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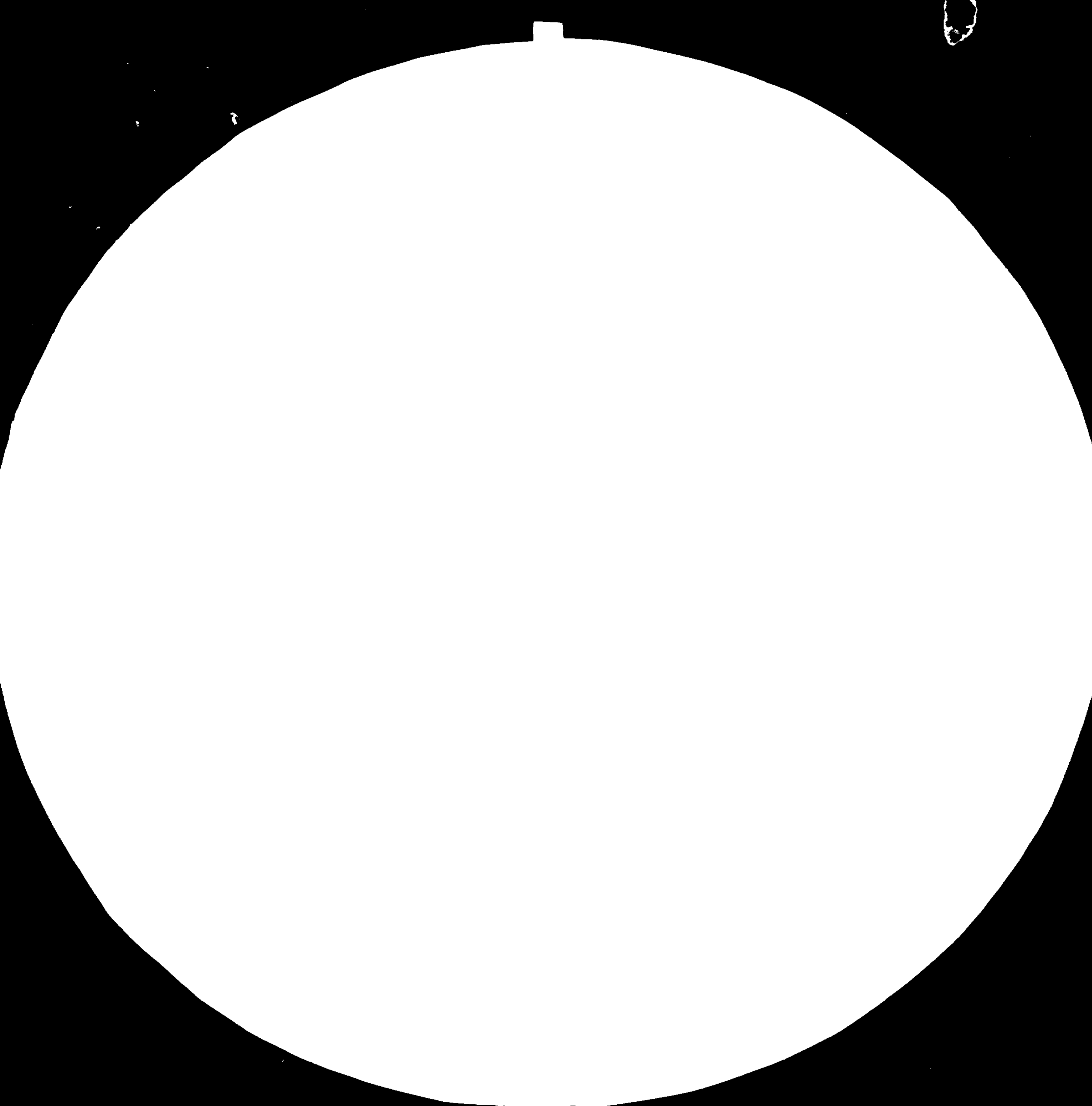
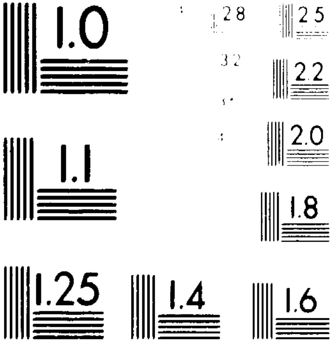




MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

STANDARD REFERENCE MATERIAL 1010a

ANSI and ISO TEST CHART No. 2

13521

RESTRICTED

December 1983
English

DEVELOPMENT OF STANDARDIZATION
AND QUALITY CONTROL
DP/SRL/82/003/A/01/37
SRI LANKA .

Technical report: Establishment of a metrology laboratory and provision of calibration services

Prepared for the Government of Sri Lanka
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Duncan Thurnell-Read
expert in metrology and calibration

United Nations Industrial Development Organization
Vienna

received from Mr. Tzitt

EXPLANATORY NOTES

1 Where references are given in the text to numbered items in the annexes, they take the form (Z9) where the reference is to the item numbered 9 in Annex Z. A general reference to an annex takes the form (Annex Z).

2 The Bureau of Ceylon Standards is referred to in the text by the abbreviation BCS. It should be noted that in some referenced documents it is referred to as the Sri Lanka Standards Institution, abbreviated as SLSI; this is the new name proposed in a statute currently (1983) in draft.

3 The following abbreviations appear in the text:

ac	alternating current
af	audio frequency
ASCA	Association for Science Co-operation in Asia
ASTM	American Society for Testing and Materials
BCS	Bureau of Ceylon Standards
BIML	Bureau International de Métrologie Légale
BIPM	Bureau International des Poids et Mesures (International Bureau of Weights and Measures), Paris
BS	British Standard
BSI	British Standards Institution
CEB	Ceylon Electricity Board
CSIR	Ceylon Institute for Scientific and Industrial Research
CRM	Certified Reference Material
CSC	Commonwealth Science Council
dc	direct current
EDB	Export Development Board (of Sri Lanka)
ESCAP	(United Nations) Economic and Social Commission for Asia and the Pacific
FEISAP	Federation of Engineering Institutions in Southeast Asia and the Pacific
FRG	Federal Republic of Germany
fsd	full scale deflection
GATT	General Agreement on Tarriffs and Trade

