cultural region--Taxila and Gandhara are place names which are very familiar to Sri Lankan ears; and finally, because of the very great personal pleasure it gives me of working once again with NBS personnel. I still have very happy and vivid memories of the year I spent there many years ago.

I have chosen as my topic "The Importance of Metrology for Pakistan," and as an additional topic, I will discuss how metrication can be used to foster its development. The latter portion of my talk is based on experiences in Sri Lanka, and it gives an idea of how we approached the subject of metrication and how, since the base and purpose of the organization servicing the Metrication Authority is metrology, we have been able to keep this in our minds and assist in the adoption of good metric metrological practices.

Pakistan is a country about a dozen times larger in area and with a population five times greater than that of Sri Lanka. Basically, we are both agricultural countries endeavoring to build an industrial leg to give more substance to the country's growth and wealth, and therefore, our problems, though different in magnitude, are essentially similar in nature. Economists and planners judge the effectiveness of agricultural outputs in terms of the yield per unit area and the price per unit quantity. They are, of course, important, but speaking metrologically, it tends to narrow one's vision. It presumes that the only quantity of measurement that is significant in agricultural production is that of mass. It would follow that if there exists a legal metrology service which can provide this measure, all the metrological needs for this sector would be met. I am not trying to devalue the use of a sound legal metrological basis (if I were to do so, I would be destroying the platform on which I stand). The importance of the measurement of mass is seen from a look at the exports from Pakistan. Just total up the value of goods exported on the basis of mass in a single year.

I will substantiate my argument with a very short story of how the transactions by mass of export produce was used by us in Sri Lanka to stress a point for early metrication. Tea, as you probably know, is our major export. In the early 1970's when metrication was still being discussed, the London Tea Auctions decided that they would operate only in metric units, and any tea sent there should be packed in metric quantities. If they were not packed in metric quantities, the equivalent weight in kilograms should be stated. They provided conversion tables for this to be done. However, when we got hold of a copy of these tables, we found that every step in the table had been rounded down. This may not appear to be very significant unless you know how tea is packed in bulk for shipment. It is packed in plywood chests containing between 55-60 kg of tea. The gross and tare weights are marked on the chest and the difference is reflected on the invoice. The marking scheme from the London Tea Auctions required that the net weight of each chest be rounded down to the nearest lower kilogram value. The invoices were to reflect these rounded metric values. Using a rough calculation, we saw that the average loss in a year would be about U.S.$150,000 based on a year in which tea prices were very low. I believe that this was one of the factors which hastened the Government's decision to adopt metrication.

Going back to my original theme that the measurement of mass is not the only quantity needed for optimizing returns from agriculture, I will go back again to tea. At one stage in its processing, the humidity of the ambient is significant. The Tea Research Institute advocates certain specifications--but even where humidity was measured in Sri Lanka, there was no calibration of the instruments. No one knew how much of "quality" was lost and, therefore, how great an economic loss was due to a failure to obtain an achievable better price.

I will mention two other examples. Once again one is of particular interest to Sri Lanka; it concerns natural rubber. Before one begins the manufacturing process, it is necessary to measure the density of the liquid latex. This is done to estimate the dry rubber content that can be extracted. This is an important measurement on small specimens for several reasons. From the agricultural point of view, good controls depend on an understanding of the relative yields of different trees. An estate would use trees of different ages--trees grown by different methods of propagation, that is, either from seedlings or from clones. In addition, the way the trees are tapped affects the yield of rubber, so the payment of incentives to the workers who tap the trees can be made based on density. This is, of course, where we come in. The instrument which measures density is a hydrometer. It has a scale in mass units of rubber based on work done in the 1920's in Sri Lanka. The instrument has a special name, a "Metrolac," and there is a specific type known as "O'Brien's

Metrolacs" for Ceylon. Unfortunately, no one quite knows how this scale was arrived at. We have found that so many corrections (commonly known as "fudge factors") have gone into it that it is impossible to find the thinking. So again we have a practice, the implications of which are not quite understood, because the measurement practice has not been properly studied, and there are possibly large unknown losses. These could be due to faulty measurements or wrong premises.

A further example is that of measurement of the moisture content of cereals. Pakistan exports rice and is, therefore, well aware of the needs for the measurement of moisture--but does it realize the need for periodic calibration of the moisture meters?

In industry I can give examples which are once again based on experiences of Sri Lanka. They are probably duplicated to some extent in Pakistan. The first is the measurement of both high and low temperatures in industry. Consider the different kinds of foundries, and there are a large number of foundries in Sri Lanka. Hardly any of them have a pyrometer. They rely on a visual judgment to determine the temperature of the molten liquid. I know that you will say pyrometers are expensive, but that is another topic about which I can talk informally elsewhere. Just consider how much is the loss in excessive fuel consumption or the loss in production due to improper estimation of the temperature of the molten liquid and the resultant increase in the number of rejects.

Lastly, I will discuss an example which reached epidemic proportions a few years back: the rush to develop rural industrial units following Schumacher's "Small Is Beautiful." The disease was particularly virulent among planners and engineers in the public sector in Sri Lanka at that time. A small village project for the manufacture and assembly of bicycles was set up, with quite a lot of fanfare. The components were to be made each in one place, but in a number of associated units. Came the day when the requisite components that were needed for assembly of a cycle were available, but alas, the matching parts did not fit. "Small" certainly could be very beautiful provided you measure well.

This brings me to the last concept of the first part of my paper--that is the cost of measurement. There are many expert studies on the cost of measurement, and unfortunately, these figures tend to boggle the minds of those who hold the purse strings. However, hardly any estimate has been made about the loss or the cost of not measuring any process. How much is the loss in energy, material resources, labor, and the effect on the price of the product?

This is something which even a large number of technically qualified persons do not realize: the savings that one can effect by basic simple rules of measurement, particularly the proper use of control systems. These are nothing new, but the ones which have been time-tested in the different environments of the developed countries. The discipline holds good--the methodology may change but not the thinking or the approach.

I come now to the appended topic of this paper. How could one use metrication to develop metrology? I would first like to give a brief summary of metrology in Sri Lanka. Prior to independence in Sri Lanka, there was little or none. Seven years after independence, that is, in 1955, a Weights and Measures Law was implemented. It had been on the statute books two years before the independence (1948), but no action had been taken on it. It concerned itself primarily with Trade Metrology (Legal Metrology) and only in terms of units of the imperial system of measurement. It was a fair start, and although it was limited in scope, it did provide a basic measurement philosophy--the concept of standards at different levels of accuracy and the concept of traceability--because one could trace the accuracy of a commercial one-lb weight to the National Pound for Sri Lanka and through the old Board of Trade to the U.K. pound, and then if necessary, to the kilogram. It seems like a roundabout way of touching one's ear. However, the base on which to build a national measurement system was there. Hence, it was not too difficult to comprehend that if the country were to adopt the International System of Units (SI), one must have legislation on (a) definitions of the units of SI, (b) standards for maintaining these units, and (c) the necessary infrastructure.

It meant, of course, that certain compromises had to be made. For example, instead of having a new act, the Weights and Measures Ordinance was only amended. The purchase of standards had to be phased into the country's metrication program. Priority had to be given to trade, both external and internal. The appended notes to this paper give the schedule of metric standards which the Division had at the start of 1979. It also lists the proposed purchases in 1979 and 1980 separately. As far as 1979, we have the money, and for 1980 we have, of course, yet to apply for it. One of the advantages of doing it this way has been that there is a certain inherent support for the development program because metrication is a national policy.

This, of course, is one of the major ways of using metrication for the purpose of developing metrology. There are a number of other ways which one can use to produce long-term benefits. One such area is in the field of mechanical engineering. We have found out that it is not only possible to improve industrial practice by standardization of components like fasteners, but also that one can improve the quality of products by improving the use of measuring tools. A study is being done by the Department of Product Engineering at one of the universities to assess the capabilities of lathes in small-scale industry. The single-lathe owners whose main function is offering their services on small special jobs are included. The study will also look into ways and means of converting the lathes using existing conversion kits for lathes. Thus, we can make a sound judgment whether a facility need be set up to polish lathe beds or even attend to lead screws, prior to conversion. We can also consider how to improve the measurement practices among the operators.

The Paddy Marketing Board is similarly using the exercise of doing away with the bushel. As I mentioned earlier, we are also studying the estimating of yields on rubber estates and the calibration of the actual hydrometers that are used.

It is in the fields of legal and industrial metrology that much of the scope for development lies. If there has to be an investment in the purchase of new measuring instruments, there has to be a scheme of calibration established to make the investment worthwhile. Calibration centers, metrology centers, and audit schemes all can be generated as a result of this change, and not to do so is to waste a very good opportunity for improving the technology of measurement in a country.

In preparing this paper prior to my arrival in Pakistan, I have tried to put forward some of my thinking as a basis for getting acquainted prior to getting down to work on the Survey. I hope it is a point of view for which you may find some use. While thanking you for your attention, may I say that I am here also to learn from you more about the very fascinating subject of metrology, standards, and measurement services.

Appended Notes on National Standards in Sri Lanka

NATIONAL STANDARDS AND PRESENT STATE OF THE ART

The information given here is solely in relation to standards in the metric system as others will shortly be obsolete. These were received from mid-1974 onwards, and real capability was achieved only from 1975.

MASS

The Sri Lanka Standard Kilogram has been calibrated at the BIPM, who assigned it the prototype No. 79. In addition to this, there is another Standard Kilogram calibrated at the NPL (U.K.) and a Secondary Kilogram (brass) calibrated at the Standards Laboratory of the Department of Legal Metrology of the Department of Consumer Prices and Protection (U.K.).

The measurement capability in relation to mass prior to 1969 was confined to the periodical calibration of secondary standards against the primary (national) standards.

In 1969, the latter has to be reverified and according to the existing law at that time, had to be sent back to the U.K. to the original Laboratory. However, prior to this being done, a loan of two 1-lb standards and two 1,000-grain standards calibrated at NBS (United States) were obtained. Experiments based on statistical designs were carried out locally, and values were obtained for the primary pound and all the other weights of this set. These standards were then sent to the United Kingdom, and these results when compared with the U.K. reference standards were quite satisfactory within the limitations of the balances that are available in this Division.

LENGTH

The National Meter is a line standard obtained on a long-term loan from France and has a correction of 1 part in 10^{-5} at 1 meter and 5 parts in 10^{-6} at 10 centimeters. This standard also has a built-in comparator with one microscope. This facility is backed up by a universal measuring machine with a 1-meter bed and a scale that has an accuracy of 1 part in 10^{6}. This equipment with its accessories provides the base for dimensional metrology. Available in the Division are also three sets of slip gages and a comparator.

The first is a set of 122 (type '0') gages from 0.50 mm to 100 mm, which has been calibrated by a laboratory approved by the National Bureau of Metrology (BNM) of France. The second is a similar set (type 1) also calibrated by the same laboratory. The third is a BSI Grade I set which is intended to be used in the laboratory as a laboratory working standard.

TEMPERATURE

The program is to establish the International Practical Temperature Scale in the range 80 K to 650 C on the basis of 2 platinum resistance thermometers (calibrated at NPL, United Kingdom) and a Tinsley bridge with an associated 25 ohm resistor which carries a British calibration certificate. In addition, there is a triple-point cell obtained from the United Kingdom with an NPL (U.K.) calibration certificate.

In addition, there are 7 mercury-in-glass thermometers, one calibrated at NPL, the rest at BSI. This unit is still being developed.

VOLUME

There are two sets of standards. The first set consists of flasks obtained on loan from France. The range 10 liters to 50 milliters can be covered with this set. In addition to this, there is a set of automatic pipettes from the United Kingdom calibrated at the Standards Laboratory at the Department of Legal Metrology (U.K.) and consists of the following:

Liters: 5, 2, 1
Milliliters: 500, 200, 100--glass automatic pipettes
50, 100--sub-divided burettes
5, 10, 20, 50, 100--single pipettes

Intercomparison between these have been done. A fairly high degree of confidence was established. Accurate volume calibrations below 25 ml will be done gravimetrically.

DENSITY

We have a set of standard hydrometers which have been calibrated at one of the BNM laboratories in the range of specific gravities from 600 kg/m^3-1850 kg/m^3. However, precise measurements of density will be carried out within the accuracy of the mass standards available.

MAINTENANCE — WORKSHOP

A small quantity of electronic instruments, oscilloscopes, digital multimeters, power supplies, and other components are on order. The aim is to build a small facility to check the defects of any instrument, and if possible, to rectify it in the laboratory itself. We also aim to be able to assemble and build any accessories needed. This facility will be useful in view of the electrical and electronic facilities planned for in the near future.

MEASUREMENT CAPABILITY

Apart from the standards activities, several institutions in Sri Lanka possess measurement capability in various physical parameters. The measurement activities of these organizations as well as that of the Standards Laboratory of the Weights and Measures Division are described briefly below:

MEASUREMENT CAPABILITY OF THE WEIGHTS AND MEASURES DIVISION

In addition to the national standard of mass, the standards for volume and temperature are also available in the Standards Laboratory of the Weights and Measures Division. This Laboratory possesses the capability to carry out the following Measurements:

A. Mass. 1 mg - 20 kg to OIML classes A or B.

B. Length and dimensional metrology.

   (1) Comparison of linear measures up to 1 meter with a standard bar with estimated errors of 10μm.

   (2) Calibration of slip gages to OIML classes 0, I, or II.

   (3) External measurement with accuracy of 2μm at 1000 mm.

   (4) Internal measurement.

      (i) Ring gages up to external radius of 660 mm.
      (ii) Snap gages.

(5) End standards up to 1000 mm.

(6) Diameter measurements up to 125 mm.

(7) Diameter of external thread measurements up to 125 mm.

(8) Measurement of taper and solids of revolution.

Distance between centers . . . 100 mm.
Max. diameter . . . 65 mm.

(9) Checking of profile of threads.

(10) Measurement of linear pitch of threads up to 200 mm.

(11) Measurement of periodic error of lead screws up to 200 mm.

C. Volume.

D. Hydrometers. 600 kg/m - 1850 kg/m.

E. Alcoholometers - Comparison with CIML method using standard hydrometers.

F. Ebuliometers.

G. Thermometers. 5° - 100°C.

(i) Using NPL Type I resistance thermometer.
(ii) Using Standard mercury-in-glass thermometer.

H. Precision balances.

(i) Error.
(ii) Sensitivity.
(iii) Repeatability.

I. Voltage.

1 mV to 1999 V with an error less than .1% + .1 mV.

J. Current. .1 mA = 1.999 A.

K. Ohm.

(i) Non-inductive resistors.
1 - 2 MΩ with accuracy .02% of reading.
(ii) 2 - 20MΩ .5%.

MEASUREMENT ACTIVITIES OF THE CEYLON INSTITUTE OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CISIR)

Primarily set up as a Statutory Body under the Ministry of Industries and Scientific Affairs to carry out industrial research and development work, CISIR undertakes a limited number of measurements of various physical quantities for industry as well as other organizations. The measurement activities of CISIR are carried out in two different sections:

(1) The Section of Applied Physics and Electronics
(2) The Section of Material Science and Physico-Mechanical Testing

The former handles the measurement of electrical quantities and temperature, while the latter handles a limited range of mechanical measurements.

D. Dr. Peter L.M. Heydemann's Contribution

Dr. Heydemann described in his submission the program planning and budget development at NBS where these procedures have recently been introduced and judged to have been valuable. He described this system to our colleagues in Pakistan because he felt it may prove useful in the development of a simpler system that would suit NPSL.

Planning and Budget Development at NBS

The National Bureau of Standards (NBS) has recently introduced a program structure for all activities that ties directly to the budget structure prescribed by the U.S. Office of Management and Budget, which directly supports the President in his function as head of the Executive Branch of the U.S. Government.

The work carried out at NBS is divided into five major "activities":

(A) Measurement Research and Standards
(B) Engineering Standards
(C) Computer Science and Technology
(D) Cooperative Technology
(E) Central Technical Support

Each of these activities is subdivided into "subactivities" and "program elements." The activity (A) consists of these subactivities:

(A-1) Physical and Chemical Measurements and Standards
(A-2) Materials and Thermodynamic Measurements and Standards
(A-3) Measurement Assurance Program
(A-4) Applied Measurement Programs

The program elements of the subactivity (A-1) are:

(111) Fundamental Physical Measurements and Standards
(112) Radiation Measurements and Standards
(113) Analytical Chemical Measurements and Standards

The smallest, and probably most important, subdivision is the "task." Each program element contains between about 5 and 15 tasks. A task combines several related projects focused on a particular output. A typical task is the "Development and Maintenance of Primary Standards," which contains all NBS work on the primary standards of temperature, mass, length, and voltage. Other tasks contain the development of transfer standards, dissemination of measurement services, supporting fundamental research, etc. An essential aspect in the organization of a task is its focus on a deliverable output. The task description, which is an important management and planning document, reflects this. It contains the following parts:

(1) Title of the task
(2) Name and telephone number of task leader
(3) Objectives
(4) Approach
(5) Interactions
(6) Justification
(7) Comments
(8) Milestones
(9) Financial exhibits

The paragraph "objectives" clearly states the planned activities, accomplishment, and output for the next three to five years. "Approach" describes how the work will be carried out. "Interactions" deals with contacts and cooperations with industry, other agencies, or other groups at NBS and other national laboratories. In the paragraph "justification," the reasons for carrying out this work are described in terms of the demand from industry, the public, and government agencies for the specific output provided by this task. This is an important paragraph since here the management has to justify the expense incurred in carrying out the proposed work. The section entitled "milestones" contains a list of specific accomplishments planned for the next few years. Each milestone has a title, short description, and a completion date. Each milestone is also tied to a cost center in the financial exhibit so that the cost of accomplishing certain outputs can be assessed. The financial exhibits show summary information on the available funds, their sources, distribution to various pieces of work in the task, etc.

A well-written task document can be of considerable help justifying a new activity since it clearly shows the planned output, the demand for it, and its cost. Several tasks can be ranked according to their priority so that rational decisions about expansion or contraction of the budget are possible. The task document for existing tasks facilitates monitoring the progress of work by means of the established milestones.

The NBS budget as submitted to the U.S. Department of Commerce and to OMB identifies details down to the subactivity level. However, in formulating this budget, NBS managers make full use of the task documents. These documents are also the basis for the annual program review and for most internal planning activities.

E. Dr. Chul Koo Kim's Contribution

Dr. Kim elaborated his concluding statement in Pakistan as follows:

Report on the Survey of Standardization and Measurement Services of Pakistan

The visiting Survey Team visited 26 organizations in Pakistan in 2 weeks. The team members learned a lot about Pakistan, the land and the people, within the limit of what we saw and visited within 2 weeks.

I tried to identify the problems which Pakistan faces in the process of industrialization, especially in connection with the standardization and measurement capability. Some of the problems that I observed were familiar ones, which are almost universal in developing countries. However, I believe that some problems in Pakistan are unique, which can only be tackled successfully by Pakistani people.

Maybe the most serious obstacles facing developing countries in modernizing their national measurement capability is the absence of awareness of the importance of precision measurements. I found that the Pakistani industry was no exception to this prevailing situation. Except at a few places like PIA and PSTC, we could observe that good measurement practices were not given high priorities. Often I heard claims that the factories had adequate measurement capability to serve their present production requirements. I observed that, in most cases, it was true, not because the service was of high quality, but because their products were often simple and straightforward. The experience from other developing countries indicates that this kind of attitude can indeed seriously hamper the industrialization process by limiting the competitiveness in the international market. However, we found that good measurement practices exist at places like the PIA and PSTC. With a little bit of help and encouragement from the proposed NPSL, these organizations can be made to function as secondary laboratories in the national calibration network. Other problems we observed were lack of proper training and education in metrology which is again universal in developing countries. In one instance, we observed that a good quality slip gage set was used for a simple test check, which could be easily carried out with a much cheaper functional gage. In another instance, a calibration certificate issued by one university laboratory indicated that the laboratory personnel had no concept of the meaning of calibration.

Notwithstanding all the problems we encountered, there were manv calibration requirements, especially for calibration of gage blocks. I observed only one case in which a gage block set was calibrated regularly. In that case, the calibration was performed in the United States. Obviously, the proposed NPSL should be equipped to fill this need. Specifically in the fields of mechanical standards, NPSL should provide reference standards in mass, volume, density, length, force, pressure, and fluid flow. In the beginning, requests from industries will be mainly in the area of dimensional measurements. I believe that it is inadvisable that NPSL develop capabilities in absolute standards or obtain equipment more sophisticated than their needs dictate at this time. Selection of the equipment should be based on the degree of precision needed and the amount of funds available. For example, for the calibration of gage blocks, it would be advisable to have a gage block comparator, two or three sets of gage blocks, a set of optical flats, and a surface plate. From this basic equipment, NPSL can build up more versatility and capability when the future needs arise. For the mass standards, we know that NPSL has already ordered a series of weights to use as reference standards. Of course, proper capacity balances should supplement the weight set. Maybe one of the most demanding customers in the field of mass measurement will be the Pakistan Mint. The Pakistan Mint has a good facility and the capability of a secondary laboratory. NPSL should consider the needs of the Pakistan Mint when it decides on its own accuracy requirements in mass. I believe that the stainless steel kilogram, which is in the possession of the Mint and which was calibrated by BIPM, can be made more useful if it is in the hands of NPSL. For the other parameters, such as volume, density, fluid flow, pressure, and force, NPSL will be able to provide adequate calibration services by being equipped with commercially available reference standards.

However, it should be remembered by the NPSL staff that NPSL should always anticipate the future needs and be prepared for them. A good measurement means good equipment properly employed by properly trained personnel in a good environment. In this sense, NPSL will need a competent staff and a controlled environment. The experience in other developing countries indicates that competitive compensation to scientists and engineers are almost a prerequisite to a successful research organization.

The main function of NPSL may be divided into three parts. First, it will be a calibration service. I would like to recommend that NPSL have a strong capability in instrumentation. Especially in developing countries, where repair parts and technical information are hard to obtain, it is quite common to see expensive equipment standing idle because of a missing spare part or a missing manual. The NPSL calibration service should fill to some extent this demand. NPSL will greatly benefit by close collaboration with the instrumentation centers at PCSIR, Central Testing Laboratory, and others. To make the calibration service accessible to maximum possible users, NPSL should try to organize a national calibration network once its own capability is established. Secondly, it is imperative for NPSL to provide training to the industrial and scientific community. This task is largely divided into two categories. One is to persuade the public that a good measurement is an essential step towards industrialization. To achieve this aim, NPSL can organize seminars and lectures at the industrial complexes and universities. The second step is the training of measurement engineers and technicians in special fields. NPSL can offer short courses either alone or in collaboration with other institutions. Of course, we should not forget that this service can be carried out only after NPSL is firmly established. The last but not the least part of the NPSL activities will be research efforts in the measurement sciences and in related areas. As it was mentioned earlier, NPSL should always anticipate the future needs and maintain excellence in measurement capabilities. This can only be achieved through continuous learning and research efforts by the staff. Some of the efforts may not be 100 percent original research. However, it should be pointed out that, without intellectually rewarding research efforts, a research institute will not be able to maintain excellence and will soon become stale. I have seen many such cases.

I am well aware of the fact that it is a difficult task to start a standards research laboratory, and it is much more difficult to serve the nation successfully. However, with the active participation of PCSIR and with the enthusiasm shown by the NPSL members, I strongly believe that NPSL has the foundation to succeed.

F. Mr. H. Steffen Peiser's Contribution

With some expansion, Mr. Peiser's closing remarks are quoted here in full:

IMPLEMENTATION OF NBS/AID SURVEYS

In my short statement, Mr. Chairman, I want to outline some general thinking that lies behind the NBS/AID Surveys of Standardization and Measurement Services in other countries. I want to talk about the opportunities of these endeavors, their limitations, and especially their hoped-for implementation in the host countries.

It is not undue modesty that I am keenly conscious of the limitations. How can relative strangers to a country in two weeks identify the needed technical measurement services, determine the means for their realization, and establish the effective delivery of such services to industry, government agencies, consumers, and for exports? Of course, they cannot.

Technical measurement capability should be chosen, maintained, and expanded by careful decisions of the people of every nation. It is part of the infrastructure every sovereign country needs if development is its objective. This need is all pervasive, and its upgrading is a never-ending process as development proceeds. The technical community of each country must develop the measurement capability with the educational, calibration, and advisory services involved when that country has made the decision to develop and seek a higher quality of life for its people. I do not claim it is the only step to be taken for development, but it is an absolutely necessary one. The principal contribution we as an international team of standards specialists can make, and as I hope, have here made, is by applying experience elsewhere to recognize with a quick eye some of your technical problems and opportunities for solutions. By constructive discussion with your officials, we can make you aware of our viewpoints which also affect possible mechanisms for disseminating the critically needed benefits of good standards practices for industrial and social development. The responsibilities, the decisions, the choice between available alternatives, and the entire implementation remain for all countries to make in their own self-reliant manner in conformity with governmental policies and priorities, as well as with existing cultural and historic background conditions.

Let me illustrate this interaction between the visiting Survey Team and the host team by an example of special relevance to Pakistan. You have firmly planned for NPSL to be the sole national center for metrology. The team would have accepted this decision under all circumstances. As it happens, team members believe that this decision was a wise one because most countries that appear to have an effective measurement standards system have a similar standards laboratory in operation. They have aimed to rely on small, technically elite institutions rather than implanting the measurement standards competences into previously existing institutions with much wider regulatory responsibilities.

I believe our team would have failed in its duty inherent in its mission had we not freely discussed with your experts what we saw as the essential implications of your NPSL plan. The elite status really is necessary for success and calls for a small staff of top-level scientists with relatively favorable fund support and good physical facilities. We have pointed out to you how some of the greatest physical scientists in Germany, Britain, and the United States were called to serve their national standards institutions during the most successful industrial development of these countries. Pakistan has that kind of talent--it should be made an integral part of your NPSL plan.

Thus, we realize that none of these surveys can succeed except by the very process you in Pakistan have chosen. The technical leaders in the host country undertake to direct and program the surveys. The visiting team members discuss the topics chosen that are of special interest to the host country. The team visits the organizations, the agencies, and the factories the counterpart home team members have selected. To succeed in this process you, our hosts, have also taken time off from a very busy life to guide the Survey, because it is you, not the visiting team members, who understand the historic, cultural, financial, and political background in which these measurement services must function. It is you who know the resources of your country and the opportunities and some of the problems, such as in interagency cooperation, which in most countries (as also, incidentally, in the most highly industrialized) is a great challenge to the effectiveness of the services.

Before the start of the Survey, you have committed your funds for the in-country costs of the Survey, and you have chosen the topics of major interest to your country. NBS has responded by the selection of the most capable and most experienced specialists on those topics, while aiming at a balance between participants from the United States and from third countries. It is with great pride that I look back on nine such surveys for which the invitation by NBS to the most distinguished visiting team members selected has almost never been turned down. This is an invitation to work for our host country, and without financial reward, to put experience and knowledge at the disposal of the host country in any way the home members want to use the visiting team members during an all-too-short, two-week period.

We are now at the end of the period of the Survey itself. The Pakistani team members have interacted effectively with the visitors. We have found that the visiting team has, during all the visits and discussions from experience in their own countries, introduced new viewpoints and pointed out some new opportunities for standardization and measurement practices. Based on previous technical knowledge, the Pakistani team members have understood all the points made. As we leave you in the next few hours, we also leave you with the greatest of challenges--the implementation of our findings. Our report may yet help a little, but the real challenge can only be taken up by you, the Pakistan leaders in standardization and measurement technology. You have to demonstrate to the industries, the universities, the laboratories, to government agencies, and their highest directorates that this technical infrastructure is desperately needed to benefit all. Only as you introduce efficient, technically sound, and needed services, will the many benefits accrue. Officials, industrialists, and the public can and must be won over to see some of these benefits, and only then will it gradually become easier to obtain resources to expand your services to a level commensurate to this country's potential. You need the tools to do your job.

Mr. Chairman, you in Pakistan have given the team a wonderful opportunity unsurpassed by any country to date; you have shared as with friends your problems and your opportunities; you have entertained and guided us superbly. We see a great potential for Pakistan, but we are not blind to your difficulties. We believe that in a self-reliant way you can succeed; you have the technical and natural resources. You have a land and a people of virtually unlimited opportunities, few of which have come to full fruition. May we wish that you have found your two weeks with us helpful, and may we keep in cooperative touch with each other as we strive to serve firstly our respective nations similarly yet separately, and secondly, the international community of standards and measurement specialists who together can work for the benefit of all.

G. Dr. John K. Taylor's Contribution

Dr. Taylor was disheartened by what he saw in chemical analytical laboratories. This is a topic of greatest significance, now seen by the Survey Team as a major bottleneck to industrial development of Pakistan. What Dr. Taylor calls for is neither cheap in equipment nor minor in training requirements. However, the visiting team has the instruction to tell honestly what members believe even if that truth is hard to accept. Therefore, we reproduce here Dr. Taylor's concluding remarks in full:

Chemical Measurements

In Pakistan chemical measurements appear to be in most places at a lower level of development than physical measurements. While the latter may be classified as basically sound but lacking in the area of calibration, the former are almost non-existent for many important materials. Often they consist in the use of out-moded or barely adequate techniques. The concepts of intercalibration and traceability to a national measurement system are virtually unappreciated.

Industries that are major users of raw materials often appear to be purchasing them on the basis of faith in the compositional measurements made by the suppliers. Such analyses as are made for quality control purposes generally utilize so-called wet techniques as were practiced in industrialized countries several decades ago, and which are now considered to be marginally useful. Laboratory facilities are generally poor to inadequate. The available laboratories are not even well maintained, and there is little appreciation for the need for quality assurance practices to upgrade chemical measurements.

This situation must surely change if Pakistan is to advance industrially, if it is to utilize locally produced raw materials to a greater extent, and especially if it is to export quality products. The accuracy of determination of major and minor constituents needs to be upgraded, and faster methods to acquire compositional data need to be adopted. The quality of many products is critically dependent on the presence in some cases and absence in others of trace constituents, the capability for determination of which is largely lacking in Pakistan. The analysis of organic substances, and especially the determination of such substances in other materials, is also an area of deficient technology. Furthermore, the ability to determine traces of both inorganic and organic substances in the environment, resulting from industrial activity, is also a neglected chemical measurement area.

These problems have already been recognized in the plans to establish the NPSL which includes a Division of Materials Science. One of its subdivisions is a Chemical Analysis Branch. This proposal is strongly endorsed, and recommendations to implement this branch, based on our observations during the Survey, are as follows:

It is recommended that the Chemical Analysis Branch consist of two groups, devoted to inorganic analysis and organic analysis, respectively. Both groups should be equipped with modern instrumentation and adequately staffed. Moreover, the laboratory space should be designed to permit trace analysis as well as analytical work of state-of-the-art accuracy. While a prime function of the Branch would be to provide essential analytical services, funding should be provided so that at least half of the time could be devoted to research and development activity. Coordination and cooperation with the planned Chemical Division of the National Health Laboratory will be most helpful.

The inorganic group should develop the capability to do accurate analysis of major and minor constituents as well as to analyze for trace elements in a variety of matrices. At the present, analyses of metals, ores, and minerals appear to be the areas of greatest need, with an increasing interest in building materials. Analysis of environmental samples and of trace elements in foods and agricultural materials will be areas of increasing importance.

The program of work of the organic analysis group is of special importance since, with some notable exceptions such as at the PCSIR, very little competence of this kind is available in Pakistan at the present time. It would share with the National Health Laboratory the concern for a wide variety of materials including agricultural products, food, drugs, pharmaceuticals, and petroleum products.

The R&D efforts of both groups should be geared to the needs of the country, and the development of Standard Reference Materials should be a major activity. Simultaneously, they will need to conduct a program to educate industry in the use of SRM's to provide traceability of chemical measurements to a national measurement system. The NPSL should also assume a leadership role to introduce modern quality assurance practices into chemical analysis laboratories throughout the country. A continuing series of seminars and workshops will be needed to attain this end.

In summary, a major upgrading in the analytical chemical field is essential to industrial development in Pakistan. Improved chemical measurement capability will also greatly assist many other aspects of the nation's program to improve the general welfare of the people in such areas as food, clothing, shelter, and health services. An outstanding Chemical Analysis Branch can provide the focal point to upgrade chemical measurements throughout the country, providing both immediate and long-term benefits. Accordingly, implementation of the recommendations given above is strongly urged.

IV. ITINERARY

A. General

The detail of visits and discussions of the NBS/AID/PCSIR Survey on Standardization and Measurement Services is summarized within the description of the itinerary. The potential value of the Survey lies to a large extent in these exchanges of information that took place enabling ideas and experience in these fields to be exchanged and disseminated among some selected leaders of industry, government, and universities in Pakistan. The reader of this report should realize that the descriptions of these visits do not and cannot include all the discussion topics without unduly extending an already voluminous report.

The numbers preceding each visit in this report begin with the date (in January 1979) followed by a sequential identification number for the visits of that day.

10.1 January 10 - Peiser's Arrival at Karachi

Mr. Peiser was met by an Assistant for Administration, Mr. Mohamad Iqbal, at the Pakistan Council for Scientific and Industrial Research in the Ministry for Science and Technological Research. Since Peiser's earlier visit (see Section I.B), Mr. Mohammad Arshad Chaudri had taken over as Minister after General Mohammad Zia-ul-Haq, Chief Martial Law Administrator, relinquished that portfolio in the cabinet in favor of civilian authority.

The morning was spent with Dr. Abdul Ghani, Chairman of PCSIR, and Dr. S.M.A. Hai, PCSIR Officer In-charge of Planning. The principal news was that Dr. M. M. Qurashi's release from the General Directorship of the Appropriate Technology Development Organization had run into insuperable difficulties and the appointment to the Directorship of the National Physical and Standards Laboratory had not been made yet (c.f., Section II.B), but later in the Survey, clearer statements were made. Under Dr. Hai, the planning for the Survey had been made with care and insight. A formal opening of the Survey had run into problems at the Ministry and had been canceled. The splitting up of the Survey Team was to be more limited than during previous surveys with clear advantages in communication between team members and logistics in travel. Roughly four days were planned to be spent in the Islamabad and Peshawar area with equal times to be spent in the Lahore and Karachi environs.

11.1 January 11 - Peiser in Islamabad for Discussions with the U.S. Embassy and AID Mission

Planning details for the Survey were completed at the PCSIR. The afternoon was spent at the U.S. Consulate General in Karachi where Mr. J. Richard Sousane is Commercial Officer, formerly of the Commerce

Department's Export Promotion Administration. Mr. Sousane deals with a surprising number of standards problems, and it was recommended that a number of NBS publications be kept in the impressive commercial library at the Consulate. Mr. Sousane is assisted by Mr. A. I. Khan, Trade Expansion Adviser, who is quite evidently no newcomer to standardization. The occasion gave Peiser an opportunity more fully to comprehend the challenges and opportunities of the Survey.

B. Visits in the Islamabad and Peshawar Area

12.1 January 12 - Early Departure for Islamabad Accompanied by Dr. Hai

A most useful discussion took place on prospects for U.S.-Pakistan relations in science and technology. Dr. M. Aslam Chaudri, Officer In-charge, National Physical Standards Laboratory, met Dr. Hai and Mr. Peiser upon their arrival in Islamabad. The rest of the visiting team arrived keen to start work. Only Dr. C. K. Kim had some last minute problems owing to a lack of a Pakistani Consulate in Seoul. However, Dr. M. A. Chaudri cleared arrangements for his visa at entry.