GDP	Gross Domestic Product
GDR	German Democratic Republic
HMSO	Her Majesty's Stationery Office, London
HoL	Head of the Metrology Laboratory of BCS
IDB	Industrial Development Board (of Sri Lanka)
IEC	International Electrotechnical Commission
ILAC	International Laboratory Accreditation Conference (held annually in different countries)
IMEKO	International Measurement Confederation
ISO	International Organization for Standardization
kgf	kilogram-force: a technical unit of force (1 kgf = 9.80665N)
MSS	Measurement Standards and Services Division of the (Sri Lanka) Department of Internal Trade
NATA	National Association of Testing Authorities, Australia
NATLAS	National Testing Laboratory Accreditation Scheme, United Kingdom
NBS	National Bureau of Standards (USA)
NML	National Measurement Laboratory, Australia
NPL(India)	National Physical Laboratory, New Delhi
NPL(UK)	National Physical Laboratory, Teddington, England
OIML	Organization International de Métrologie Légale (International Organization of Legal Metrology)
ppm	Parts per million
QC	Quality Control
RAPRA	Rubber and Plastics Research Association of Great Britain
rf	Radio frequency
rms	root mean square
ROSTSCA	Regional Office (of UNESCO) for South and Central Asia, New Delhi
SIRIM	Standards and Industrial Research Institute of Malaysia
SISIR	Singapore Institute of Standards and Industrial Research
SLR	Sri Lanka Rupee
SLSI	Sri Lanka Standards Institution (see note 2 above)
SLS mark	Sri Lanka Standards mark (a quality certification mark demonstrating conformance to standards)
SO	Standards Officer

SSO	Senior Standards Officer
TELARC	Testing Laboratory Registration Council of New Zealand
UK	United Kingdom
UNDP	United Nations Development Programme
UNESCO	United Nations Education, Science and Cultural Organization
UNIDO	United Nations Industrial Development Organization
USA	United States of America

4 All measurements in this report are expressed in units of the SI system (K77) except where indicated otherwise. Additional useful references are given in Annex K on units (K78 to K79) and on terminology (K80).

ABSTRACT

As part of a project "Development of Standardization and Quality Control" (DP/SRL/82/003/A/01/37) to assist the Bureau of Ceylon Standards fulfil its national role, the three month mission reported on covered the metrological needs of the Bureau and of Sri Lankan industry.

Following a survey of measurement needs and resources in Sri Lanka, involving visits to a sample of organizations, recommendations are made for the establishment of a metrology laboratory and for the provision of calibration services. Outline specifications are provided covering the layout and environmental control of the laboratory, and the equipment required for electrical, mechanical, thermal and other measurements. The use of certified reference materials is recommended. Organization, staffing and training needs are also covered.

In addition to recommendations pertaining to the laboratory, suggestions are made for a laboratory accreditation scheme, for the further examination of the country's instrument maintenance needs, and for more formal coordination of the role of technical institutions in Sri Lanka. It is also recommended that the Ceylon Electricity Board's meter testing facilities should be modernised and re-equipped.

Included in annexes are reports of visits, lists of equipment recommended with specifications and suggested suppliers, training and fellowship proposals, and a bibliography.

TABLE OF CONTENTS

INTRODUCTION

This introduction provides background information on the project, its objectives and official arrangements, and also on the aims and achievements of the mission which is the subject of the following chapters of this technical report. Details, as appropriate, appear in the various annexes which should be read together with the text. Annex K contains a list of reference documents.

A. Project description

The primary aim of this four year project (K1), initiated in 1982, is to develop the Bureau of Ceylon Standards (BCS) so that it can take the lead in promoting product quality in Sri Lankan industry. Particular emphasis is placed on improving overall industrial performance so as to compete more effectively in the international market.

Immediate objectives of the project

a) Implement standardization, quality control and product quality certification of local goods with special emphasis on products manufactured by State-owned organizations,

b) Be the official agent of foreign standards/quality certification institutions for Sri Lanka in export products as well as imported products,

c) Carry out consultancy services at factory level in order to implement quality control and standardization procedures and practices.

B. Co-operating agency

The Bureau of Ceylon Standards (BCS) is a public body set up by statute (K2) and operating under the aegis of the Ministry of Industries and Scientific Affairs. It already performs most of the usual functions of a standards institute

i.e. ___ preparation and publication of documentary standards (normes)

___ acting as an information centre on standards

___ providing testing facilities for products and materials

___ certification of products.

In addition, BCS monitors the quality of certain consumer products on the domestic market, operates an export inspection scheme (effectively compulsory for certain food products), and provides training facilities. A proposed new statute (K3) will amend the Bureau's constitution and functions and re-name it as the Sri Lanka Standards Institution. Fuller details of BCS, its functions and organization, are to be found in Chapter III and in a report by a previous UNIDO consultant (K4).

The Laboratory Services Division of BCS provides the testing facilities mentioned above. It is within this Division that a metrology laboratory is to be established to ensure proper measurement support for testing activities and to provide a calibration service for industrial instruments used in production processes and for quality control. A new building is proposed to house this Division. A list of international and counterpart people involved is given in Annex A.

C. Mission objectives

The mission, for which this is the technical report on completion, was executed in Sri Lanka between 15 September 1983 and 6 December 1983 by a UNIDO appointed expert, Mr. D.P. Thurnell-Read. The following objectives were set (K5):

1) Assess the present requirements and assist in planning the future needs of (the BCS) metrological laboratories.
2) Advise and assist in the organizational and managerial aspects of (BCS) metrological laboratories' activities.
3) Identify requirements specifically for the metrological and calibration section, including equipment, staffing, programmes and laboratory working procedures.
4) Develop methodologies for checking, calibrating and inspecting weights, measures and measuring instruments in existing laboratories, departments and relevant industrial, governmental and other organizations.
5) Develop and implement a training programme for training (BCS) staff on-the-job and make recommendations for overseas training in the performance of the above-mentioned duties.

These five objectives could not be fully pursued since the mission took place before the creation of a fully fledged metrology laboratory as a distinct organizational entity and its installation in a new building properly equipped for its functions. Moreover, the designated head of the metrology laboratory was absent overseas on a training fellowship for the whole duration of the mission. Nevertheless, much was achieved, as shown in the main body of the report and summarized in D below.

The methodology adopted was, in brief:

a) To visit a representative sample of Sri Lankan industry to assess the country's measurement needs (Annex B).

b) To study the calibration requirements for the BCS testing laboratories' own equipment.

c) To study and evaluate the measurement resources already available within BCS and other Sri Lankan institutions.

d) To determine the range of measurements which the metrology laboratory should cover, and advise on the facilities and equipment required, in the light of findings a, b, c above.

e) To conduct a training seminar on the principles of measurement and to advise on training of BCS staff.

It should be noted that the objectives of the mission are in support of the overall project aims by providing a sound basis for measurements made in the course of product testing (A.a above) and for acceptance of BCS by foreign institutions (A.b above).

D. Mission achievements

In summary, these are (using corresponding numbers to the five objectives in C above):

1) Through industrial visits, and discussions with BCS staff and others, fully achieved.

2) Could not pursue, as laboratory not yet established.

3) Fully achieved in respect of laboratory functions, layout, environmental control and largely achieved in respect of equipment and staffing. Work on programmes and working procedures must await establishment of the laboratory as a functioning unit in the proposed new building.

4) Little achieved in the absence of the head of the metrology laboratory, but some advice given directly to the heads of the various testing sections.

5) On-the-job training in metrology was not practicable, but 15 BCS staff attended a two-day training seminar (Annex H), together with some 27 people from industry. Advice was given on overseas training and on the further development by BCS of in-house training for its own staff together with technologists from industry. Further comment on the seminar,and on training needs in the future, are given in Chapter IV.

E. This report

This report is the work of the appointed UNIDO consultant, Mr. D.P. Thurnell-Read, formerly a senior member of the staff of NPL (UK), and now of 39 Turnpike Road, Connor Downs, near Hayle, Cornwall TR27 5TD, England. He will welcome comment or enquiries concerning the content.

The report is intended to guide the BCS, and the responsible officials of the Sri Lanka Government, in achieving the objectives of the project (K1) in respect of the metrological infrastructure and facilities that the BCS should possess in support of its own testing and certification activities and for technical assistance to Sri Lanka industry. It will also inform UNDP and UNIDO staff of the achievements of the mission and the further actions recommended.

Although the report is intended only for limited distribution as indicated above, it could also be of interest to certain other organizations active in the South/South East Asia region (e.g. the Commonwealth Science Council) as well as to other Sri Lanka institutes possessing complementary measurement facilities. A list of suggested recipients (subject to de-restriction by the Sri Lanka Government) is given in Annex L.

I. SUMMARY OF FINDINGS AND RECOMMENDATIONS

A. Findings

1 Although handicapped by unsuitable accommodation, inadequate equipment and too few experienced staff, the Laboratory Services Division of the BCS is active and the staff are keen to develop its work on a sound technological base.

2 Given technical help and encouragement, and adequate funding, the Division could meet many of the testing needs for product certification and become a centre of expertise in testing and calibration of considerable help to Sri Lankan industry.

3 Although BCS sub-contracts some testing to other organizations, no formal basis has yet been established; consequently, technical control is lacking thus hazarding the reliability and credibility of the tests.

4 Other organizations in Sri Lanka overlap, or have the potential to overlap and duplicate, some of the testing functions of BCS. However, there are no policy agreements between BCS and these organizations, and hence there is a possibility of unnecessary duplication of facilities and concomitant waste of national resources.

5 The present testing capabilities of BCS are not well known to Sri Lankan industry and are consequently under-used.

6 Few measuring instruments used by Sri Lankan industry are regularly re-calibrated, some not at all; there is only limited awareness of the need for this or of the beneficial effect this could have on production efficiency and on quality control.

7 Competent and accessible maintenance and repair facilities for measuring instruments used in manufacture and in laboratories are lacking in Sri Lanka, thus putting the reliability of such instruments at a premium.

B. Recommendations to BCS management

8 The BCS metrology laboratory should be equipped and staffed to provide measurement and calibration services in the following fields of measurement:

a) Electrical at dc and low frequencies (up to about 1 kHz),

b) Mechanical, viz dimensions, angle, form, surface finish, hardness, force, pressure,

c) Temperature over the range -40 to +1500°C, but excluding radiometry,

d) Photometry — total light output of tungsten filament lamps and illumination levels only,

e) Reference materials — equipped with certified reference materials to check spectrophometers, viscometers, hardness testing machines, pH meters, etc.

9 At the present time, the BCS metrology laboratory need not be equipped for the following measurements, but the need should be reviewed periodically once it is operating successfully in the fields of measurement recommended above:

a) Electrical measurements at high frequencies, also pulse measurements,

b) Acoustic measurements and vibration,

c) The generation of forces by force standard machines,

d) Radiometry, e.g. optical pyrometry,

e) Photometry of fluorescent lamps,

f) Measurements on optical systems, e.g. lenses, filters,

g) Colorimetry,

h) Measurements of mass volume and density,

j) Flow measurements,

k) Measurements of time and frequency (except as incidental to other measurements).

10 With minor layout and environmental control modifications suggested in this report, provision of a metrology laboratory of a nominal gross area of 128 m^2 should proceed as planned (see specification in Annex C).

11 The new metrology laboratory should have a staff of four, including an experienced metrologist who is also a competent manager as Head of Laboratory (HoL) at SSO level. At least one of the other staff should be a graduate engineer or physicist, having at least three years post-graduate experience in precision measurement or testing, at SO level.

12 The equipment specified in Annexes D, E, F and G should be procured and commissioned so as to provide the measurement services recommended (8 above).

13 Certain existing items of metrological equipment, and some new items recommended, should be calibrated by suitable organizations (in general, a national measurement laboratory that participates in intercomparisons under the aegis of BIPM, or a national calibration service) so as to provide traceability to internationally recognized measurement standards. Regular re-calibration of these items should be arranged. Where appropriate, the Measurement Standards and Services Division (MSS) of the Department of Internal Trade might provide these calibrations.

Remaining items of equipment, and all measuring equipment used throughout the BCS Laboratory Services Division and by its sub-contractors, should be regularly calibrated by reference to those items referred to above, thus providing traceability for all measurements for which BCS is responsible.