Discussions at USAID and the Embassy--Mr. Walter Stettner at USAID is encouraging and interested in the Survey. Similarly, Mr. L. J. Kennon, Economic-Commercial Counselor at the U.S. Embassy, was favorably impressed and commented on opportunities for Pakistan's further development.

13.1 January 13 - Telephone Industries of Pakistan (TIP), Haripur

Telephone Industries of Pakistan is a company well equipped and sufficiently competent to meet the requirements of telecommunication equipment of various kinds in the country. TIP is located about 50 km from Islamabad in a complex which also houses the Telecommunication Research Center and the Telecommunication Staff College along with another factory, the National Radio and Telecommunication Corporation (NRTC). The entire team was present and was received by Mohd. Rafiq Ahmed Khan, General Manager, and other members of the staff. The facilities inspected included: the Materials Testing Laboratory, Metrology Laboratory (Length), and Plating Shop.

The business policies, organizational structure, equipment to be manufactured, and the management are subject to the control of the Board of Directors who are nominated by the Government of Pakistan and by Siemens (of West Germany), which also contributes most of the know-how and measurement equipment. The Secretary of the company has his office at Karachi. The number of staff employed by TIP is approximately 4,000, including 400 field staff and about 35 graduate engineers. Attempts are presently being made to recruit a further 20 graduates, mostly for research and development work. Extensive in-house training is provided.

The Factory Department absorbs about 55 to 60 percent of the total staff and maintains 16 different workshops. Included are 2 shops for tool manufacturing and tool repair, which are capable of manufacturing parts with tolerances as little as 1 μm. For the maintenance of standards of precision, TIP has a precision measuring laboratory.

The principal output of the factory is mechanical equipment, assembly of units for electro-mechanical telephone exchanges, switchboards (PBX's), and telephones. Manufacture of all electronic components is at Islamabad, and the Haripur operation is essentially one of assembly but does not include the winding and construction of relays. All of the assemblies observed were wired. No printed circuit boards were observed in the small part of the assembly work which was shown to the team.

The scale of production since 1962 has been 30,000 exchanges (this presumably being PBX's) and 70,000 telephones. More recently the factory has also made teleprinters and typewriters. Standard typewriters are used in Pakistan while portables are exported to Europe. It appears that this type of diversification was undertaken to offset the tendency for electronic parts to replace mechanical ones.

In general, our hosts expressed no measurement problems. Their gages were purchased with calibrations to better than DIN standards. They use ISO standards. The gages appeared clean, and the comparators were very adequate. They have no procedures for testing (recalibration) of their gage blocks. This should be done periodically. However, the factories do not interface appreciably with others at present. Drift in measurement standards would sooner or later cause problems. The chemical part of its materials testing laboratory has very limited facilities. They do not have facilities for testing raw materials and apparently depend on the reputation of the suppliers. This part could be upgraded with predictable benefit. They have used PCSIR for consulting on the cleanup of discharges from their plating operation.

The principal needs for accuracy are in the tool room, since the factory makes a large number of small press tools. There is a small mechanical standards room; the temperature is controlled but not recorded. There are neither humidity controls nor effective clean-room precautions. All the working standards have a recalibration interval marked on them and are recalled for regular checking by the laboratory. They are checked by micrometers and dial gages against working (German) slip gages, which were checked by a comparator against a similar master set of slip gages. No intercomparisons or buildups are carried out, and none of the master set has been externally recalibrated since the date of supply (presumably mid-1950's).

TIP has equipment that is good enough for present production purposes, which are rather simple and do not need precision machining.

Even if TIP does not implement any calibration and quality control in the near future, it will still be able to manufacture conventional telephone products. However, if they decide to manufacture new electronic switches or other new products, they very soon will face problems of quality control and precision measurement. Even in the case of present production, the quality control of parts is important if their products are going to face competition in the market. For example, the coin-operated public phone will not last very long if it barely meets the specifications. In this sense, a far better precision than the specification may eventually bring a substantial saving to the user.

There are no requirements for accurate measurement of electrical quantities, and the principal testing is functional. Crude measurements are made of insulation resistance, using equipment made in-house. It was said that there were some multi-range meters (although none were observed). Reliance was placed without question upon the accuracy and constancy of the instruments.

This operation would find benefit from:

1. Simple education in needs for accuracy, and competent maintenance of standards even at low accuracy.

2. Reference standards for electrical measurements.

3. Calibration, possibly at NPSL, for these electrical standards, and for existing mechanical standards.

4. Calibration procedures, programs, and documentation.

Dependence on advice from Siemens will save TIP from major troubles. The greater the Pakistani wish for self-reliance, the more desirable will be the contribution which NPSL can make to TIP. It can be summarized as follows:

1. Providing simple traceability.

2. Training in quality control and the importance of metrology.

3. Advice and training in handling equipment and gages for future use.

13.2 January 13 - Visit to Dr. Z. A. Hashmi, President of Pakistan Science Foundation and Chairman of National Science Council of Pakistan

Owing to a recent bereavement under tragic circumstances, Dr. Z. A. Hashmi, (President of the Pakistan Science Foundation and Chairman of the National Science Council of Pakistan--NSCP), was prevented from taking part in the Survey activities. However, Dr. Abdul Ghani, Dr. M. Aslam Chaudri, and Mr. H. Steffen Peiser did pay a visit to his home to express condolences and the hope that Dr. Hashmi, a member of the Advisory Committee on Science and Technology of the United Nations General Assembly, would take a leading role in the forthcoming U.N. Conference on Science and Technology for Development.

Dr. Hashmi discussed the NSCP reviews of scientific research in major fields related to economic and social development. The first volume on current research in agriculture had just been published, and a copy of this very interesting volume was received. It demonstrated clearly that the research effort was not well coordinated with the priorities in agricultural products. Had wheat been near the top of the research effort, as it deserved, perhaps the unfortunate decline in seed quality might have been avoided as a result of which there had been a serious shortfall in the previous year's harvest which could not be attributed to the weather. The subjects of hides, feed crops, pastures, and agronomy also were under-represented.

The publication mentions the research of 60 institutes and similar organizations throughout Pakistan, of which the Survey Team was to see only 7, and most of these briefly because the field of the Survey was somewhat remote, although it became abundantly clear that better measurements in agriculture could contribute greatly to even the smallest producer. For example, 4-ton loads of molasses are at times driven to 3 truck scales which differ significantly so that an average is taken of actual weighings, rather than establishing a correction factor or even adjusting the scales. There seems to be no general and reliable trace analysis capability in Pakistan.

There are about 1,200 research scientists in agriculture, of whom about 15 percent have Ph.D.'s.

13.3 January 13 - Visit to the Minister for Science and Technological Research

Mr. Mohammad Arshad Chaudri, Minister for Science and Technological Research, accompanied by the Additional Secretary, Dr. Nisar Ahmad, received the visiting Survey Team under the guidance of Dr. Abdul Ghani. The Minister received the party with cordiality and most emphatically endorsed the objectives of the Survey as they were explained. He assured the team of open support and free discussion of this consultative mission. He also discussed his forthcoming visit to the U.S. for attendance at a preparatory meeting of the U.N. Conference for Science and Technology for Development. Mr. Peiser took the opportunity of inviting him to the NBS laboratories. As matters turned out, he was unable to visit.

13.4 January 13 - PCSIR Dinner

The Chairman of PCSIR introduced the Survey Team to high ranking Government officials at a dinner to inaugurate the Survey. A favorable reaction to the Survey plan was expressed.

14.1 January 14 - Visit to the Heavy Mechanical Complex at Taxila

The full team (Pakistani and foreign) was received and briefed by Mr. Usman Umar, Deputy General Manager, Sales and Marketing Division, who said he was himself a mechanical engineer. The complex consists of a steel foundry, cast iron foundry, hammer forge, heat treatment shop, press forge, fabrication shop, machine shop, tool room, and a metrological laboratory which is small but adequate. The metrology laboratory is intended to calibrate the measuring instruments used in the various shops, which aim to work with a capability of achieving an accuracy of 1 μm.

The mission of the organization is to manufacture heavy machinery used in sugar mills and cement mills, road rollers, overhead electric transmission cranes, package-type boilers, vehicle chassis, railway axles, and other steel structures. The production capacity is 46,000 tons of heavy machinery per year, but actual production is only around 10,000 tons per year.

The team was informed that the entire complex had been initially donated by the Peoples Republic of China as a turn-key operation. To help in start-up, a declining number of Chinese technicians are assigned to the plant over a period of some years.

When Pakistan was created, it had to import most of its industrial equipment. In 1965, the Pakistan Industrial Development Corporation was established to provide for and set up industry where private enterprise was not available. The idea was eventually to sell a working establishment to private enterprise. The loan establishing the Heavy Mechanical Complex has now been made into a grant at a cost of $300 million. This was adequate because the basic plant was provided by the PRC free of cost to Pakistan. The Complex is housed on 125 acres and includes a training center and school. The training center enrolls students from high school who are trained for 1 year and may receive further training for up to 3 years.

The Complex first went into production in 1971. Production was initially planned in accordance with imported Chinese technology, but output began to respond more and more to purchase orders and export markets. Accordingly, the planned production mode made way for diversification, especially for export purposes. This conversion causes problems in exporting, especially to Western countries, for example, cranes to Holland, where complex financial questions have to be negotiated. In general, the applied technology is borrowed. The low production figure arises from lack of good balance between orders to fit the available facilities. Pakistani engineers themselves probably should show more confidence in the products of this Complex. Another problem is said to be a restricting condition with many loans to buy basic plants from the donor nations. There is some diversification, mentioned earlier, for smaller items which do not help to reach the programmed capacity which depends on machining of large objects.

Accompanied by the engineer in charge of quality control, the various shops were observed, including the metrology laboratory. In a briefing which covered his particular operations, it was discovered that one of his responsibilities was to issue certificates for the suppliers (all foreign companies) of steel and pig iron. It was also mentioned that certain materials such as sand and sodium silicate are tested in the central laboratory of the Heavy Foundry and Forge Complex which is a parallel and sister organization.

The machine shop has a variety of machine tools which includes a turret lathe with a capacity of 15 cubic feet which could handle a work piece of 54 tonnes mass and a heavy duty lathe (50 cubic feet). This shop also houses a tool and metrology room. The former has more precision machine tools, and the latter has a jig-boring machine and a thread-testing machine.

The metrology laboratory is air conditioned, and it was claimed that the temperature of the ambient was maintained at 20°C. No temperature recordings were available. The laboratory is well equipped, having an optical dividing head, a wear measuring comparator, an optical profile measuring device, a screen tester, a surface plate, a height measuring gage, an optical comparator, and a measuring machine with a bed of 3 meters. There were, in addition, a number of sets of gage blocks of which the metric sets numbered 6, a few of which were of Chinese origin. They had been supplied together with the remaining machines. Two others were imported from Germany subsequently. None of them had been calibrated after the original calibration, nor had an intercomparison between the sets of gage blocks been performed. The metrology laboratory is in fact equipped with more items than would best suit the needs of the Complex. For example, 2 sets of slip gages, a working set and a calibration set which would act as the master set for the factory, would be quite satisfactory.

The team observed that sophisticated measurements are provided only for tools. Most of the manufacturing is performed to larger tolerances, and most processes involve heat treatment. A central laboratory is provided where mechanical and chemical tests are performed. The Engineering Design and Planning Departments operate on a mixture of American, European, and Chinese systems. The raw materials used are mostly steels. During the first five years of operation, these materials were provided by the PRC, but presently, they are acquired wherever credit is available. Heavy castings and forgings are now provided by a sister corporation. Otherwise, there are facilities available for the production of the basic components for a variety of chemical plants.

This is an organization which will benefit greatly by the establishment of the NPSL, especially in: (a) the achievement of a measurement capability linked to a hierarchy of measurement, (b) the training of its engineers and technicians in the use of metrological instrumentation, and (c) the maintenance of norms on a statistical basis.

The Complex does have a rather extensive range of equipment and gages which are in relatively good working order. With proper training of their staff by the NPSL, they could make good use of the equipment to produce precision products, and in turn, they could function as a secondary laboratory providing calibration services to other factories in the region.

However, good standardization alone cannot turn the fortune of this facility, which was so well conceived and established. The principal problem seems to lie outside the scope of this Survey and can probably best be cured by additional standards training of middle and top management.

14.2 January 14 - Visit to Heavy Foundry and Forge at Taxila

With the coming into operation of other heavy engineering industries, the need for a Heavy Foundry and Forge came into sharp focus. The Government of Pakistan accordingly approved in March 1972 a project for the setting up of a Heavy Foundry and Forge at Taxila in the vicinity of other heavy engineering production units. Heavy Foundry and Forge is a limited company fully owned by the Government of Pakistan. The Foundry has six major production units:

Steel foundry
Cast iron foundry
Hydraulic press shop
Forge shop
Machine shop
Pattern shop

The Heavy Foundry and Forge Company produces heavy steel castings up to 21 tons, steel ingots up to 40 tons, and can handle large forgings with a 3,000-ton press, make iron and non-ferrous castings, and can make composite structures by machining and welding. The facility itself is also a gift of the Peoples Republic of China who stayed with the facility until Pakistani managers were able to take over the plant without further assistance, after which the Pakistan Government then took control.

The principal problem is to keep the shops busy with orders. The tendency is said to be for development projects such as for cement, sugar, fertilizer, and other plants with financial support from the U.N. or industrialized countries to order the components from the industrialized countries that wish to keep their heavy industry employed. Before accepting this viewpoint in its entirety, one would have to study the acceptability of the company's products, its reputation with customers, the Government's and the company's marketing policies, etc.

The team suspects that a successful quality control program and an expanding Pakistan industry could keep this facility fully employed, provided it aggressively seeks to upgrade its plant, such as with more convenient and larger steel arc-melting furnaces. This, however, was a well-conceived plant, well built with originally suitable equipment. Good standards management should be capable of turning it into a great asset for Pakistan.

14.3 January 14 - NBS Dinner

The entire visiting Survey Team hosted a dinner for the Pakistani team members, officials of PCSIR, and senior Government officials from several ministries. The USAID Director, Mr. W. A. Wolffer, and members of the U.S. Embassy also attended.

15.1 January 15 - The Peshawar Laboratory of PCSIR

The Peshawar Laboratory is concerned with studies in the areas of mineralogy, biology, pharmacology, fibers, textiles, and food processing, related largely to the Northwest Frontier region of Pakistan. The Survey Team did not tour the laboratories but received an overview presentation of the program at Peshawar and witnessed an exhibition of the work and products of all the PCSIR laboratories which had been shown in the principal cities of Pakistan and which happened to be visiting the area. All three laboratories (Karachi, Lahore, and Peshawar) had impressive exhibits attractively presented and clearly enjoyed by the public which included school children accompanied by teachers. One of the products demonstrated, a rice husk cement, had been developed at the Peshawar laboratories and had attained an ultimate strength of well over 50 percent of normal cement. By simple gadgeteering, the Peshawar Laboratory had developed a carpet knotting machine which was remarkably much faster than hand-knotting and could be readily operated for complex multi-color designs.

Before departure, Mr. Peiser did make a visit to the laboratories concentrating particularly on the crystallographic section where worthwhile work was in progress on clays by thermo-gravimetric analysis backed by powder X-ray diffractometry. The coupling to commercially viable products was not obvious although such projects probably could be found. As soon as PCSIR has made a determination where to have the prime emphasis on X-ray diffraction, whether in Karachi or Peshawar, it would become desirable for NBS to supply the necessary but quite expensive reference literature needed for this work, and one would hope also that some organization would supply the needed modern equipment. This section could be highly cost effective in the development of Pakistan.

The principal industries in the Northwest Frontier region of Pakistan are concerned with mining and forestry. It is entirely appropriate, therefore, that the PCSIR laboratory in Peshawar concentrates its efforts to a considerable degree on the support of the mining industry. Work in mineral products and extraction metallurgy, therefore, has its place and is well represented. The division of responsibilities with the Geological Survey in Pakistan is not entirely clear to the team members who did not visit the headquarters of the Geological Survey in Quetta, Baluchistan. The Survey Team's meeting with Dr. Shah, the Director, and his staff was very cordial and had a ceremonial emphasis.

15.2 January 15 - Pakistan Forest Institute

The description of this Institute must be understood in relation, on the one hand, to its standing as the prime forest research organization of Pakistan, while on the other hand, Pakistan has a devastating forest management problem. Deforestation continues at an alarming rate, desertification overtakes thousands of acres a year, and erosion proceeds over much of the potentially most productive agricultural regions.

Pakistan's climate is diverse and includes tropical, sub-tropical, and climatically temperate regions where water is plentiful and where land lies barren. In the warmest regions, evaporation causes salinification of the soil which, in turn, causes semi-permanent loss to agriculture.

The Pakistan Forest Institute is a branch of Peshawar University. Its scope includes education and research, the management of forests and gamelands, and training for the forest service. Its program is oriented by approximately 75 percent on research and 25 percent on education. The Director of the Institute has a military background and is well aware that the organization is understaffed and that it does not have a sufficient number of research workers. The latter are difficult to secure primarily because of their salary requirements. All advanced work in forestry is done abroad because students leave for more attractive opportunities.

On paper, the Institute appears to have an ambitious program, but it is only partially active. It does have laboratories where good work could be performed on forest products, including mechanical tests of wood, wood laminates, chipboard, and the like, and it does cooperate with PCSIR at Peshawar. Even though some mechanical testing is done, the required accuracy is quite low. Therefore, it is believed that NPSL can be of some help even if only for providing a small number of calibration services.