14 Equipment recommended for procurement should be scheduled for delivery so that it can be commissioned and put into use as soon as it is delivered, without delays or removal after unpacking which might result in damage or deterioration. This entails postponing delivery of some items (indicated in the relevant annexes) until after the new building is complete and the metrology laboratory adequately staffed and functioning.

15 Consideration should be given to the use of certified reference materials (CRM) to provide calibrations or functional checks on certain testing equipment, particularly that used in analytical testing. The metrology laboratory should be responsible for the provision of CRMs, for their care in storage and for procedures and records of results obtained by their use.

16 The present capability of the BCS to calibrate industrial instruments, as well as its facilities for products and materials testing, should be published and widely distributed in Sri Lankan industry and research institutes. As the services develop, this information should be frequently up-dated through a mailing list and other means.

17 Training of the metrology laboratory staff in relevant measurement disciplines (see 8 above) should be planned, using local resources where possible, with on-the-job training by the designated HoL on his return from overseas training. The co-operation and assistance of other organizations, e.g. MSS, CISIR, Moratwa University should be obtained.

18 The designated HoL should pay short (one to two weeks) familiarization visits to the national measurement facilities in other countries in the region, including at least NPL (India), SIRIM (Malaysia), SISIR (Singapore), NML (Australia). He should explore the prospects of closer co-operation with these institutes in the maintenance of measurement standards and their intercomparison, the operation of calibration services, and metrological training. Such visits should be arranged in consultation with MSS, the authorized holder of Sri Lankan national measurement standards.

19 The BCS should conduct further training seminars in metrology for people from industry as well as for its own technical staff. These should comprise half- or one-day seminars, including both lectures and discussions, each treating a particular aspect of measurement in depth, at frequent intervals (i.e. one to three months) preferably with the aid of other organizations, e.g. lecturers from technical universities and institutes.

20 A scheme for the accreditation of testing laboratories should be established to formalize and control the arrangements under which BCS sub-contracts testing (or calibration) work to other organizations. This scheme should follow guidelines already established (K6) and use methodology based on that adopted by such schemes in other countries, e.g. NATA (Australia), TELARC (New Zealand), NATLAS (UK). When

implemented, it could be extended to place additional testing (and hence certification) facilities at the disposal of BCS.

21 BCS should seek and increase its metrological contacts and co-operation with other organizations in Sri Lanka and overseas, particularly with MSS, and through MSS, BIPM and OIML, also the CSC Asia/Pacific Metrology Programme, ROSTSCA, ESCAP, ASCA and FEISAP, as well as the institutes mentioned in 18 above (see Explanatory Notes on page 2).

22 BCS should consider seeking corporate, or individual membership for a member of its staff, as appropriate, of overseas organizations which could provide technical assistance in metrology or the testing of materials or products, e.g. The Instrument Society of America, IMEKO, also various industrial research associations in the UK such as RAPRA.

C. Recommendations to the Sri Lanka Government

23 The Sri Lanka Government is recommended to provide the encouragement and financial resources necessary to enable the BCS to fulfil its role in the national economy, and in particular to develop as a centre of expertise in industrial measurement and as the principal provider of calibration services to industry in accordance with the foregoing recommendations 8 to 22.

24 The Sri Lanka Government should examine the roles and policies of all public bodies in Sri Lanka which have, or may develop, testing and measurement facilities and ensure that any overlap in role or responsibility should not lead to unnecessary duplication of facilities or to waste of national resources in men, money, or equipment. This examination should include specialist institutes serving particular sectors of industry as well as those with a role in education, training, standards and research.

25 The recommended accreditation scheme for testing laboratories (see 20 above) should be considered as the potential basis of a national scheme which could secure international acceptance within the framework of the GATT Standards Code and the recommendations developed by ILAC and ISO

so as to enhance the export potential of Sri Lankan industry by diminishing barriers to trade connected with product testing and its acceptability. Arrangements should be made for Sri Lanka to participate in the annual ILAC meetings.

26 The Ceylon Electricity Board's testing station for electricity meters, which should be the primary facility for electrical power/energy measurement and for the calibration of instrument transformers, should be modernised and re-equipped so as to fulfil its function of ensuring an equitable basis for charging consumers, including industrial organizations, for electrical energy supplied. This would complement the BCS electrical measurement facilities.

D. Recommendations to UNDP/UNIDO Project Management

27 Every possible assistance and encouragement should be given to BCS to ensure that the new laboratories, including the metrology laboratory, are built and commissioned at the earliest possible date. In particular, consideration should be given to the appointment by BCS of a member of the project team whose full-time duties would be:

a) to effect the necessary liaison between those who will manage and staff the laboratories and those responsible for design, erection and the provision of building services and furnishings,
b) to monitor the progress made with the aforementioned work, and report regularly (say, monthly) to BCS management and to the project management,
c) to plan in detail the removal of the present laboratory facilities to the new premises, and their successful installation, so as to minimise damage to and loss of use of these facilities, extending the plan to embrace new equipment being provided.

28 To provide further help to the metrology laboratory when it is commissioned so as to assist the HoL in setting equipment to work, providing or arranging on-the-job or other training where necessary, preparing measurement procedures, and organizing the management of the laboratory and its calibration services. This help might comprise two

or three short (i.e. about one month each) consultancies by UNIDO appointed experts, each covering a particular technical sector of the laboratory's work.

II. MEASUREMENT IN SRI LANKA: NEEDS AND RESOURCES

A. The country and its economy

The economy of this South Asian tropical country has long been based on agriculture. However, because of the varied climate in different regions, there is considerable crop diversity. The principal exports are black tea, rubber, coconut products and spices. In recent years basic industries have been developed, at first mainly in the public sector. In 1977 a change of government gave increased encouragement to the private sector and started to attract inward investment by tax holidays and other incentives. The accompanying liberalisation of imports and financial transfers have improved the climate for development but also led to a worsened balance of payments which has been exacerbated by increased world prices for oil and other essential imports. In consequence, capital for investment is now largely dependent on foreign grants and loans, leading to an increased debt ratio.

Increases in domestic prices over the last few years have held back improvements in living standards, especially for the large proportion of the working population engaged in agricultural production for which world prices have increased less than the prices of imports to Sri Lanka. Attempts to improve the balance of payments have led to diversification into tourism and the export of manpower, mainly domestic but also technical, to other countries, particularly to those in the Middle East. Home remittances from those working abroad contribute significantly to the balance of payments, but the loss, even temporarily, of those with technical skills has probably retarded industrial development.