In general, the equipment used in the testing laboratories appeared to be adequate. The machine for testing the compressive and tensile strength of woods could easily be calibrated by NPSL once it is set up. However, what appears to be needed, even more, is some advice and instruction on measurement--its basic characteristics and approach and the statistics of the measurement process from plan to interpretation. To illustrate this point, samples of wood were being prepared for testing machines where a dial micrometer was being used to determine the dimensions, while a crude beam balance was employed for the mass. The difference in accuracies of these measurements amounts to an inconsistency. If accuracies of the first measurement are needed, then a finer balance should be used. If not, a quicker method of linear measurement would suffice.

The team out of personal interest rather than because of relevance to the Survey asked some questions on reforestation. Our guides told us their work in this field was concentrated in the Northwest Frontier region. Under study for somewhat lower regions is the dalbergia sissoo. The principal need seems to be elsewhere in Pakistan. The consideration of Leucaena leucocephela if not under study elsewhere is to be recommended as a fast growing tropical tree with edible leaves and seeds. Its roots have bacteria that fix atmospheric nitrogen, and the wood is excellent for furniture. Mr. Michael Benge's advice at USAID is probably second to none.

16.1 January 16 - Visit to National Health Laboratory, Islamabad

The National Health Laboratory is a major resource of Pakistan; it is housed in attractive surroundings and employs 500 people. It is a progressive laboratory and will welcome the availability of national standards. In turn, it could provide certain standards in the health domain and could do so in cooperation with and under the guidance of NPSL. The Laboratory has four divisions at present: Public Health, Drug Control, Biological Production, and Nutrition. Recently, it has received approval for establishing a Division of Chemical Research and a 200-bed research hospital.

The Public Health Division standardizes methods, establishes national norms for samples of human sera, isolates and identifies pathogens, and conducts similar tests for hospitals throughout the country for diagnostic purposes.

The Drug Control Division is involved in the control of imported basic drugs and remedies, performs micro-biological testing, and investigates domestic drugs such as herbs, for example, to discover active principles of local remedies, and especially for the presence of possible toxicants.

The Biological Division is the largest and produces all the vaccines for the country. It will soon produce polio vaccine. The production of anti-venom sera for snake bites is very important since this is a problem in rural areas. Because there are four kinds of poisonous snakes in the country, the Division produces a four-component serum because the attacking snake is often not identified. This is a unique service within Pakistan, and the export opportunities are being examined. The Laboratory sends its sera to the World Health Organization and accepts samples from other countries thereby introducing a mechanism for quality control.

The Nutrition Division is making national surveys in the country to try to upgrade the diet. Some checking is done on foodstuffs sold in the open market, and a program to identify aflatoxins has been initiated. Research on indigenous foods, such as pulses, is being carried out with the hope that recipes can be devleoped that will be acceptable to the general public.

16.2 January 16 - Visit to Carrier Telephone Industries Factory

The factory of the Carrier Telephone Industries was set up by the West German Siemens Company in joint venture in 1965. Its standards are based on CCITT for performance standards and German Industry Norms (DIN) for construction and measurement. Quality control has been, and still is, under the control of Siemens. The Technical Manager responsible for quality control is Mr. Labeur (Siemens). CTI is now also adopting German Post Office constructional standards, which will help to provide opportunities for alternative supplies since modules made for the German Post Office will be compatible with CTI production. CTI makes multiplexing equipment (frequency division multiplexing/frequency modulated) for the Post, Telegraph, and Telephone Authority and is now starting to make rf transmission equipment at uhf and expects to take on microwave transmission equipment and pcm (pulse code modulation) systems in the near future.

CTI manufactures most of its own components, except resistors which are supplied by Siemens. Transistors are made by Siemens from doped, sliced, and tested silicon. Consumption is almost entirely in Pakistan because the field staff and organization are not available for installation and servicing overseas.

In the quality control department, which was well lit and air-conditioned (no temperature recording was observed), the measurement instruments were of the highest commercial quality. Mr. Labeur was aware of the need for independent reference standards and had standard resistors and capacitors on order, together with ac/dc transfer standards and a high-quality dc voltage calibrator. Given periodic calibration (which he hopes will be available from NPSL), these will be quite adequate for CTI needs. He also proposes to obtain a cesium beam time standard, although he could not justify the need for its accuracy.

Siemens advisers have evidently done an excellent job here, and the factory and its quality control department would match many of those in industrialized nations except for the absence of standards, which advisers here are aware of and which is being rectified. The people sent by Siemens impressed us as having much high quality experience and being highly motivated. The appreciation of the need for higher standards and measuring equipment seen here, as compared with TIP (see visit 13.1), may be due in part to the continued control exerted by Siemens. CTI, however, is in a higher technology field than TIP; one would expect, in any case, better attention to measurement standards at CTI. NPSL can certainly be of help to calibrate CTI's secondary standards. The cesium frequency standard, which has been ordered, can perhaps be used as a temporary reference standard for NPSL.

16.3 January 16 - Visit to NPSL Laboratories in Islamabad on the Campus of Quaid-E-Azam University

Team members present were Dr. S. S. Zaidi (Controller of Weights and Measures), Dr. M. Aslam Chaudri (of PCSIR), Dr. C. K. Kim, and Mr. H.L.K. Goonetilleke. The team was received by Dr. M. Aslam Chaudri of PCSIR and Dr. Z. A. Khan.

Under the amendments to the weights and measures laws, NPSL is the custodian of the prototype kilogram and the standard meter. This function is the nucleus for NPSL as it is to be constituted. The purpose of the visit was to assess the standards of length, mass, and volume which are already available.

The present facilities are purely temporary until such time as the NPSL receives its own buildings. Dr. Aslam Chaudhry has a plan for the laboratories which had been sent to NBS for review and comments. The land is available, and it is expected that construction of the laboratory buildings will start this year.

Standards--Mass: A mass standard with a calibration from BIPM is on order and a set of weights obtained from France, from 1 kg to 1 mg, is maintained. A certificate is now available but was not immediately accessible, hence their accuracy class could not be ascertained. Available are two-pan and single-pan balances, but work has to be done on them to determine the standard deviation. Publications by NBS on this topic have been supplied, so that a start could be made on determining the degree of confidence in the performance of these balances under the given operating conditions.

Length: A meter (rectangular cross section) marked at the points built into a comparator has been obtained from France. This has an uncertainty of 1 part in 10^5 at 1 meter.

Dimensional metrology: A universal measuring machine has been purchased with accessories and will suffice to handle linear measurements.

Volume measurement: Automatic volumetric pipettes from 20 liters downwards calibrated at the standard weights and measures division are also available. There appears to be more than one set.

Electric measurement: A certain number of electrical measuring instruments, such as a vernier potentiometer and a Weston-cadmium cell, are maintained. Substandard resistances of 10,000 Ohms to 0.1 Ohm in decades and ac/dc watt and Ohm meters are available, and they have all been certified recently.

With the standards on order, the mass, length, and dimensional laboratories of NPSL should be sufficiently equipped for a modest start to be made. None of the technical staff currently working in the laboratory has been working in any national metrology laboratory on basic measurements. It is strongly recommended that students working in these laboratories have some exposure to experimental design for measurements near the highest attainable accuracies. As some items appear to be in excess of requirements, as for example, in pipettes, one set may be transferred to the Institute of Weights and Measures. This would prove useful to that Institute for cutting down the time for calibration of working standard measures that are submitted there. NPSL should be equipped with standard hydrometers to calibrate hydrometers used in industry.

16.4 January 16 - Visit to the Weights and Measures Offices at Islamabad

The first of a two-day visit to the Pakistani authorities regulating all commercial measurements in retail markets was made to the Office of the Controller of Weights and Measures, Islamabad. The second visit was to the Office of the Controller of Weights and Measures of the Province of Punjab at Lahore (see 21.1). Dr. S.S.H. Zaidi, the Controller of Weights and Measures of Pakistan, was available and accompanied the Survey Team on both occasions. Mr. Chaudri Maskur, Additional Controller of Labor, who is also ex-officio the Controller of Weights and Measures for the Province, was also present for the Islamabad visit. (For further details, see 21.1.)

Dr. S.S.H. Zaidi, as Controller of Weights and Measures, reports to the Ministry of Industry. He is a former member of PCSIR and a strong supporter of the establishment of NPSL with which he expects to maintain the closest working relationships. Moreover, he has written a note emphasizing the need for NPSL to engage in physical research, including solid state physics, fluid dynamics, and production engineering. His Ministry looks to NPSL to establish a leadership position in these fields that are relevant to Pakistan's industrial development.

C. Visits in the Lahore Area

17.1 January 17 - Visit to the Pakistan Industrial Technical Assistance Assistance Center (PITAC)

The Pakistan Industrial Technical Assistance Center (PITAC) was created in 1962 by the merger of the Industrial Research and Development Center (IRDC) and the Industrial Productivity Center (IPC) which received assistance from UNESCO and USAID. The Survey Team was received at PITAC by its Director, Brigadier M. A. Faruqui. PITAC's main office and workshops are in Lahore, but branch offices in Karachi, Peshawar, and Quetta are being strengthened. Annual expenditure is approximately 4 million rupees. Reimbursements received amount to approximately 0.8 million rupees. The total staff of 300 includes 150 technicians and 11 mechanical engineers.

PITAC serves the metal and machine industries by training operatives, providing consultation, and undertaking special design and prototype construction jobs on a reimbursable basis. Its help is applied particularly to small industries by contributing design and manufacture, if necessary, of tools and jigs. PITAC's mission can, therefore, be summarized as follows:

a. To develop advanced technical "know-how" in the fields of design and manufacture of high precision tools, production dies, moulds, jigs, and fixtures.

b. To train highly skilled technicians.

c. To provide technical advisory services to industrial organizations primarily in the private sector.

d. To improve productivity and quality.

The facilities include: a machine shop, engineering design office, foundry, heat treatment, electroplating shop, and testing laboratory. PITAC is entering into the field of low-cost automation, especially by retrofitting with hydraulic electric systems to automate manual machines. This is a pilot program to encourage industry to take this approach which is more economical than retooling.

There is a well-equipped tool room, but it contains some obsolete tools. Grinding is done in the machine workshop. There are very limited standards. No documented calibration is carried out. The measurement room is kept at a roughly constant temperature, but there is no recording instrument or record kept. There is nothing applicable to electrical measurement in this organization. Electroplating is principally for decorative or protective purposes, which excludes any consideration given to electroforming or electro-polishing. PITAC feels a definite need for standards. Gages are adequate, but it is known that they need rechecking.

Trainees hold B.S. degrees or engineering diplomas and train at PITAC for 24 weeks. Because PITAC trains technicians in the machine and metals sector, it could also train technicians in quality control and metrology. For this purpose, the laboratory would need to be substantially enlarged, and the staff could receive training from NPSL.

PITAC cooperates with the Asian Productivity Organization, UNIDO, and others for the training of its engineers and staff and to keep abreast of modern techniques in highly industrialized countries.

17.2 January 17 - Visit to the Lahore Engineering University

The University provides education in all branches of engineering, architecture, city planning, applied sciences, and data processing. It operates a graduate school granting M.S. and Ph.D. degrees. There are 80 postgraduate students, a good proportion of them attending part time. The University trains some 650 engineering graduates a year. Moreover, the University offers services in electrical engineering and testing, provides consultation and advisory services to industry and government, and claims to be the principal authority for testing in Pakistan. The work is done on a reimbursable basis, the proceeds of which are distributed equally to the University, the staff, and expenses. Services offered include calibration and measurement, and at one point, a claim was made that this is the best mechanical testing laboratory in Asia.

The Dean of the University, who received the Survey Team, stated that "our work is accepted as final." The University has a series of standards such as proving rings and electrical standards which are used for their own purposes as well as to calibrate engineering instruments for others. The Dean also stated that he would welcome a national calibration center which could calibrate its own standards, thus providing for traceability.

At the metrology room of the Department of Mechanical Engineering, discussions centered on the use of laboratory equipment and their traceability. The Department is equipped with the basic measuring equipment needed for teaching and for carrying out specific measurement of gages, both linear and angular and also for diameter. It has a capability to check the profiles of several kinds of gears to reasonably high precision. It has proving rings initially calibrated on deadweight machines, but none of them has had any subsequent calibration to the original certificate supplied by the manufacturers.

Dr. Shah Mobinal Haque, Professor of Electrical Engineering, accompanied Mr. Cyril Dix to the electrical engineering department, where in fact, there were no electrical standards of any sort to be found. The department maintained some electrical machines used for teaching purposes and some pointer instruments which had not been calibrated against anything better since they were purchased. It is difficult to see how it could offer any services for electrical calibration, although the Survey Team later discovered some calibration certificates which had been issued by the University.

The team also visited the chemistry laboratories which are adequate for instructional purposes and possibly for routine tests. These laboratories perform classical rock analysis, for example, and can probably perform the basic tests but not minor constituent and trace element analysis.

The dimensional metrology laboratory has equipment which needs regular calibration service. With adequate support from NPSL, it can function as a secondary laboratory. However, it appears that the laboratory staff are not familiar with the basic principles of calibration. The laboratory maintained no environment control which is required if the precision desired is in the range of 1 µm.

The Engineering University at Lahore can greatly benefit from NPSL by improving measuring capabilities at the University. This can be accomplished by establishing a direct linkage to a national system of measurement which adopts the philosophy and techniques of good measurement. If properly grounded, it could serve industry in the provincial regions much more effectively than it can now. The Survey Team understands that this University holds an unexcelled position and responsibility in Pakistan's technical development. Its students are among the most gifted. A strong faculty and excellent facilities here are a key to this nation's future.

17.3 January 17 - Visit to the Pakistan Mint

The facilities inspected included the assay room of the Mint where the secondary standards and working standards manufactured by the Mint for the provincial governments are kept. The facilities available in this laboratory are more than adequate for the purpose of the work carried out. Recently, a set of reference standards from 20 kg to 1 mg have been calibrated at NPL, Teddington, United Kingdom. The Mint has purchased a stainless steel kilogram weight which has been calibrated and certified by the BIPM in Paris. This may be more accurate than necessary for the work that the Mint performs.

There does not appear to be a temperature recorder for checking temperature during calibration. Mr. N. M. Butt of the Pakistan Mint states that sensitivity tests are carried out on the balances, and a measure of the standard deviation is obtained, but no records appear to be kept. Difficulties arise in having balances repaired. This situation is a factor which NPSL should also consider especially in setting up a supporting service within NPSL to handle precision work of this nature. It is doubtful whether any organizations handling the maintenance of governmental weighing instruments can at this time handle this kind of work. It would be realistic to hand over the 1 kg standard calibrated at BIPM to the NPSL for use as a "Primary

Standard" when its laboratory is fully operative. The Mint's reference standards can then be sent for calibration to the NPSL. It may also be useful if records were kept of the performances of the best balances each time they are used. In this way, ample warning is obtained, for example, of a deterioration of the knife edges.

The Survey Team visited the weighing facilities which appeared well equipped and capable of doing accurate weighing. Calibrations are provided for outside users. The laboratory is well maintained, and the staff seems to be well informed. The security seemed minimal for such an important place. The Survey Team was told that the Mint has a good chemistry laboratory capable of doing work with the accuracy required for coinage analysis, but the team did not see it. The laboratory would use SRM's if available.

17.4 January 17 - Visit to PCSIR, Lahore Laboratory

Under directorship of Professor M. K. Bhatty, the Lahore establishment of PCSIR is engaged principally in applications of chemistry, and much of its work is process oriented. The Laboratory is capable of providing the necessary engineering to acquire adequate design and fabrication facilities for building pilot plants of moderate size. These functions are carried out for a growing number of development schemes. The total staff includes 700 employees, of whom 225 are scientists including 60 Ph.D.s.

Although there has been little time allotted for chemical research, chemical analysis services are available for performing the control analyses required for pilot plants that have been developed. Current work includes verification of low-grade iron ores, graphite from low-grade ores, aluminum from clay, production of titania, dehydration of vegetables, production of baker's yeast, and oils from rape and mustard seeds. The Laboratory also engages in the production of analytical grade chemicals on the pilot plant scale.

Currently, the Laboratory is operating with eight divisions:

1. Chemical Engineering and Pilot Plant Design and Development
2. Food Technology and Fermentation Division
3. Glass and Ceramic Division
4. Ore Processing Metallurgy Division
5. Chemical Standards and Testing Division
6. Industrial Organic Chemicals Division
7. Oils, Fats, and Waxes Division
8. Solar Energy Division

There are a good number of development and in-house projects under investigation in the various divisions, and some development projects are near completion and ready for industrial exploitation.

The important current R&D activities involving sophisticated and appropriate technology at Lahore involve:

1. Dehydration of vegetables--A pilot plant with a dehydration capacity of 1.5 to 2 tons per day is in operation. Pilot production of several vegetables is being carried out and new avenues in this direction are being examined.

2. Baker's yeast--Know-how has been developed and a pilot plant of 200 pounds per day capacity has been set up.

3. Minerals--Pakistan has considerable deposits of various minerals and ores spread throughout the country. Some of these ores are of low-grade quality and cannot be readily utilized. In such cases, before they are subjected to extractive procedures, they require preprocessing.

Other important research projects at Lahore include:

1. Quality control of laboratory glassware and optical glass is studied by measurements of index of refraction to assure homogeneity and accuracy of product definition.

2. Synthetic fats from chemical and bio-chemical reactions are produced on a laboratory scale, and the setting up of a pilot plant is in progress. Early results are being evaluated.

3. A small bran stabilization unit for recovery of rice bran oil for food and industrial purposes has been fabricated and tested in the laboratories.

Lively discussions on these and other topics continued during a dinner hosted by PCSIR/Lahore under Dr. Bhatty.

18.1 <u>January 18 - Visit to Radio General Appliances (RGA)</u>

The Radio General Appliances Company manufactures television receivers, designed and made under license by Toshiba, with an annual production capability of 25,000 monochrome and 5,000 color sets. Another factory of the firm carries out small-scale assembly of radios. Eighty percent of the television components, including the tubes, and twenty-five percent of the radio components are imported. At present, very little technical assistance is supplied by Toshiba although agreements have been made for training the staff by sending them to Japan and Germany.

RGA makes extensive use of about 30 subcontractors and reports great difficulties in obtaining components to specification. Some lack inspection equipment, and consequently, it is very difficult to enforce any control of quality, even for the use of go/no-go gages. Imposing strict quality control on products of these subcontractors by a rather abrupt approach would cause bankruptcy in many cases. To avoid this, RCA tries to persuade subcontractors to establish test facilities. They would wish to train subcontractors in quality control by providing test equipment. However, for this purpose, RCA would have to provide instructors and secondary standards, both of which are presently lacking. NPSL should be in a better position to assist RCA's suppliers by educating them in measurement and quality control, providing them with inspection facilities, and assisting them in the manufacture and supply of test equipment. RCA claims that its product sells on quality rather than price, but it is often forced to press into use, by selection or adaptation, subcontracted items which are not to specification.

The most basic electrical measuring instruments which RCA has are frequency counters, a Yokogama dynamometer, and a digital voltmeter. None has been calibrated since purchase. RCA also undertakes some production for a defense project and, in this context, has a fairly wide assortment of mechanical gages and measuring tools which are used by mechanics to gage each component as it is produced. These gages are monitored and periodically sent to Karachi for checking. The elements of a traceable quality control system are thus being realized, and it is likely that the experience thus gained will lead to an improvement also of metrology in the firm's commercial operations.

18.2 January 18 - Visit to the Electronic Manufacturing Company, Lahore

The Electronic Manufacturing Company, owned by Philips of the Netherlands, is well equipped with binocular microscopes to assemble integrated circuits from electronic chips. It is essentially a labor-intensive international operation with a total staff of 200 employees and sited in Pakistan simply because of the labor situation. It manufactures one product at a time. During the visit this was a 7400-series digital quad gate.

The raw materials are diffused slices. They are mounted, connected, and encapsulated with physical or optical examination at each stage. Some samples are tested on a Tektronix transistor tester. The quality is recorded for each worker on a daily basis showing the number of defective units produced. A two percent loss at any one point and a four percent loss at final inspection are considered acceptable. All quality control information is sent to Signetics. The entire output of the factory is shipped to Korea for electrical testing, and then back to Philips in Holland for marketing.

ELMAC claims to have made successful use of PCSIR. The advantages to Pakistan from this operation are that it provides work and some training to ELMAC's staff and appreciation for quality control in the long term.

18.3 January 18 - Visit to PAK Electric Ltd., Lahore

Pakistan Electric Limited manufactures heavy electrical equipment such as transformers, switchgears, motors, and generators. Transformer cores are obtained from the United States, Germany, or Japan. Transformer losses are measured thermally using a large bench with uncalibrated deflection instruments. It is claimed that transformers are tested by BS specifications. Epstein square equipment is available in the factory, but it has no connections or auxiliary apparatus.

Despite requests, the Survey Team was unable to observe any standards or a calibration room. The only measurement equipment available is located at the production sites, and it seems likely that there is, in fact, no higher grade electrical equipment in this factory. Available are some AEG 0.2 percent meters calibrated by the University and used with motor dynamometer testing.

18.6 January 18 - Visit to the Textile College, Faisalabad

Dr. Bhatty accompanied Mr. Goonetilleke and Mr. Peiser to Faisalabad. They first visited the Textile College, where many of Pakistan's textile industry leaders were trained. The faculty, numbering about 20 specialists, showed a great deal of devotion to the teaching of about 200 four-year students, but less interest in research. The experimental and library facilities were modest. The buildings are impressive and suitable for accommodating more demonstration and laboratory material. The expertise of the faculty is an important resource for the industry. These people understand the importance of reliable measurement and quality control. By experience in other countries, it would appear that stronger support for the College from industry and Government would be cost effective. Cooperation with NPSL would prove effective for reproducible measurement standards and standard reference materials.

18.7 January 18 - Visit to Kohiner Textile Works, Faisalabad

Dr. M. S. Bhatty, Mr. H.L.K. Goonetilleke, and Mr. H. S. Peiser visited the Textile Works and were received by the mill manager and quality control officer. The quality control laboratory is well equipped in that it has sufficient facilities to exercise quality control at all stages of the operations, from the grading of raw cotton purchased to the color fastness of its cloth. There is a machine for grading cotton. Standard samples of types of cotton used by the USDA are available for comparison as are photographs of specimens illustrating ASTM practices. They have machines for testing lea strength of yarn (120 yds) and the breaking strength of single strands of yarn, plus instruments for combing the number of naps in the cone of cotton yarn. Quality control is also exercised in the purchase of dyes and other materials. A Loribund tintometer is also available. NPSL can provide the facilities needed for calibration of any of the weights used, the balances, and other equipment. A remark made by the mill manager in relation to raw materials is very significant: "They (the suppliers) know that we test them here so that they do not supply low-grade material." This is the key to problems most industries in Pakistan face in the absence of any standards in the purchase of raw materials.

18.8 January 18 - Visit to the Agricultural College at Faisalabad

The Agricultural College is very well known and has a beautiful and extensive site. Our visit was very short, and its interest falls outside the scope of this Survey. Dr. Z. A. Hashmi at one time was head of this college.

18.9 January 18 - Visit to National Fertilizer Corporation

This is a conventional superphosphate plant, which manufactures its own sulfuric acid from elemental sulfur. The company operates good chemical and soil laboratories offering farmers soil test services for organic matter, P_2O_3, N, K, and pH. The management and staff experiment on innovative ideas, but presumably are hampered by the small scale of operations. The manufacture, for example, of sodium polysulfide by reduction of ammonium sulfate with carbon in the presence of salt is recognized by the management as economically marginal. However, this company may be very well suited for cooperation with the Lahore Laboratories of PCSIR, which hope for more pilot laboratory facilities.

19.1 January 19 - Visit to Climax Engineering Company Ltd., Lahore

Climax Engineering Company is an electric equipment company of major size which manufactures a wide range of medium and heavy electrical engineering equipment such as transformers, electric motors, fans, induction furnaces, mining equipment, cement mixers, and agricultural equipment largely to DIN standards. The firm claims to meet 60 percent of Pakistan's needs in this area and manages to export to the Middle East. The Company was set up initially in collaboration with the General Electric Company of the UK but is now independent and privately owned.

All measurements are carried out at the production site, using reference instruments, usually meters generally of 0.5 percent accuracy with a makers' certificate. They are taken to the measuring site when required. The firm claims to have all the necessary test facilities, but no standards room was shown.

The measuring equipment probably is as good as that owned by customers. The firm thus manufactures and supplies items with a claimed specification which could not be substantiated in a reliable way, but which no one in Pakistan would be likely to be in a position to challenge. This observation is not a criticism of this organization, but rather a description of the prevailing situation in the majority of places which the Survey Team visited.

20.1 January 20 - Visit to Pakistan Engineering Company Ltd., Lahore

The Pakistan Engineering Company is a large, state-owned company, established in 1948 with German assistance, manufacturing lathes, drilling machines, power looms, crushers, cement mixers, rolls for rolling mills, diesel motors, pumps, and fire fighting equipment. It employs 2,600 people including 50 engineers and has its own training center. Present departments include:

1. Rolling mills, having 10", 14", and 16" diameters.

2. Arc furnaces with 4- and 6-ton capacities.

3. Inspection, quality control, and central testing laboratory.

4. Foundry and pattern shop for ferrous and non-ferrous casting.

5. Refractory shop for manufacture of special items for in-house consumption.

6. Forging and blacksmith shop.

7. Assembly and fabrication of pylons, towers, vessels, gates, etc.

As well as the following departments organized by product lines:

8. Automatic power looms (in cooperation with Japan) having widths of 46, 70, 85, and 100 inches.

9. Concrete mixers, cranes, miscellaneous heavy equipment.

10. Pumps and engines, compressors, and generators.

11. Machine tools sold in Pakistan and exported to Australia, Turkey, and Thailand.

This Company manufactures machine tools; it does have a quality assurance scheme operative in all manufacturing sections devoted to a particular product; it has a quality control equipment room, but it is not quite adequate. The greatest asset is in the person of a very effective quality control manager, Mr. Ali Ahmad, who has been active during the last five years introducing many quality control practices despite initial opposition.

The established quality control procedures are not considered rigid because of the usual problem. The claim is made that the shop is asked to work with excessively tight tolerances. If true, this would result in excessive cost or an unnecessarily high rate of rejections with a consequent loss to the Company, and if true, such a policy would cause unsatisfactory performance of products in service. In practice, if the customer is satisfied with the product, it will be sold even if it is not quite in keeping with standards.

Incoming material is monitored, generally using BS specifications where possible but also using the believed fitness for use as an overriding criterion. As a result of better quality control of raw materials, casting rejections have been reduced from 25 percent to 8 percent.

In this factory, quality control areas are clearly labeled and well demarcated at every stage of production. The standards room maintains good records of all gages and wear of all critical tools. A quality control document accompanies each item or batch, and nothing is released at any stage unless the quality control document is signed by a QC man. Where appropriate, the document applies to batches on a sampling basis.

Because PECO will continue to provide the country with a large portion of its machine tools, its needs for metrological assistance and statistical control are great. NPSL could contribute substantially in this important industry which depends critically on good measurement.

20.2 January 20 - Visit to Packages Ltd., Lahore

Collaboration between Sweden and Pakistan in 1956 led to the establishment of the modern plant of Packages Ltd. which manufactures paper and board from rice straw (a principal raw material) and produces finished packaging and printed cartons. The company performs all its own laminating, art work, printing, and subsidiary work. Its aim is to increase production (by a further 6,000 tons) in 1979 to the point where it will saturate the facilities at the site and use all the local raw material supply. The factory obtains virtually unlimited supplies of water (4.8 million gallons per day) from nearby deep wells.

The firm's laboratories are responsible for ensuring quality, especially of the paper and paperboard. They are well equipped and adequately staffed. There is no doubt that there is adequate competence within the firm to handle its measurement needs. Packages Ltd. is equipped with all the basic equipment for testing the characteristics of paper for tensile strength, bursting strength, porosity, smoothness, thickness of paper and board, reflectivity (brightness of surface), moisture permeability, etc. The reference standards, the printing section, and all samples are kept under standard conditions for the testing of paper. The firm maintains that it calibrates its instruments against test samples that are provided by the Swedish manufacturers. However, there still is an acknowledged need for NPSL to provide basic calibration facilities.

The company is completely independent of suppliers and expects not to be affected by a Government of Pakistan decree which calls for paper and paperboard to be manufactured in the international standard A series. The Government of Pakistan may find it advisable to open constructive discussions with this firm to avoid misunderstandings and losses. Dr. Zaidi states that there is a definite instruction to use these international paper sizes.

21.1 January 21 - Visit to the Office for Weights and Measures of the Government of the Punjab

The weights and measures activities in the provinces come under the Labor Department which is very active in its publication program. For example, it has issued Enforcement Rules using the International System (SI) in 1975 which were revised and expanded in 1976. It explains:

(a) The authority to maintain secondary and working standards, and standard instruments.

(b) The appointment of officials and inspectors with power to inspect, verify, forfeit, or adjust and stamp.

(c) The imposition of penalties on manufacturers, users, and inspectors for breaches of these regulations.

(d) The prohibition of demanding or receiving quantities different from those determined from the standards.

(e) The power to make further rules.

In the 1976 revision, the construction and tolerances of the standards are given in great detail, with the conversion factors from and into customary units (in most cases with an excessive number of significant figures).

21.2 January 21 - Visit to Ravi Rayon Ltd., Kala Shah Kaku

Ravi Rayon was built by a German firm which has introduced the production process, the equipment used, and the test procedures employed. This firm has been Government regulated and managed since 1972. Plans for this plant were made in 1959, and the project went into commercial production in 1966. It is the only integrated man-made fiber plant in the country for the production of acetate rayon yarn. It consists of 20 different chemical processes working as integrated units producing cellulose di-acetate which is the chemical name of acetate rayon produced from molasses and cotton linters. The firm finds a declining enthusiasm among its customers for this product in competition now with polyesters and the other newer man-made fibers. The company finds it very hard to adapt its plant to new products. For major decisions, local management is subject to control from Islamabad. Encouragement for innovative local initiatives in adaptive technology might put this plant back on a profitable basis.

Chemical testing is largely confined to acceptance of molasses used as starting material in the process. Physical tests include measurement of viscosity of the cellulose acetate solutions to provide proper spinning and specific gravity (degree Brix) of the molasses which is a key measurement determining the expected weight of the polymer. Physical tests are also performed on the finished yarn, and performance testing of the finished product is made at an experimental weaving plant.

Most of the tests are manual wet methods according to the standards of the German Institute for Standardization (DIN) and the American Society for Testing and Materials (ASTM). Some samples of rayon are maintained as quality control standards which are used from time to time in molecular weight testing, while specific gravity (Brix) is made with hydrometers using manufacturers' calibrations.

Ravi Rayon claims to have no major complaints but would like to have a molecular weight standard and possibly calibration services for their hydrometers. The Survey Team neither observed nor heard of test of product for service life, such as sunlight fading or washability. In a competitive market, such tests would become necessary.

Some Survey Team members were taken through the power generation facility which generates its own power and has a capacity of 6.6 MW in three 2.2 MW sets. Normally 2 out of 3 of these are in use and generation is at 11 kV, supplying 70 percent of the factory's needs, and all that is used for the operation of machinery. The power measuring instruments, provided with the generators, are of German origin. They are said to be recalibrated when suspect. The team never discovered what was meant by "recalibrated."

The principal measurement needs of the plant are for the maintenance of pneumatic and electrical transducers which are widely used for process control in the chemical plant. Thermometry is performed by using platinum resistance thermometers and thermocouples. The temperature range of principal interest is from 0° to about 200°C. The accuracy required is said to be at best 0.1 degree. The laboratory winds its own resistors for on-site checking of resistance thermometers. They are checked on a Hartmann and Braun four-decade bridge. Thermocouples, made in the laboratory, are calibrated on the Hartmann and Braun potentiometer, which is similar to the resistance thermometry bridge in that it is regarded as "absolute." Although some resistors in the potentiometer had burnt out and had been replaced, no recalibration had been carried out.

The plant experiences a particular problem in the measurement of flowmeters following damage. The laboratory can only repair them so that the appearance and operation come as close as possible to their previous condition. It is not possible to suggest any quick and easy solution to this problem, since the measurement is for large flow rates.

21.3 January 21 - Visit to Daud Hercules, Sheikhupura

Daud Hercules, founded in 1967 in cooperation with Hercules of the United States, produces urea for fertilizer. The plant has always run at approximately 100 percent of the design capacity. It is now operating at 110 percent of that capacity and can sell everything produced. Natural gas, which is 94 percent methane, is the principal raw material. The methane is reacted to give carbon dioxide and hydrogen which are then catalytically reacted with air to yield first ammonia in a Kellogg plant and, by further reaction with the carbon dioxide, ammonium carbamate and then urea. In this process, sulfur in the natural gas is removed by reduction to hydrogen sulfide, which is then reacted with zinc.

The firm has a laboratory that controls the process at various stages. It is somewhat small and does not test incoming gas. The product is only certified to contain at least 45 percent of nitrogen which corresponds to approximately 98 percent urea, the remainder being mostly moisture.

Daud Hercules is well designed, well managed, efficient, and did not present any major mechanical or electrical measurement problems. The control of biuret is the major chemical problem. No attempt is made to produce more than one grade for different sensitivities of crops to this undesirable dimer.

21.4 January 21 - Visit to the Electric Equipment Manufacturing Company Limited

Commonly known as "EMCO," this factory is in the private sector and produces all types and sizes of high- and low-voltage porcelain insulators and other porcelain products in technical collaboration with NGK Insulators Limited of Japan. The plant is meeting Pakistan's entire demand for insulators and has a big export potential, because these products are likely to stand up to international competition for production cost and product quality.

The Survey Team was shown the entire manufacturing operation and the laboratory that controls acceptance of materials and the experimental pilot plant to produce and test formulations. The Company is quality-control conscious and performs many tests at various stages of production, including some on the physical and chemical characteristics of the clays, the viscosity of slips, the firing temperature with Seger cones, voltage breakdown, thermal shock, and dye penetration. It has extensive contacts with PCSIR with whom it maintains a rather close liaison.

All the raw materials used are of high quality and available from Pakistan, mostly from the Northwest Frontier Province. The raw materials are batch tested, and the initial inspection is accomplished principally by eye. After crushing and milling, samples are monitored for particle size, shrinkage, strength, firing, and thermal expansion. There is close quality control at every stage of the pre-firing operations. Material rejected because of unsatisfactory particle size, water content, or cast strength can be returned to earlier stages for reuse. After firing, rejected material cannot be reused.

After forming and drying, the insulators are fired in a reducing atmosphere for 72 hours, with temperature monitoring by potentiometric recorders all the way down a long tunnel furnace. Obviously, the factory has a fairly widespread need for temperature monitoring and control. The accuracy needed is 2° to 3° at 1200°C. Thermocouples are calibrated against a temperature cell, and those in use are checked against other "standard" thermocouples at 3-month intervals if they are temperature cycled or at 6-month intervals if they are maintained continuously at temperature. After completion, the insulators are examined with a fluorescent dye for cracks and are given thermal shock and mechanical strength tests. They are also subjected to a spectacular flash-over test which would detect any internal cavities or cracks.