Other factors affecting the development of Sri Lankan industry have been poor efficiency due to inadequate investment in modern machinery and methods, low utilization of plant, loss of markets through competition, and the inability of some managements to handle these problems, particularly in the public sector where previously sheltered monopolies have ended under the new policies. Another factor which may have restricted growth and affected efficiency has been shortage of electric power due to rising demand and limited generating capacity, particularly in times of drought because of heavy dependence on hydroelectric systems. Emergency remedies by the installation of gas-turbine driven generators have been moderately successful but caused large increases in generating costs and hence in energy prices. However, several major hydroelectric developments now in hand and planned for completion over the next few years should improve the situation considerably, although increased consumer demand from rising urban living standards and rural electrification schemes may offset considerably the gains in generating capacity.

In some industrial sectors, despite labour costs lower than in many competing countries, production costs have remained high and quality poor, resulting in the loss of export market opportunities and in diminished domestic sales. In the latter case this appears to have been due more to lower prices of imports than to better quality. The importance attached to low prices is not surprising in a low wage economy where consumers have not yet learned to judge goods on quality, reliability or style rather than on price. Limited purchasing power also restricts domestic demand for those higher technology products which might find export markets also. To some extent, therefore, industrial organizations have to aim either at the domestic market (low prices) or at exports (quality) but cannot readily produce for both.

The availability of sufficient skilled workers and competent managers is another limiting factor. The education system appears to provide sufficient numbers of graduates and less qualified staff, but there are at present inadequate arrangements either nationally or within industry to provide practical training especially at the craftsman and technician level. Several current and planned programmes aim to remedy this. Management education is also receiving some attention but in this area there is no ready substitute for natural ability combined with long experience in a motivating environment, and hence remedial measures will be slow to take effect.

Further problems for industry arise from the siting of some major plants away from the main sources of their raw materials. Those in the remoter locations suffer from high turnover in skilled staff who are in demand elsewhere and from high transport costs. Transport difficulties are increased by the inadequacies of the national transport system, particularly neglect of roads whose construction and condition often fails to match the density of traffic and the weight of modern vehicles. The railways carry fewer goods in bulk than their capacity would allow, and their further development as a service to industry has been largely overlooked. Coastwise sea transport is lacking.

Table 1 sets out some basic facts about the economy. The figures given are drawn from several different sources (K7 to K11) and should be treated with reserve. In general, the figures relate to 1981; current figures may differ considerably.

TABLE 1: Some facts about Sri Lanka

Land area	6 561 000 hectares	
Population	15 000 000	annual rate of increase 1.8% p.a.
Workforce	5 500 000	average wage SLR 700 per month
Railways	1 435 km	freight traffic 219m tonne. km p.a.
Roads	27 000 km (of which 19 000 surfaced)	
Electrical generating capacity	in 1981 500 MW	
	in 1986 890 MW (forecast)	

Gross Domestic Product (GDP)		SLR 78 500m	
annual rate of real growth		6% p.a.	
Imports		SLR 35 250m	
Exports		SLR 20 600m	(100%)
including	Tea	SLR 6 440m	(31%)
	Textiles	SLR 3 000m	(15%)
	Rubber	SLR 2 900m	(14%)
	Coconut	SLR 1 440m	(7%)
Tourism Sector	(3% of GDP)	SLR 2 500m	
Manufacturing Sector	(17% of GDP)	SLR 13 700m	
Agricultural Sector	(29% of GDP)	SLR 22 500m	

comprising the following principal crops:

Crop	Area (hectares) '000	Annual Production (tonnes) '000
Rice	688	2200
Coconut	486	
Tea	245	188
Rubber	225	124
Manioc	42	328
Chillies	36	32
Maize	34	35
Cow Pea	30	41
Gingelly	29	18
Green Gram	17	13
Sugar Cane	15	24
Tobacco	15	18
Ground Nut	12	14

Crop	Area (hectares)	Annual Production (tonnes)
	'000	'000
Red Onions	12	110
Black Gram	10	6
Others	149	
TOTAL	2020	

k = thousand

m = million

SLR = Sri Lanka Rupee

US $1 = SLR 22.80 in April 1983

B. Sri Lankan Industry

A survey of industry was considered essential if its true measurement requirements were to be identified. Prior to the consultancy reported on here, the only known survey relevant to this objective was a postal questionnaire circulated in December 1979 by Mr. D.D. Kodagoda of the BCS (K12). Of 70 addressees, some 25 replied, almost entirely in private industry. 6 firms said that they did not use measuring instruments; the balance of 19 replies, covering a wide range of light industry, can be analysed as follows (some firms had needs in more than one field of measurement) :

Dimensional measurements	14
Weighing	11
Pressure and vacuum	6
Volume	2
Other mechanical measurements	6
Electrical	10
Electronic/radio-frequency	1
Temperature	6
Photometry	2
Moisture	2
pH	2

A further study was made, therefore, in October and November 1983 of a number of organizations, some being users of measuring instruments and others providers of measurement facilities. Their names, dates visited, and other details are given in Annex B.

While the circumstances and particular problems of individual organizations were not the primary subject of this study, it is possible to form a general impression of the state of Sri Lankan industry as well as evaluating in more detail its need for metrological support. Some firms had well-organised QC systems, the majority did not. It was not uncommon to find that preoccupation with production volume prevented management from taking the steps necessary to raise quality, even though this would of itself have helped to raise output by reducing defects and production hold-ups. Few firms adhered to Sri Lanka Standards, or to other national or international standards. Lack of investment in modern machinery and methods deprived many firms of potential cost savings through improved productivity as well as the means to raise quality to a competitive level. Nevertheless, in the best organizations visited, energetic and able managers had been able to go a long way towards overcoming these difficulties. From the sample of organizations visited, it seemed that private industry had had more success than the state corporations in attracting competent managers.

Few of the manufacturers visited provided any organized training for their workforce; it is probable that greater attention to such training would assist in increasing both productivity and quality. There is perhaps a role for BCS in providing on-site training in quality assurance, with the emphasis on motivation and practical aspects. Clearly, such courses would need to be tailored to particular industries.

It may be noted here that, although Sri Lanka has adopted the metric system, some older equipment is graduated in other units, e.g. the technical units of force; some references to these can be found in the summaries of visits made (Annex B).