This plant appears to have a well-controlled operation and to produce a high quality product. Electrical measurements could not be regarded as traceable to any well-defined standard, but the accuracy required is not high so that this small deficiency is not of great importance. Some additional clay-swelling tests would probably be found useful.

D. Visits in the Karachi Area

22.1 January 22 - Visit to the Pakistan Standards Institute, Karachi

The Pakistan Standards Institute (PSI), with an annual budget of 1.6 million rupees (U.S.$160,000), is the national organization, the counterpart to the American National Standards Institute (ANSI), the British Standards Institute (BSI), and the French Standards Association (AFNOR). PSI sets quality standards for Pakistan and interfaces with international organizations such as the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). It is under the Ministry of Industry and develops standards as the need arises. It bases them on ISO standards, BSI standards, or standards of other countries, in that order, with modifications as needed for local conditions. If Pakistan industry cannot meet a standard which is based on an international standard, the Pakistan standard may be relaxed for one year. A charge of .05 percent of the annual production is levied on products based on standards which are not mandatory.

PSI, with a permanent staff of 100, operates through a General Council consisting of 60 members; an executive committee of about 15 members; a finance committee; Divisional Councils in Mechanical Engineering, Building, Textiles, Electrical Engineering, Chemical Engineering, and Agriculture, each of which constitutes a division headed by a deputy director; and Sectional Committees, the latter being assigned for specific temporary purposes. Some 1,400 voluntary standards have been developed to date and are periodically reviewed. There are a few mandatory standards established where health or safety are involved. A standard can become mandatory by an order in the Official Gazette based on a decision by a standing committee consisting of representatives from the export department, PSI, manufacturers, etc. The Government publishes lists of items for which standards are mandatory, and the items for which they apply must then be marked.

After satisfying inspection, PSI permits companies to affix its seal to products that meet PSI standards. There is a provision for withdrawal of approval and of the permission to use the PSI seal.

The scale of fees is as follows:

Application	100 rupees (about US$10)
Annual license	250 rupees (about US$25)
Marking fee	.05 percent of production cost

The income from this source represents 10 percent of the PSI budget.

PSI maintains a good library of the standards of ISO and other countries. It thus can be considered a national resource.

The NPSL would find it rewarding to actively cooperate with PSI by serving on various committees. It could also provide inspection services in special cases, and in general, cooperation would ensure that PSI standards are compatible with good measurement practices.

22.2 January 22 - Visit to the Central Testing Laboratories, Karachi

The Central Testing Laboratories (CTL) in Karachi were established in 1956 and function under the Ministry of Industry alongside the Pakistan Standards Institution (PSI) and the Pakistan Industrial Technical Assistance Center (PITAC)--see 17.1. Testing is carried out in chemicals, building materials, textiles, and in electrical and physical fields. The laboratories never aim to test to accepted PSI standards.

The mechanical laboratories, for example, possess the basic instrumentation for product and gage testing and calibration, but they do not demonstrate traceability and have not carried out the basic calibrations for some time. The laboratories use slip gages with a measurement accuracy of 10 μm and a maximum length of 1 meter. Maintenance procedures for equipment need to be overhauled. There is a definite need here for assistance and further instruction, such as eventually could come from NPSL.

CTL has applied to the U.N. Industrial Development Organization (UNIDO) for assistance in improving its equipment. A wide range of very good equipment to be supplied under UNIDO auspices has been recommended. An excellent standards laboratory has been designed and already installed. The UNIDO adviser was forced to do so because of the lack of a good national standards laboratory. To mix a test laboratory with the primary measurement standards function may not really be desirable for Pakistan. It is desirable, of course, to have CTL equipment considerably improved, but the majority of equipment recommended would be more appropriate for a primary laboratory rather than for use in testing, which is presumably the function of CTL when NPSL is in operation. If this equipment is to be supplied to Pakistan with UNIDO aid, it would be desirable to have it transferred to the national laboratory. The Survey Team is well aware that such a transfer between different ministries may be impractical. The alternatives of abandoning the NPSL plan and making CTL the national standards laboratory is equally unacceptable. A third and probably least offensive solution lies in acceptance of the luxury of some wastage of optimum UNESCO equipment utilization.

22.3 January 22 - Visit to the Pakistan Institute of Cotton Research and Technology, Karachi

The Pakistan Institute of Cotton Research and Technology has an impressive building, extensive laboratory space, and a qualified staff. It is the first location visited by the Survey Team where relative humidity and temperature are recorded. There is no electrical metrology, although mechanical properties of cotton are tested. Assistance by NPSL would be welcomed.

23.1 January 23 - Visit to the Pakistan Space and Upper Atmosphere Research Committee (SUPARCO), Karachi

Pakistan is rightly proud of its Space and Upper Atmosphere Research Committee (SUPARCO) and its associated facilities which are more generously funded than corresponding PCSIR functions in support of industry. Dr. Salim Mehmud, the Executive Director of SUPARCO, who hosted a dinner for the entire NBS/AID/PCSIR Survey Team, is keenly aware of the problems and needs associated with standards measurement in Pakistan. Dr. Mehmud plans to visit the National Bureau of Standards in the near future and looks forward to close cooperation with NPSL, when fully in operation.

The visit to SUPARCO provided a rare view of modern science and technology in Pakistan. The institution is a relatively new one, started in 1964, and has since moved its modern building to the outskirts of Karachi. The present building is not yet extensively utilized and undoubtedly offers space for expansion. The work is aimed at two principal activities:

(1) Radio beacon experiments to deduce electron contents in the upper atmosphere.

(2) Acquisition and interpretation of LANDSAT data through a cooperation program with NASA.

The first of these involves a series of experiments to investigate upper atmosphere ionization. Ionospheric measurements are being made by Ionosonde and VLF measurements from fixed transmitters with satellite ground reception stations located at Peshawar and Karachi. All of this work is principally aimed at ionospheric propagation with considerable interest also in ionospheric physics. Information from these experiments is used to provide forecasts of radio propagation to civil aviation, radio Pakistan, and others.

Since 1973, SUPARCO has acquired LANDSAT 1 and 2 data through arrangements with NASA and from the U.S. Earth Resources Data Center (EROS) and, thus, has a very good coverage of the whole country. Undoubtedly, this is a method of gathering useful information about the geography, agriculture, and forestry of Pakistan. Nearly all of the interest is in techniques of data presentation and data processing which can be used to isolate particular features, such as snow volumes, changes in the course of rivers, water quality, foliage, insect pests, shortage of soil nutrients, etc.

23.2 January 23 - Visit to the PAK-Swiss Training Center, Karachi

Scientific and technical institutions use a large variety of intricate instruments and apparatus for which adequate service and maintenance are required. New countries in development like Pakistan soon find a priority need for such services.

The PAK-Swiss Training Center started functioning in September 1965 as a joint project of the Swiss Foundation for Technical Assistance and the Pakistan Council of Scientific and Industrial Research. It aims at training a corps of technical personnel to be experts in the techniques of precision mechanics and the maintenance, repair, and fabrication of scientific instruments and other precision equipment. After receiving their diplomas, these young men find employment throughout the technical institutions and manufacturing companies of Pakistan. The Center is situated within the campus of the PCSIR Laboratories in Karachi. The PSTC is equipped with precision machines and equipment to manufacture jigs, punching tools and dies, tablet punches, simple and compound gages, precision types of machine components, and quality control equipment. Dimensional accuracy up to 0.003 mm and radial accuracy up to 2 seconds can be achieved.

Since 1965, the Center has steadily progressed and expanded its activities. It has two divisions, namely the Training and Service Divisions. The Training Division offers a three-year diploma course of Associate Engineering in Instrument Technology and advanced courses in industrial electronics, optical technology, and instrumentation as applied to process control.

The Service Division gives realistic experiences to the trainees and, at the same time, solves problems in the industrial environment, for instance, by manufacturing a specific replacement part or by designing a new equipment system. The Service Division was first introduced in 1968 and has expanded into three major sections:

1. Production services.
2. Design services.
3. Instrument repairs and calibration services.

The PAK-Swiss Center has established its name very well, not only as a training center but as a first aid to the engineering industries. On the Service Division side, it is, for instance, the biggest manufacturer of tablet punches and dies for the pharmaceutical industries. It is also making various types of comparators for the quality control of ball bearings. The Center has the technical know-how and equipment to undertake repair, maintenance, and calibration of electrical instruments such as temperature control equipment, electronic instruments including measuring and testing devices, and optical instruments which include theodolites and profile projectors.

Since facilities for training technicians in the Asian region are few, the Center could play an important part in the region through arrangements with other national and international agencies. It may well be able to expand its services and take in more students, especially from Pakistan itself. The ease with which all former students of the Center are absorbed in industry is proof of the relevance of the training. Without such training, industry cannot meet its challenges.

23.3 January 23 - Visit to PCSIR, Karachi

The visiting Survey Team received an especially warm welcome at the Karachi Laboratories of the PCSIR, the home base for many of the counterpart team members.

The important research and development activities involving sophisticated and appropriate technology at the Karachi Laboratories of PCSIR are briefly mentioned below.

Traffic signals: PCSIR has developed traffic signals from locally available parts, which are less expensive than the imported varieties. Many signal units have been installed in Karachi and elsewhere in the country.

X-ray generator units: X-rays are finding ever increasing use in the techniques of structure determination of chemical compounds, metals and alloys, and of large biological molecules. They are also used in the phase and elemental analysis of materials, including minerals. Such X-ray diffraction equipment is being widely used in material testing laboratories and in industries. The development of know-how in this area will aid in quantity production if it is considered desirable.

Mazri fiber: Mazri leaves have been used for preparing matting, fans, baskets, hats, sandals, and other articles for a long time. The fiber when separated out can stand tensile and flexural strain better than raw leaves. These leaves are available in huge quantities as a result of wild growth in Baluchistan, and at the invitation of the Baluchistan Government, a chemical and mechanical process for the separation of fibers was developed by PCSIR.

Fish protein concentrate: The product developed is meant to eradicate protein deficiency in the population, particularly in children and lactating mothers. Fish protein concentrate containing 90-95 percent protein is made from the non-bony fish and can be incorporated for public use in various food items such as wheat flour and biscuits up to 1 percent without being detected and without affecting its baking quality. Laboratory scale studies have been conducted and are complete.

As with the other PCSIR establishments, the majority of the work performed in the various research divisions (electronics, agro-industrial chemical, applied biology, chemical engineering, plastics, and pharmaceuticals) does not involve precise electrical metrology. The electrical measurement laboratory maintains instruments which have been calibrated against a reference instrument and bear calibration labels even though they have not been calibrated since purchase. The majority of the best instruments have been transferred for use to NPSL. On the basis of competence, it would seem desirable to have this laboratory serve as the electrical measurement facility at Karachi, acting as a "Karachi branch" or subsidiary laboratory of NPSL.

24.1 January 24 - Visit to the Pakistan Machine Tool Factory

The Pakistan Machine Tool Factory is a large and modern state enterprise which works to DIN and JIS standards. The materials testing department of the Factory works as an independent unit comprised of six different laboratories equipped with precision apparatus and a qualified staff trained under foreign experts. Its mechanical testing procedures are excellent except that most of its equipment presently needs recalibration. Quality control exists at each manufacturing step, and it maintains tight control of incoming supplies.

Both the metrology laboratory and the tool room of the Pakistan Machine Tool Factory have been extremely well equipped with universal measuring machines of different bed sizes and a jig boring machine with a precision of 1 μm by Oerlikon of Switzerland with whom there is a joint venture program. Records of temperature and humidity are maintained, and the gages are tested periodically. A spectrometer in excellent condition is being used largely to check the composition of lots of metal for identification.

24.2 January 24 - Visit to the Pakistan International Airlines Laboratory, Karachi

The Pakistan International Airlines Laboratory lies outside the Pakistan context in that it is a typical international airline calibration laboratory with the same high standards of calibration procedures, quality control, and reference standards which one encounters in airline maintenance laboratories worldwide. There are two large computer-controlled automated testing systems in use which are similar to those in the United Kingdom and the United States.

The principal electrical standard is a compound "calibration transfer standard" made by Boonton which was initially recalibrated by the makers at one year intervals and is now recalibrated every eighteen months. The laboratory maintains rubidium and cesium beam frequency standards calibrated by the Pakistan air force to produce the highest accuracy in frequency measurement. When standards are required for defense work, which of course includes air operations, calibration has been obtained from the armed services laboratories.

In most countries, the armed services have led the way in metrology and standards, and it could well be that they could do so in Pakistan, particularly if the interplay between industry and the armed services were increased. For some, it would appear to be a serious omission to exclude the armed services from contributing to metrology and standards for the country. However, in countries which need or choose to maintain a strong defense posture, costly resources are often more readily available for the military than for the civilian sector. Military advisers from more highly industrialized countries understand and insist on the application of standardization practices. Guidance of the civilian by the military standardization system, however, does not work well in practice, because of the priority that the military must claim for its own needs; the confidentiality which the military would desire for its best capabilities; and the limitless relatively unorganized demand from the private sector.

24.3 January 24 - Final Team Discussion

The Survey Team met in executive session during the afternoon and evening. The principal points raised have been recorded in Section II. The atmosphere was most cordial, and there was every expectation for all Survey Team members to remain in cooperative touch with one another by correspondence.

25.1 January 25 - Visit to U.S. Consulate General

Mr. Peiser reported the outcome of the Survey to the U.S. Consulate General and the Karachi Branch of USAID, whose officials would have wished that the AID Mission in Islamabad had requested their participation in the Survey visits in the Karachi region. Mr. Peiser hosted a discussion dinner for Dr. Ghani and members of the U.S. Consulate General and AID personnel in Karachi.

27.1 January 27 - Visit to the Chamber of Commerce and Industry

After departure of the remainder of the Survey Team, Dr. A. Ghani and Mr. H. S. Peiser were received by the President of the Chamber of Commerce and Industry (CCI), Mr. A. Majeed Suleman Bawany, and Mr. Agha M. Ghouse, Secretary and Economic Adviser of the CCI. CCI was planning a high-level quality control seminar followed by a training seminar in February. Dr. Ghani was invited to present a paper on the Survey Team's preliminary conclusions which are given in a letter to Dr. A. Ghani (see Section III.A). Mr. Bawany requested that an additional paper from NBS be presented, but this was impractical. Also discussed was an article on the Survey published in "Dawn," the most important English newspaper in Pakistan (Appendix 2). It followed similar articles in other papers and news reports on the Pakistan radio.

CCI is strongly supportive of PCSIR, NPSL, and quality assurance programs in Pakistan industry. The problems are understood here, although perhaps those concerned with labor are overemphasized relative to those with management. The principal objective of CCI is to revitalize private enterprise, and it is permitted to do so with limited Government support. A personal visit to CCI was made by the President of Pakistan, General Zia-ul-Haq, who had indicated that constitutional guarantees would be given against further nationalization. CCI plays a voluntary role in health and education services, as well as for programs of more direct benefit to commerce and industry such as the export processing zone to be established near Karachi. CCI has held well documented conferences on ports and customs facilities, the trade imbalance, and productivity. There are about 500 CCI company members and 5,000 individual associate members.

V. NOTES ON THE ECONOMY OF PAKISTAN

(Basic Information Intended for U.S. Readers)

Pakistan is basically an agricultural country with about 74 percent of its population living in rural areas constituting 55 percent of the civilian labor force and 34 percent to the GNP. Agriculture continues to be the mainstay of the economy since it meets the requirements of food and the raw materials for agro industries. Until recently, the rural sector has been the source of cheap labor, cheap raw materials, and whatever capital was available. This sector has also provided the markets for the industrial goods manufactured by the modern sector.

The GNP of Pakistan is about $20 billion; that is per capita about $250; the growth in real terms during the last 10 years is no more than 10 percent. Diverse taxes, duties, high interest, and government regulations are seen as a burden. Nationalization by previous administrations--often without compensation--has lowered productivity, virtually stopped expansion, and resulted in factories running at a loss though continuing their output of useful products. The chain of necessary approvals for innovative expansion at Government-owned factories makes it difficult for the present administration to reverse the trend. Private industry fares better now, but the talk of an aim to a zero-interest economy may either discourage foreign capital or perhaps cede too much control of Pakistan's industrial growth.

Pakistan has a serious negative balance of payments in general and with respect to the United States, the United Kingdom, South Korea, and Sri Lanka, in particular, but Pakistanis working abroad, especially those in the Middle East, send home about $1,600 M per year. These remittances, if present trends continue, will exceed total commodity exports by next year. Actual exports include rice, salt, cotton in yarn and cloth, raw cotton, silk, rugs and carpets, soda, sulfuric acid, paints, bicycle tires, paperboard, fans, surgical instruments, sports goods, and airline services.

In manufacturing, the modern sector comprises mainly large- and medium-scale establishments, around 20 percent of which are owned or controlled by the Government. The modern sector produces close to 75 percent of the country's total output of manufactured goods, which include the bulk of the consumer goods. The traditional sector, consisting of small-scale manufacturing establishments and cottage industries, are mainly located in the rural areas, especially around Lahore, Gujranwala, and Sialkot. It accounts for around three-quarters of the manufacturing labor force, but is estimated to contribute only around one-quarter of the total output of manufactured goods.

Foreign trade has become exceedingly important to the economy since the end of the 1960s. Despite the advances that had been made in manufacturing, enabling it to supply most of the country's requirements of consumer goods, the country still has to import most of its capital goods, a considerable part of its intermediate goods and chemicals, as well as fluctuating quantities of wheat, edible oils, fertilizer, and other foodstuffs. The Government has increasingly exerted pressure on the private sector to raise the level of its exports, in order to finance a larger part of the import bill and thereby offset the decline in foreign aid and the rising costs of the foreign debt.

Between 1950 and 1965, the large-scale manufacturing sector had expanded rapidly while agriculture stagnated. In the late 1960's and early 1970's, the roles were reversed. Agriculture expanded under the influence of the new agricultural technology, but private sector large-scale manufacturing, reacting negatively to the difficulties the economy was undergoing (including after 1971 government nationalization of industry), reduced investment to well below the levels of the early 1960's. As a result, new investment tended to be limited to the small-scale manufacturing sector, which the Government, it was generally considered, would not bother to nationalize.

VI. NOTES ON SCIENCE AND TECHNOLOGY IN PAKISTAN

(Basic Information Intended for U.S. Readers)

A. General

In the first few years after independence, Pakistan had inherited almost no technological capability, and the needs of the country were largely met through imports. This is not to say that efforts were not also made to develop an indigenous industrial base. The development of industry had been accomplished mainly by importing foreign technology, which resulted in a partial industrialization of the country but in the lack of a proper science and technology infrastructure. This process of importation of technology to meet the immediate requirements of the country continued out of necessity.

In industry, the tendency had been towards the wholesale introduction of technology from industrialized countries, often as turnkey projects. The modern sector thus built has tended to be capital intensive, labor saving, and dependent on imported machinery and chemicals, and much of the transferred technology in Pakistan has taken place in the agro, chemical, and engineering industries.

There are few large industries which have reasonably adequate inspection and quality control facilities, and there is a great need for proper guidance in selecting the right materials, quality control, maintenance, interchangeability of parts, and work-study techniques for mass production. A critical future development need for Pakistan in the process of industrialization involves the formulation of standards for finished products and strict enforcement of quality control. An institutional framework for this does exist in the form of PCSIR, PITAC, etc., but it is somewhat underutilized.

Of particular interest to Pakistan currently is the development of an indigenous capability for the manufacture, repair, and maintenance of scientific equipment. There are substantial quantities of equipment presently lying unused, either due to a lack of spare parts or the technical know-how for repairs, but information available suggests that Pakistan has an acute shortage of technically trained manpower.

It is axiomatic that scientific and technical information is an essential prerequisite for the development of a country. Pakistan's capacity for acquiring, processing, and disseminating such information is limited as regards institutions, trained personnel, and financial resources. On the other hand, this information is a major component of a nation's policy for science and technology. A primary objective would be to establish an organization for the collection, processing and dissemination of scientific findings from national as well as from foreign sources. Only recently, a full-fledged Ministry of Science and Technology has been created to perform the functions of overall coordination and assisting the Government in the identification of the S&T programs relevant to national requirements.

Scientific and technological research currently going on in Pakistan is concentrated mainly in Government-financed research establishments like PCSIR which acts as liaison with Government-owned and private industries. In this regard, it must be noted that Pakistan has made substantial progress towards the creation of an institutional infrastructure activity. Nevertheless, the growth has not been within the framework of organizations which have their own laboratories and research divisions.

There is a wide variety of existing experience and capability which needs to be identified, organized, promoted, and utilized to respond to the national needs through an objective and realistic policy.

After 30 years, Pakistan has developed a reasonable level of capability in S&T, but has not yet reached the stage when indigenous efforts could contribute significantly to industrializing the country.

In Pakistan, R&D funding has been erratic and inconsistent. Recently as a result of the efforts of the Ministry of Science and Technology in collaboration with the National Science Council and the Pakistan Academy of Sciences, a draft policy for S&T was formulated, discussed, and revised in a workshop organized in collaboration with the U.S. Academy of Sciences in October 1976. Over 200 scientists and engineers participated in this exercise. However, this plan has yet to be approved by the Government of Pakistan. There is clearly a need for a national policy and plans which are clearly defined. They should allow for views and initiatives to pass both up and down organizational lines of management. Identification of priority areas in R&D has proceeded successfully as judged by the awareness of the scientific community of some major governmental objectives.

Although no one could deny that some Pakistanis are among the world's most successful and the most erudite scientists and technologists, the identity and number of specialists available for service in Pakistan is not well known. Individuals go abroad temporarily, and even more permanently, when attractive opportunities are offered. Their loyalty to Pakistan is rewarding to the economy. Within the country a shortage of competent teachers and technologists persists. Manpower data is said not to have been comprehensively collected, and a far-sighted plan for manpower development is widely advocated. Self-criticism is often heard on the subject of natural resource development. For example, Pakistan is potentially the second largest supplier of natural gem crystals after Brazil. The scientific community is not convinced that the economic development of this resource through indigenous technical know-how is adequately supported. The Survey Team, however, had not the opportunity to verify or challenge this viewpoint.

Despite the existence since 1974 of a Pakistan Scientific and Technological Information Center (PASTIC), information gathering and dissemination is said to be still deficient. In the standards area, this was generally confirmed by the Survey Team although PSI has a good collection of product standards, but it seems relatively little used by industry.

Difficulty is experienced in good scientific communication on a fully international and regional level. Some selected communication links with the outside world could benefit Pakistan greatly. The outstanding welcome received by the Survey Team is indicative of this need being strongly felt by the scientific community in Pakistan.

The salary structure of scientists and technologists, especially those in Government service, is seen as a serious obstacle to the maintenance of excellence. Key roles in science and technology are assigned to the following organizations:

1. Planning Commission
2. Ministry of Science and Technology
3. The National Science Council of Pakistan
4. The Pakistan Science Foundation
5. The Pakistan Council for Scientific and Industrial Research
6. The Pakistan Institute of Development Economics
7. The Appropriate Technology Development Organization
8. The Pakistan Academy of Sciences
9. The Pakistan Association of Scientists and Scientific Professions
10. The Hydrocarbon Development Institute of Pakistan
11. The National Design and Industrial Services Center
12. The Pakistan Atomic Energy Commission

A description of each of these would be inappropriate within the confines of this report. It might just be mentioned that NBS has had a PL-480 project on trace analysis with the research institute PINSTECH associated with the Pakistan Atomic Energy Commission. However, at this time cooperative research fields cannot be maintained because of unavoidable restrictions associated with that establishment.

A fuller description of only PCSIR and NPSL because of their prime relationship to this Survey follows:

B. <u>The Pakistan Council of Scientific and Industrial Research</u>

With headquarters still in Karachi, the former capital of Pakistan, the Pakistan Council of Scientific and Industrial Research under the Ministry of Science and Technology was the initiator and principal host to this Survey of Measurement Standards in Pakistan. It is a knowledgeable, active, well-recognized, and industry-connected technical agency of the Pakistan Government.

The scientific and technological manpower of PCSIR comprises 600 qualified personnel with a complement of support staff of about 1,300 persons. PCSIR has directed its major activities at its multifunctional laboratories in Karachi, Lahore, and Peshawar to the support of selected industries judged most important to the economy. It also operates the Fuel and Leather Research Center, the Pak-Swiss Precision Mechanics Center (Section IV, 23.2), and the Instrument Training Center. The Survey was principally concerned with the PCSIR plan, now approved and funded, to establish a strong National Physical and Standards Laboratory in Islamabad.

Publications include the Pakistan Journal of Scientific and Industrial Research (bimonthly), Science Chronicle, and Technology Digest. The principal research projects are described in Section IV on team visits to the component laboratories. Compared with Mr. Peiser's visit in 1974, this Survey Team found few really new initiatives. Nevertheless, the achievements of PCSIR are impressive in research, development of industrial processes, import-substitution and defense-oriented projects, successes in problem solving, quality-control and advisory services, and also in training programs. However, PCSIR, like counterpart institutions in other countries, has found it difficult to demonstrate leverage through significant returns in benefits to Pakistan or to obtain reimbursement for the majority of its projects. The result has been a reticence by the Government to provide even incremental support to PCSIR. In consequence, the PCSIR staff considers the organization underappreciated and underfunded.

A short history of PCSIR (up to 1977) by Dr. S. M. Abdul Hai was in the hands of the Survey Team members prior to their departure for Pakistan and is available from NBS.

C. The Plan for the National Physical and Standards Laboratory

It is very important to acknowledge that it is not this Survey on Pakistan's Measurement Standards by the PCSIR and the Pakistani Government who made the decision to establish a national measurement laboratory, to staff it with highly qualified scientists, to support it also with buildings and equipment, and to lead it into close cooperation in support of industry. When one takes into account the difficult years which this country has suffered since the plan was first enunciated in 1972, one must admire the foresight and understanding with which the leaders of PCSIR have carried this project to the beginning of implementation when no similar plan for other centers was permitted to survive and the country suffered for seven years with virtually no important industrial development.

The strongest endorsement for the Government's decision was already communicated by the team to Dr. Abdul Ghani, the Chairman of PCSIR, in the letter delivered during the closing ceremony of the Survey (Section III.A). The PC-1 Plan itself is available as a public document. It calls for the expenditure of about Rs26 million (equivalent to about US$3 million) mostly in plant and equipment, some of this in foreign exchange, a really courageous decision by the Pakistani Government. NPSL will have a Physical Standards and Measurements Division and a Materials Division analogous to similar laboratories in all industrialized countries. The Survey Team believes that the rapid implementation now is absolutely essential to the development in Pakistan. Moreover, the Survey Team endorses the basic description of the Plan for which purpose sections 11.a through 11.d of PC-1 are reproduced in full in Appendix 1.

It might be noted that there were voices in Pakistan who would have wished for the Survey Team to recommend that NPSL be relocated in Lahore, in proximity to more industry, stronger academic institutions, and the homes of a greater number of potential NPSL recruits than in Islamabad. The Survey Team did not wish to make such a recommendation, even though the arguments for a change in location may appear to be convincing. The reason is partly that Islamabad also has advantages, such as the availability of a site and the proximity to the National Health Laboratory and the Government offices. Principally the Survey Team strongly believes that this kind of a decision is one which the Pakistani authorities themselves best make without influence of the possibly unbalanced viewpoint of foreign technical experts.

A special acknowledgment is needed to NPSL for having carried out a wide-ranging industrial survey of needs for their services in Pakistan, and this in 1977 prior to any discussion of this NBS/AID/PCSIR Survey. The results of that internal survey are well documented in a report that was in the hands of the international Survey Team members before their visit to Pakistan, and are in no way superseded but just supplemented, by this international Survey report.

APPENDIX 1*

From PC-1 Proforma and Feasibility Report on the National Physical and Standards Laboratory

11. Description of project:

a) Give brief history: proposed facilities and justification of project. Indicate the basis for selecting the area of research and justify the priority that should be given to the area Indicate the benefit of research to the sectors and the economy :

Modern developments in fields like optics, electronics, molecular physics, materials science, and nuclear science have done a great deal to bring the applied physics to the fore-front. Today, physical instruments, techniques, and devices are finding increasing use in industries, as well as, in scientific organisations, In Pakistan, although some emphasis was laid on the application of science to industrial development, but it has been only with the growth of modern industry and sophistication in industrial quality-control and measurements that research in applied physics has assumed greater significance. There is, therefore, a greater need for stimulating the application of physics and physical techniques of measurements to industrial and scientific problems in the country, particularly with regards to the improvement of standards of measurements, and the development of special purpose materials, alloys and instruments. In order to meet the growing needs of the sophisticated technologies now being adopted in the country, it has become necessary to carry out applied and objective basic research in applied physics and in the bordering areas of physics and chemistry, viz. instrumental analysis and physical chemistry, to cater for the developmental requirements of the country, particularly in those areas for which facilities do not exist in the country in present. As a first step towards this objective there is an urgent

*This entire appendix is in the form of a quotation. The introductory phrases marked off in this copy by horizontal lines (as in 11.a above) evidently indicate the standard format in which such program plans are presented within the Government of Pakistan.

need for the development of all aspects of physical standards and of precision measurements required for specific purposes (such as, quality control and developmental work for new manufacturing processes) by industrial and scientific organisations and defence.

Thus, to start with, it is proposed that the N.P.S.L. should comprise of the following two divisions:

1. Physical Standards and Measurements Division,
2. Materials Division.

The justification of the project is discussed in the Feasibility Report.

The real impact of N.P.S.L. will be felt in terms of the ultimate improvement in the process industry, and the scientific and technological base of the country, as a result of improvements in standards, refined measurements and materials. In terms of immediate benefits, one can mention as an example the efforts for developing and producing secondary & working standards of weights and measures. This is discussed in Appendix 1.*

The basis for selecting the areas of research and justification of priorities are given in chaper III of the attached Feasibility Report. A brief summary of functions of the various divisions of N.P.S.L. is given below:

PHYSICAL STANDARDS AND MEASUREMENTS DIVISION:

The functions of Physical Standards and Measurements Division will be mainly:

a) Maintenance of basic or primary physical standards and calibration of secondary standards.

b) Development and production of secondary standards using facilities available in the country.

c) National and international liasion with other institutions of similar kind.

d) Advice on the standard practices for measurements.

The Standards and Measurements Division will in the first instance acquire and maintain the basic standards for the measurements of length, mass, temperature,

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*Not reproduced here.

electrical current, luminosity and some of the derived standards. The secondary standards would then be calibrated for industry, scientific organizations and other relevant agencies against the primary standards. Secondary and Working Standards may also be maintained by organisations like the C.T.L., P.M.T.F., P.O.F., and the Engineering Universities. The division will cooperate with PSI in the formulation of standards specifications to develop measuring techniques, and will keep liasion with international bureau of weights and measures and other relevant international and foreign agencies.

MATERIALS DIVISION:

The Materials Division will be concerned with the following:

a) Determination and compilation of the physical, physico chemical, and thermodynamic properties of materials, and providing information service on materials.

b) Physical, and physico-chemical studies of the surface properties of constructional materials.

c) Applications of electro-chemistry to the protection of metals from corrossion and production of high purity metals.

d) Research on the physical, and molecular structure of the materials, and development of special materials having specific properties for use in science and industry.

e) Production of standard reference materials for quality check of the industrial products with reference to their chemical composition.

f) Providing, after thorough research, authenticated and standard analytical methods for determining chemical compositions of materials.

g) Advanced instrumental analysis, and advisory service to industries and other users on standard materials, and analytical techniques.

h) Physical, and physico-chemical testing of materials and related instrumentation.

BENEFITS OF THE PROJECT:

a) The National Physical and Standards Laboratory would serve as a focal point for the activities connected with the applications of physics to industrial and scientific problems, with specific reference to standards, precision measurements, and materials. The National Standards of Mass, Length, and other Physical quantities will form the basis of quality assurance for all industrial products, which can then be certified for correctness of dimensions and quality to compete in the international market.

b) The Materials Division will provide high-purity substances and standardized materials for use as test and comparision specimens, etc. in the industries thus facilitating quality control, and will also develop alloys and materials having specific properties for special uses. The equipment in this division will make possible the rapid and precise analysis of samples from any source, using a combination of several accurate physical, physico-chemical, and analytical techniques.

INSTITUTIONAL STRUCTURE OF THE N.P.S.L.

As described in the proceeding pages the N.P.S.L. is envisaged to have two divisions. The structural arrangements for these divisions and the laboratory are indicate in Table 1.

ADVISORY BOARD:

The National Physical and Standards Laboratory will have an Advisory Board to examine and lay down the research and development policy from time to time and to ascertain priorities for the work to be undertaken at the N.P.S.L. in accordance with the national needs. It would also advise the various divisions on the introduction of new fields of research and development, and assess the progress made in the on-going project. The constitution of the Advisory Board is proposed as follows:

1. Representative from Defence Science Organisation.
2. Representative from National Institute of Electronics.
3. Controller of Federal Weights and Measures.
4. Representative from National Engineering Laboratory.

5. Representative from Defence Production or P.O.F.

6-8. Three representatives from Industry, one from public sector and two from private sector.

9-11. Three Eminent Scientists, two physicists, and the third a physical chemist/metallurgist from university/colleges.

12. Director of C.T.L.

13. Representative from P.A.E.C.

14. Director of N.P.S.L.

MANAGING COMMITTEE:

The Director of the laboratory will also be assisted by a Managing Committee in organising the research activities and laying down the policy for the internal administration of the laboratory. The composition of the Managing Committee would be as follows:

1. Director of National Physical and Standards Lab.

2. Representative from P.C.S.I.R./Ministry of Science and Technology.

3. Representative from P.A.E.C.

4.5 Representatives from Universities (by rotation through the University Grant Commission) one physicist, and the other a physical chemist/metallurgist.

6-7 Heads of the Divisions of N.P.S.L.

8. Representative from Finance.

NOTE: The representatives from research organisations and universities should have a tenure of at least two years on this committee.

11(b) Indicate relationship with other programme in the same sector studies and in other sectors.

The programme of work at N.P.S.L. will have relevance with every industrial, scientific and technological activities of industries and research institutes as regards the standardisation and measurements of the various physical and physico-chemical parameters either for quality-control or for development of new processes, and even in the development of new technologies.

11(c) Mention the intermediate outputs in the form of number of studies papers to be produced within the next five years. Indicate whether these studies would result in commercial application or commercial leasing out of the process developed. If so, indicate expected income:

As can be gauged from the details given in the Feasibility Report, many intermediate outputs will be forthcoming. A few may be enumerated below:

i) A regular service programme for calibration of physical standards will be initiated, (ii) accurate analytical service to industries and research labs. will be provided, (iii) advisory service on measurements will be provided, (iv) oriented basic studies on measurements, testing, and development of materials will be made, (v) secondary standards will be produced. (vi) research papers will be published.

Calibration work, analytical service and instrumentation will naturally be the regular source of income to N.P.S.L., but no estimates of income can be made presently, Perhaps a good deal of effort will be required to educate industries to appreciate the significance of standardisation and quality control.

11(d) Administrative arrangements for conducting research. Give availability of man-power in the specialised field. Indicate methods of dissemination of research findings:

The relevant man-power is available in P.C.S.I.R., PAEC, Pakistan Mint, P.O.F., Suparco, Meteorology Departments of Engineering Universities

It is estimated that from these sources most of the staff requirements will be met.