Most of the manufacturing organizations visited were involved in continuous or quasi-continuous production processes, necessitating on-line measurement. Weighing and temperature meausrement were the two most common requirements. The latter frequently used thermocouple instruments, at temperatures from ambient up to about 1200° C. Pressure measurements up to about 10 bar, often of steam, and electrical measurements were next in importance, the latter generally ancillary to other measurements where electrical transducers (e.g. thermocouples) were used. Vacuum measurements were rare. Dimensional measurements were more usually necessary in the QC laboratory and in the maintenance of plant and machinery. However, hardness measurements were a critical requirement in several organizations. Minor requirements were for the measurement of force, pH and for photometry. These findings are in general agreement with those of the BCS survey in 1979 (above), with the exception of dimensional measurements. These were probably considered more important in the earlier survey because most respondents were concerned with batch production or the manufacture of individual items.

It was noted that few organization recognized the need for periodic calibration of instruments used, often regarding this need as limited to those occasions when an instrument was repaired. In particular, many thermocouple installations were checked only by checking the electrical indicator, without recourse to temperature standards. Even where the need for periodic calibration on a planned basis was recognized by technical staff, it was rare for there to be any organizational arrangements for this. It is clear that any educational or publicity programme aimed at improving this situation has to be directed primarily at higher management. The need for regular calibration of all instruments should be stressed as part of training courses in quality management and in projects to improve product quality.

It was noted also that the availability of repair and maintenance facilities for measuring instruments was regarded as a problem area by some firms. A defective instrument was likely to be out of use for a considerable period for lack of technical expertise to diagnose and rectify the fault or for lack of replacement parts. Few importing agents for manufacturers possess any technical facilities for such repairs; distant manufacturers vary in their willingness to respond helpfully to enquiries from users. While BCS should not undertake to provide repair facilities, it should at least be able to verify performance following repair for those users who lack their own calibration facilities. It would be wise for the Sri Lanka Government to consider whether a central instrument repair and maintenance facility should be established, and also whether co-operative arrangements with other countries in the region could enable this to be effected more economically.

Summary of findings and recommendations

The present testing capabilities of BCS are not well known to Sri Lankan industry and are consequently under-used.

Few measuring instruments used by Sri Lankan industry are regularly re-calibrated, some not at all; there is only limited awareness of the need for this or of the beneficial effect this could have on production efficiency and on quality control.

Competent and accessible maintenance and repair facilities for measuring instruments used in manufacture and in laboratories are lacking in Sri Lanka, thus putting the reliability of such instruments at a premium.

The Sri Lanka Government should consider the establishment of a central instrument repair and maintenance organization and also explore the possibility of making arrangements with other governments and organizations in the region (e.g. India, Malaysia, Singapore) for co-operation in the provision of such facilities.

C. Measurement resources in Sri Lanka

Several organizations which might provide measurement and calibration services alongside BCS were visited (Annex B). The leading metrological organization is of course the Measurement Standards and Services Division of the Department of Internal Trade (MSS). While MSS has a good range of standards and measuring equipment (B12), its legal metrology duties are necessarily the principal occupation for its small staff. It is well set up for mass measurement and should be relied upon, with the support of regional weights and measures staff, for the routine calibration of weights, weighing machines and balances used in Sri Lankan industry, including those employed in quality control as well as those in use for trade. However, it is not clear whether present staffing levels will prove sufficient to meet the demand that could arise, since weighing is a very common type of measurement in industry. Further details of the measurement facilities of MSS, and of some other organizations may be found in a Commonwealth Science Council report (K13).

Traceability of measurements is of course necessary for consistency and for securing international agreement on test results. As the holder of the Sri Lanka national standards of measurement, MSS must be the focal point for international comparisons and for dissemination of the units of measurement within Sri Lanka. However, because of the limited resouces of MSS, it is considered wise for other major users of measurement, particularly BCS as a provider of calibration services to industry, to obtain direct links to other national laboratories by means of certification of the calibration of their best standards and instruments. This could be a valuable back-up for MSS.

The CSIR has provided some measurement services to industry, and also to BCS. From the visit to the CSIR electrical laboratory (B11), it was clear that at the present time staff shortages prevent such assistance to industry from being effective. It may be that a similar situation exists in the non-electrical areas of CSIR activities. Thus, although CSIR is quite well-equipped, at least for electrical measurements, it should not be relied upon to provide a routine calibration service.

Another electrical laboratory visit, to the CEB Meter Calibration Laboratory (B17), was disappointing. It might have been expected that this would be well equipped for power frequency (i.e. 50 Hz) measurements of current, voltage and energy, and perhaps power factor also, as well as for the calibration of energy meters and of current and voltage transformers. Its present facilities are very limited and need extensive overhaul in order to meet even CEB internal needs and to ensure an adequate level of consumer protection. Since it appeared from discussions that the calibration of electricity meters falls outside the present remit of MSS, the arrangements do not provide for any independent monitoring of the CEB laboratory's activities and competence. This laboratory cannot be expected to provide any assistance to industry at the present time.

Only one university was visited; this was Moratuwa University, a primarily technological university, where several laboratories were seen (B5). On the whole, these possessed a good range of equipment, though some was quite old (especially in the textile laboratory), and some not too well cared for. It is understood that the textile laboratory provides some testing services to industry, and that part or all of the fees charged are retained by the university staff concerned as a supplement to their regular remuneration. It is the author's experience in the UK that educational institutions do not find it easy to provide a regular and hence effective service to industry by use of their technical facilities, partly because of the competing demands of teaching and research, and partly because of the pattern of terms and vacations. A further difficulty is that the access of inexperienced students to precision, sometimes delicate, equipment can be a hazard preventing the achievement of reliable results through undetected maladjustment or even damage.

It is of course appropriate that any services provided to outside organizations should be paid for. To the author, it is surprising that the staff should receive additional remuneration for such work, since this could reduce the attention given to teaching activities. It would perhaps be better if such income were applied to improving facilities, e.g. in the case of the Moratuwa University metrology laboratory, to provide proper stable mountings for the equipment.

It is suggested, therefore, that universities and other educational institutions should not be relied upon to provide routine services to industry although their research expertise could be of great help in solving quality problems. Where routine services are provided, however, this ought to be by the engagement of additional staff for the purpose and be limited to those facilities unavailable from non-educational institutions.