Dissemination of Research Findings:

The method of disseminating the research findings of N.P.S.L. will be through:

a- Consultancy Services,

b- Selling Standard reference materials

c- Limited production of those essential items of materials and instruments which it may be uneconomic to produce on a large - scale commercially.

APPENDIX 2

Articles from newspaper "DAWN"

Article from January 27, 1979, issue:

Physical & standards laboratory: survey completed

By Our Staff Reporter

Six international experts have completed their survey of the country to evaluate the potentials for the setting up of the proposed National Physical and Standards Laboratory at Islamabad.

The team headed by Dr. H. S. Peiser, head of the International Relations Office of the National Bureau of Standards, United States, visited Islamabad, Peshawar, Taxila, Lahore, Gujranwala, and Karachi.

The team accompanied by Dr. Abdul Ghani, Chairman, Pakistan Council of Scientific and Industrial Research (PCSIR) visited industrial units in those places besides the laboratories of the PCSIR at Lahore, Peshawar, and Karachi.

In Karachi, the team members visited the PIA Electronics Laboratory, the Machine Tool Factory at Landhi, SUPARCO, etc.

The visit was rounded off with a dinner hosted by Dr. and Mrs. Abdul Ghani in honour of the six experts at Hotel Intercontinental.

The other experts were; Dr. Heydemann, National Bureau of Standards, United States; Dr. J. K. Taylor, Center for Analytical Chemistry of the National Bureau of Standards, United States; Mr. C. H. Dix, National Physical Laboratory, Britain; Dr. C. K. Kim, Standards Research Institute, South Korea; and Mr. H.L.K. Goonetilleke, Chairman, National Metric Conversion Authority and head of the Weights and Measures Division, Sri Lanka.

Dr. Peiser and Dr. Ghani told "DAWN" last night that the proposed laboratory at Islamabad would be set up on the pattern of the United States laboratories and with the assistance of the U.S. National Bureau of Standards.

Dr. Ghani said that the laboratory will help improve the process industry, and strengthen the scientific and technological base of the country, as a result of improvements in standards, refined measurements, and materials.

Dr. Peiser said his team conducted a two-week survey of the existing facilities in Pakistan on calibration and standardization in industries, research institutions, and other similar establishments.

The U.S. expert and the team leader said that standardization is a symbol of good management, and it is needed in all fields.

Article from January 31, 1979, issue:

Need for National Physical Standards Laboratory Stressed

by H. A. Hamied

The six-member team of technical specialists from the U.S.A., Britain, Korea, and Sri Lanka has recognized the urgency, importance, and widely accepted need for the establishment of the National Physical Standards Laboratory at Islamabad.

In a six-page preliminary report to the Chairman of the Pakistan Council of Scientific and Industrial Research, Dr. A. Ghani, the team, headed by Dr. H. Steffen Peiser, head of the International Relations Office of the National Bureau of Standards, United States, has said that measurement capability is needed equally for raw material discovery, evaluation and selection, for industrial process control, for quality assurance of products, for the rule of equity in domestic and international markets, for protection of the work and home environment, for the enforcement and demonstration of compliance with regulations, for the delivery of health services, the evaluation of soils, the control of power sources, the operation of transportation and communication systems, etc.

Measurement capability is indispensable for higher technologies, such as a significant domestic instruments industry and the reception of modern technology.

It may be mentioned that the survey of the needs for measurements in Pakistan was organized by the U.S. National Bureau of Standards, jointly sponsored by the U.S. Agency for International Development and Pakistan Council for Scientific and Industrial Research. The team members included Dr. Heydemann, National Bureau of Standards, United States; Dr. J. K. Taylor, head of the Analytical Division of the NBS, U.S.A.; Dr. C. K. Kim, Standards Research Institute, South Korea; and Mr. H.L.K. Goonetilleke, Chairman, National Metric Conversion Authority and Head of the Weights and Measures Division, Sri Lanka.*

The team will be submitting a full report to the PCSIR in about three months. In the preliminary report the team suggested that a national center for measurement of science and technology can serve the nation in the following ways:

—It is equipped and staffed to maintain national measurement standards and to disseminate the accuracies inherent in them to provide compatible, internationally recognized measurements,

—It develops, implements, and consults on test methodologies in conformity with engineering, product safety, and process standards,

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*The omission of Mr. C. H. Dix of the National Physical Laboratory, England, is clearly an unintended error. Moreover, Dr. J. K. Taylor's affiliation should have been the Center for Analytical Chemistry.

—It advises and acts as technical referee to maintain order in domestic and international markets; for instance, to verify compliance with standards, specifications, codes, or contracts,

—It acts as national focus for know-how, training, and international contact in quantitative measurements at or near the highest attainable accuracy, and

—Through professional societies and seminars introduces a nationwide awareness of the discipline of measurement control so essential in modern science and technology.

It was the unanimous opinion of the team which visited Pakistan from Jan. 13 to 24 that Pakistan would benefit significantly from an availability of the following:

—One effective focal point for self-reliant measurement science and technology in contact, abroad, with other national and international metrology centers, and, at home, with all institutions and companies where good measurements are needed,

—Extension, information, coordination, and training services to disseminate a widespread awareness of the need for good measurement controls. The aim would be to develop an appreciation for good "housekeeping" and reliable records of test, for the limited constancy of standards and instruments calibrations, and for the dangers from build-up of small errors to damaging, unforeseen departures from planned operations, and

—Analysis of saving of many ineffective calibrations using some instruments badly or relying on instruments with unjustified confidence all with the result of escalating costs of non-interchangeability of parts, industrial rejections and waste. The cost to Pakistan of NPSL probably would be far less besides enabling the country to export more goods and produce higher technology products.

To perform the relevant functions adequately in Pakistan, NPSL will need excellent facilities and outstanding staff. In the opinion of the team, the choice of a modest building-site located in Islamabad was endorsed, provided continuing contacts, advice, and consultation are sought from industrial regions of Pakistan and also from institutions such as the PCSIR Instrumentation Center, the Pakistan Standards Institution, and the Central Testing Laboratories, all of which have missions closely related but different from NPSL.

The team members submitted that the selection and training of staff presents greater problems. The work of NPSL could become effective more rapidly if carefully selected staff members would be given assignment to other national centers abroad such as NBS. NPSL management should develop a comprehensive training plan, possibly with the help of the U.N., the World Bank, or other assistance organizations such as USAID.

What the Pakistanis need to be shown is a national commitment to the scientific method and technological advancement that will make their specialist knowledge relevant to the developing society.

In summing up, the team suggested that some desirable functions of NPSL should be:

1) Provision of internationally traceable national primary standards maintained under excellent and fully documented conditions;

2) Dissemination of their accuracy through calibration services,

3) Accreditation of lower-level laboratories for calibration,

4) Spreading education and awareness of metrological practice through contacts with industry, seminars, attachment of industrial personnel, etc.,

5) Provision of guidance publications,

6) Maintaining liaison with other national laboratories, both directly and through the International Bureau of Weights and Measures (BIPM) and other international organizations, and

7) Provision of an advisory service on measurement problems to industry, universities, and government.

APPENDIX 3

Biographical Data of NBS/AID Team Members

Cyril H. Dix of the United Kingdom was born in 1923. After leaving the armed forces in 1947, he attended London University and graduated with highest honors in physics in 1951. Until 1966 he worked in the research laboratories of the (British) General Electric Company on microwave magnetrons and as head of a research and development team on traveling wave tubes. In 1966 he joined Varian Associates to work on the 600 MeV electron accelerator being designed for Germany. In 1968 he joined the newly formed British Calibration Service as an expert in microwave measurements. He is a fellow of the (British) Institute of Physics and Institution of Electrical Engineering.

In 1970 Mr. Dix moved to the (U.K.) National Physical Laboratory where since then he has served as head of the direct current and low frequency electrical measurement group, which is responsible for the U.K. national standards. In 1975 he received the highest award of the Institution of Electrical Engineers for a paper on electrical standards and has recently advised the Government of Hong Kong on the need for an electrical standards laboratory to support that colony's development objectives.

Hugh L.K. Goonetilleke was born in 1927 in Ceylon and obtained his B.Sc. at the University of Ceylon and an M.Sc. in Measurement Science at George Washington University in Washington, D.C. He was a guest worker at the National Bureau of Standards in 1967-8 and is a member of the Sri Lanka Association for the Advancement of Science. Mr. Goonetilleke was appointed as Examiner of Standards in the Department of Commerce of Sri Lanka in 1952 to set up the Standards Laboratory under the Weights and Measures Ordinance, as well as to satisfy the scientific and technical requirements for implementing it. He went on a six-week study tour in the Weights and Measures Department of Bombay in India. In 1956 he was appointed Deputy Warden of the Standards and placed in charge of the Weights and Measures Division. Since 1973 he has also served as Chairman of the National Metric Conversion Authority which is in charge of the implementation of the metrication program in Sri Lanka. Since 1970 he has chaired the Metric Divisional Committee of the Bureau of Ceylon Standards. In 1976 he was a member of the Governing Council of the Bureau of Ceylon Standards. From 1968 he has been Sri Lanka's delegate in the International Committee of Legal Metrology and from 1976 a member of the Presidential Council of the International Organization of Legal Metrology.

Mr. Goonetilleke has attended seminars on metrology held in Tokyo in 1971 and 1978, New Delhi in 1975, and in Seoul in 1978. In 1971 for one month he has held a traveling fellowhip from UNIDO to assist international understanding in metrology. The Division of Measurement Standards and Services in Sri Lanka is engaged in two metrology projects--one a program with the National Physical Laboratory of India and the other in the Commonwealth Science Council of the United Kingdom. Mr. Goonetilleke was responsible for organizing the UNESCO Regional Seminar in Metrology and Legal Metrology in Sri Lanka, held in 1978.

Peter L.M. Heydemann was born in 1928 and obtained his education at the University of Goettingen in Germany. He received his Ph.D. with the subjects of physics, physiology, and chemistry in 1958. He joined the staff of the University in the fields of polymer physics and acoustics, especially underwater sound. In 1964 he came to the United States to work at the National Bureau of Standards on problems related to accurate measurement at very high pressures. In 1971 he was placed in charge of the Pressure and Vacuum Section of NBS. Since then, he has devoted his efforts to the development of better pressure standards and much improved services to industry.

Dr. Heydemann has published more than 40 scientific papers on very high pressure physics and technology, physics of polymers, ultrasonic interferometry, and measurement standards. He has lectured extensively in the United States, Europe, and Asia on measurement techniques for scientific and industrial applications. In early 1978 he was assigned to the NBS Director's staff where he was soon promoted to lead the NBS Program Office. At present he is Director of the Center for Thermodynamics and Molecular Science.

Chul Koo Kim was born in Korea in 1946 and educated at Seoul National University, obtaining a B.S. in applied physics. In the Korean Army he served as signal corps officer, and in 1970 he returned to SNU as teaching assistant. He subsequently came to the United States where he earned a Ph.D. in physics at Purdue University. After one year as visiting scientist at the Max Planck Institute for Solid State Research in West Germany, he became a research associate first at Purdue and later at the University of Illinois. Since 1977 he has been Chief of the Force Standards Laboratory at the Korea Standards Research Institute, where he now also coordinates all work on the mechanical and physical properties of materials. Dr. Kim's original publications are in the solid state physics of semiconductor materials.

H. Steffen Peiser, a U.S. citizen by naturalization, was born in 1917 near Berlin, Germany. His father was Swiss. Mr. Peiser spent much of his life in England where he attended Cambridge University obtaining his B.A. in 1939 and M.A. in 1943 in chemistry, physics, mineralogy, and mathematics. In 1939 he was awarded a Hutchinson Research Studentship at Cambridge University in crystal chemistry and in 1965-6 he was Visiting Professor at Harvard University, Cambridge, Massachusetts.

From 1941 to 1947 Mr. Peiser worked on the structure of polyethylene, the texture of nylon and polyesters, and on the structures of high temperature forms of uranium and its carbides and oxides. After a brief period in 1947-48 as senior lecturer at Birkbeck College, London University, as deputy director of the Nuffield Cement Research Laboratory, he joined the research staff of Hadfields Ltd. as head of metal physics research and also as principal scientist of the Aeronautical Inspection Directorate's Test House. In April 1957 he joined the U.S. National Bureau of Standards, originally under the free-radicals research program, and later as Chief of the Mass and Scales and Crystal Chemistry Sections. In 1970 he became Chief of the NBS Office of International Relations and Manager of the NBS Special Foreign Currency Program and continued in those capacities until his retirement in October 1979. He has been a U.S. delegate to several international meetings.

Mr. Peiser is an X-ray crystallographer interested in aspects of precise measurement and characterization of pure crystals. He is editor of several publications on X-ray crystallography, crystal growth, and technical development of less industrialized regions. He became a Fellow of both the (British) Institute of Physics and the Royal Institute of Chemistry. He is a member of Sigma Xi, the American Crystallographic Association, and the American Chemical and Physical Societies. For six years Mr. Peiser was Secretary of the Commission of Atomic Weights of the International Union of Pure and Applied Chemistry. He has traveled extensively and has led diverse technical missions, especially to the following countries: Bolivia, Ecuador, Guyana, Indonesia, Korea, the Philippines, Poland, the Sudan, Thailand, Turkey, and Yugoslavia. From 1963 to 1968 he served as Secretary of the Panel for Exchange of Information and Materials of the U.S./Japan Program for Scientific Cooperation.

John K. Taylor was born in Maryland, United States, in 1912 and received his B.S. from the George Washington University in 1934 and his M.S. and Ph.D. degrees from the University of Maryland in 1938 and 1941, respectively. He joined the National Bureau of Standards in 1929 as a laboratory aide and after a seven-year period in the Optical Instruments Section, he transferred to the Chemistry Division. A major part of his work has been concerned with the application of physical methods to chemical analysis. He has conducted research in polarography, coulometry, and other areas of electrochemical analysis. Other areas of research interest are refractometry, methods of separation of isotopes, and Standard Reference Materials. He is the author of over 150 scientific publications, is the editor of one book, and has contributed chapters to several books on analytical chemistry.

During the past several years, Dr. Taylor has supervised in the NBS Center for Analytical Chemistry a research group concerned with development of advanced methodology in the area of gas and particulate science and the certification of Standard Reference Materials for validation of environmental data. Dr. Taylor is a past Chairman of the Chemical Society of Washington, the American Chemical Society Division of Analytical Chemistry, and of the Washington Academy of Sciences.

Dr. Taylor actively participates in national and international standardization activities. His participation in the American Society for Testing and Materials includes: D19 on Water, D22 on Atmospheric Analysis, and E34 on Occupational Health and Safety. For the International Organization for Standardization, he has been active in both ISO/TC 146, Air Quality, and ISO/TC 147, Water Quality, and has served as Chairman of ISO/TC 147, SC-2 Physical, Chemical, and Biochemical Methods. He is presently Chairman of the ISO/TC 147. He also participates in ISO/TC 48, Laboratory Glassware and Related Apparatus.

Dr. Taylor was awarded the U.S. Department of Commerce Gold Medal in 1967, and in 1974 he received the NBS Edward B. Rosa Award for "many contributions to measurement standards and for effective leadership and coordination through national and international voluntary standards organizations."

APPENDIX 4

Abbreviations Used Repeatedly in This Report

ADB	-	Asian Development Bank
ASTM	-	American Society for Testing and Materials
BIPM	-	Bureau International des Poids et Mesures
BSI	-	British Standards Institute
CCITT	-	International Telegraph and Telephone Consultative Committee
CENTO	-	Central Treaty Organization
CTL	-	Central Testing Laboratories
DIN	-	German Institute for Standardization
ISO	-	International Organization for Standardization
JIS	-	Japan Institute of Standards
NBS	-	U.S. National Bureau of Standards
NPSL	-	Pakistan National Physical and Standards Laboratory
NSCP	-	National Science Council of Pakistan
OIML	-	Organisation Internationale de Metrologie Legale
PCSIR	-	Pakistan Council for Scientific and Industrial Research
PIA	-	Pakistan International Airlines
PINSTECH	-	Pakistan Institute of Nuclear Science and Technology
PL-480	-	U.S. Public Law 480; "Food for Peace Act"
PSI	-	Pakistan Standards Institute
PSTC	-	Pak-Swiss Training Center
SRD	-	Standard Reference Data
SRM	-	Standard Reference Materials
UNCSTD	-	U.N. Conference on Science and Technology for Development
USAID	-	U.S. Agency for International Development

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15. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

Following similar projects conducted by the National Bureau of Standards in other countries, the Ministry of Science and Technology of Pakistan and under it the Pakistan Council of Scientific and Industrial Research invited NBS to organize a six-man international team of experts in selected topics of metrology to advise on the adequacy and needs for standards and measurement services and to comment upon the plan to establish a new laboratory in Islamabad which would be the primary national standards body under the title of National Physical and Standards Laboratory. This Survey was undertaken with shared funding and guidance from the Government of Pakistan and the U.S. Agency for International Development. The team was composed of specialists from Korea, Sri Lanka, and the United Kingdom, joined by three NBS staff members, and visited industrial, academic, and governmental establishments (Section IV). They were accompanied by a strong Pakistani counterpart team with highest level representation from the PCSIR laboratories under the continuous personal direction of Dr. Abdul Ghani, the PCSIR Chairman. The team strongly endorsed the NPSL plan, having found every indication that a national focal point for good measurements appeared as a critical need for Pakistan's development. A summarizing letter of conclusions and recommendations is reproduced with other recommendations and relative remarks by visiting team members (Section III). For readers not familiar with Pakistan, Sections V and VI give some background on science and technology in Pakistan.

17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)

Agency for International Development; development assistance; industrialization; less developed countries; measurement technology; Pakistan; standardization.

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