With very few exceptions (e.g. B6) the manufacturing organizations visited did not possess facilities likely to be suitable for assisting other firms. Often these facilities were barely adequate for the need of their owners. There is thus little opportunity for industry to meet its measurement needs from existing internal resources on a co-operative basis. It seems clear that there is a substantial need in industry for good calibration facilities such as are proposed for BCS (see Chapter III).

From discussions, e.g. with the Chief Technical Adviser of a UNIDO project (SRL/79/054) to establish a Textile Training and Service Centre, and visits it became apparent that there is considerable potential for overlap between institutions in the public sector in providing testing and measurement facilities. There appears to be no established mechanism for considering and formulating policy in this area, either in government or among the institutions themselves. A few examples will serve to illustrate the potential difficulties.

In the textile industry a major UNDP/UNIDO project aims at establishing the Textile Training and Service Centre to serve the textile industry and help it to improve quality and productivity and to match its products to market needs. The initial phase of this project lies in the provision of training to those in industry, but a possible extension would add substantial technical facilities especially in providing quality testing equipment. There are also technical and training facilities in various educational institutions, such as the textile laboratory at Moratuwa University, perhaps also in CSIR, and the BCS has been active in textile testing for some 7 years (Chapter III). Other facilities in the textile or garment area may exist or be in contemplation. Clearly, a supportive technical institute for the industry can be a great help in improving production potential and quality.

Equally, the educational institutions should be able to provide some training for undergraduates intending to enter the industry. The BCS has a national role in the testing of products for conformance to standards and in the certification of such products. However, if all these institutions, and perhaps others, are allowed to develop completely independently it may result in unnecessary duplication of some facilities and in competing requirements for skilled staff.

In the rubber industry the Rubber Research Institute is primarily concerned with the growing of rubber as an agricultural crop, though it presumably has an interest in rubber processing also. The recently established IDB laboratory is to be concerned primarily with the processing and admixing of raw rubber but will also have an interest in rubber-based products which will used the processed rubber. Here again, CSIR and educational institutions may also be involved. BCS does not at present have any testing facilities aimed specifically at rubber materials or products but this could readily be regarded as within its remit. Again, unco-ordinated development of facilities could prove wasteful of resources through overlap in the roles of different organizations.

In the electrical field both MSS and CSIR possess good electrical standards though neither has adequate staff to fully utilize its equipment. The BCS, concerned with a wide range of electrical products such as lamps, motors, cable and fittings, needs improved facilities for testing these and for the provision of a calibration service for instruments in use in industry. While there are good relations between these bodies at the personal level, there is no mechanism for ensuring that future co-operation remains effective.

In the view of the author, while no serious overlaps exist at present, these could readily arise as the Sri Lankan economy develops, and both money and scarce staff could be saved by the adoption of suitable means for formulating inter-institutional development policies in these and other areas.

Summary of findings and recommendations

Other organizations in Sri Lanka overlap, or have the potential to overlap and duplicate, some of the testing functions of BCS. However, there are no policy agreements between BCS and these organizations, and hence there is a possibility of unnecessary duplication of facilities and concomitant waste of national resources.

It follows that the Sri Lanka Government should examine the roles and policies of all public bodies in Sri Lanka which have, or may develop, testing and measurement facilities and ensure that any overlap in role or responsibility should not lead to unnecessary duplication of facilities or to waste of national resources in men, money or equipment. This examination should include specialist institutes serving particular sectors of industry as well as those with a role in education, training, standards and research.

The Ceylon Electricity Board's testing station for electricity meters, which should be the primary facility for electrical power/energy measurement and for the calibration of instrument transformers, should be modernised and re-equipped so as to fulfil its function of ensuring an equitable basis for charging consumers, including industrial organizations, for electrical energy supplied. This would complement the BCS electrical measurement facilities.

III. THE BUREAU OF CEYLON STANDARDS

A. Role, organization and testing facilities

The role and organization of BCS have been outlined in the introduction and are described and evaluated in more detail in the project document (K1) and in an earlier report (K4). This chapter, therefore, will deal only with its testing facilities and activities and recommendations relating to the proposed new laboratory building and the metrology section.

The present laboratory facilities are divided between two buildings about 2 km apart. The analytical, microbiological and mechanical testing laboratories are at 5, Galle Road, Colombo 6 and the electrical and textile laboratories at 618 2/1 Galle Road, Colombo 3. The BCS library, to which the laboratory staff need ready access, is in very cramped accommodation at yet a third location, viz 53 Dharmapala Mawatha, Colombo 3. The problems in this area of BCS activities, as well as in many others, were highlighted in the BCS Corporate Plan for 1981-85 (K14). Remedial action on some of these matters is embraced by the present UNIDO-aided project, in particular the provision of a new building to house the laboratories. A site for this building has been acquired. It is the present intention of BCS management to have this building ready for use during 1984 although building works had not been started by December 1983.

The Corporate Plan envisaged the establishment of metrological services to industry and the draft new Act (K3) duly includes as an object

> "to make arrangements or provide facilities for the testing and calibration of precision instruments, gauges and scientific apparatus, and for the issue of certificates in regard thereto as to comply with the required standards;"

In passing, it may be queried whether the last few words of this sub-clause "as to comply ... standards" are necessary; it seems to the author that they could be construed in an undesirably restrictive manner as referring to formal Sri Lanka Standards only, whereas calibration is frequently performed to the manufacturer's specification.

An internal note by Mr. D.D. Kodagoda, dated 5 June 1980, made proposals for the development of a metrology and calibration section of some 200m^2 with a staff of 9 and specified a range of dimensional measuring equipment some of which has since been procured. This note commented that the present laboratory buildings were not suitable to house the proposed metrology section; this view was endorsed in the Corporate Plan. In consequence, accommodation for the proposed metrology and calibration section is included in the plans for the new building.

A survey of BCS testing facilities was made in order to assess calibration requirements for testing equipment so that it operates to the required level of accuracy:

Textile laboratory (Mr. D.S.D. Liyanaarachchi):

a) Tensile tester (J.J. Lloyd T5002 Grade A, acquired April 1983). Equipped for 3 of 4 ranges, viz 5, 50, 5 000 N; load cell for 500 N range has yet to be obtained. Used principally on 80/20 and 65/35 polyester/cotton, also nylon yarns for fishing nets and on coir fibre. Occasional tests on electric cable insulation and on conductors up to 2.56 mm dia.

b) Bursting strength tester (James Heal & Co Ltd. model 111A).

c) Fibre bundle strength tester (Textest (Switzerland) model RM103).

d) Single yarn strength tester (Goodbrand & Co Ltd. model 23).

e) Quadrant balance (Goodbrand & Co Ltd.).

f) Electronic balance (Oertling Ltd. model R20).

g) Projection microscope (Optical Works Ltd.).

h) Light fastness tester (James Heal & Co Ltd. model 225).

j) Tintometer.

k) pH meter.

l) Incubator (James Heal & Co Ltd.).

In addition to the above there are a number of other specialized instruments most of which give test results assessed subjectively rather than by measurement. Additional items are required if the laboratory is to be equipped to cover fully all the tests called for in existing Sri Lanka Standards applicable to textiles. Advice was sought from the Chief Technical Adviser (Mr. J. Woolfenden) of the UNIDO project (SRL/79/054) to establish a Textile Training and Service Centre who advised on relative priorities for additional equipment considered necessary. He also commented on the possible overlap between various institutions concerned with textiles, discussed in Chapter II.

Electrical laboratory (Mr. G. Ganegoda):

This laboratory possesses a considerable number of electrical instruments which require regular calibration. They are summarized below:

a) dc instruments - analogue meters of class 0.5 from 0.1mA to 30A fsd, from 0.3V to 1000V fsd, also class 2.5 within these ranges.

b) ac instruments - analogue meters of class 0.5 from 100mA to 50A fsd, from 75V to 750V fsd, from 30W to 1200W, also class 2.5 within these ranges and a recording instrument with ranges up to 260V or 300A fsd.

c) Resistance bridges (Kelvin, Wheatstone) and standard resistors from 1 ohm $\pm$ 0.01% to 11 111 ohm, also insulation testers to 100M ohm at 500V nominal.

d) A universal impedance bridge and another on order (error about 0.05%) and capacitance boxes of inferior accuracy.

e) Multimeters and oscilloscopes, the best of the former (Hewlett-Packard 3466A) having ranges from 20mV to 1200V and from 200µA to 2A dc, from 200mV to 1200V and from 200µA to 2A ac, from 20 ohm to 20M ohm, with errors as low as 0.05%.

f) Various power supplies, variable transformers, and a high voltage test set to 30kV dc.

g) Electronic instruments (on order) including a frequency counter (Marconi Instruments 2432A) signal generator (Marconi Instruments 2018), function generator (Hewlett-Packard 3312A), distortion factor meter (Marconi Instruments 2331A), rf millivoltmeter (Farnell TM8), af power meter (Farnell 2085).

h) Anemometer (Griffin and George P4) for measuring ceiling fan performance, stroboscope, and a digital tachometer (on order).

A number of additional instruments are needed to cover the tests called for in existing Sri Lanka Standards, e.g. for photometric measurements of electric lamps. It was noted that some of the items listed above could form the nucleus of the electrical standards and instruments needed for the new metrology laboratory; these are listed in Annex D along with others required.

Analytical laboratory (Mrs.S. Peiris):

This laboratory covers general analytical work (chemicals, metals, trace elements) and also the testing of foods. An attached microbiological laboratory covers some of the food tests. The principal equipment needing calibration includes:

a) Double-beam spectrophotometer (Perkin Elmer 124).

b) Atomic absorption spectrophotometer (Varian AA1275).

c) Refractometer (Bellingham and Stanley 60/ED).

d) Polarimeter (Schmidt Haensch Lippich model 14170).

e) Two viscometers (Brookfield RVT, Stanhope-Seta Redwood no.1).

f) Two pH meters (Beckman Orion 55-S).

g) Electronic balances (Stanton, Mettler).

h) Various test sieves.

j) Thermometers fitted to water baths, incubators, ovens and furnaces.

k) Pressure and vacuum gauges.

Mechanical laboratory

This laboratory possesses a range of micrometers, calipers, height and depth gauges, bore gauges, thread gauges, etc., and the following items:

a) Gauge blocks, grade 1 to BS 4311, set of 41 (Yorkshire Precision Gauges Ltd.).

b) Gauge blocks, grade 2 to BS 4311, set of 88 (Verdict Gauges Ltd.).

c) Mu-checker, 4 ranges ± 3µm to ± 300µm (an electronic comparator) (Mitutoyo 519-130?).

d) Optical flats, 45mm and 60mm dia. (Mitutoyo 158-118 and 158-119).

e) Optical parallels, 2 sets of 4, for checking micrometers 25mm and 50mm (Mitutoyo 157-903 and 157-904).

f) Electronic level (Rank Taylor Hobson Talyvel 2).

g) Impact tester (Avery Denison).

h) Compression testing machine 2MN (Avery Denison), primarily for crushing tests on concrete specimens.

j) Universal testing machine 5000kgf (Avery Denison) for tensile and compression tests.

k) Profile projector (Mitutoyo PV-600).

l) Balances: 160g (Mettler H54)
1610g (Welch Scientific Co)
250kg (Avery 3901AAG)

m) Lovibond Tintometer type D (Tintometer Ltd.).

n) Hardness testing machine for Brinell, Rockwell B and C and Vickers scales, with Rockwell test blocks.

p) Microhardness tester for Vickers and Knopp scales (Leitz Miniload 060-366.012) with test blocks.

Of the above items, a to f, and p might more appropriately be transferred to the new metrology laboratory. Other items have been obtained, but were received damaged by corrosion; replacement or repair is awaited. These were a large cast iron surface table, precision rollers, and a sine bar.

The present accommodation for this laboratory is ill-lit and provides a far from satisfactory environment for even routine dimensional measurement. As no records of relative humidity are kept, it is difficult to judge whether there is a risk of corrosion of the equipment; this is likely if the humidity exceeds 70% RH. Once rusted,many of these items will be useless.

General

There are at present no facilities for the measurement of pressure or temperature, other than the gauges and thermometers built into testing equipment. In consequence, such instruments are not normally recalibrated.

The laboratories make no use of certified reference materials, other than hardness blocks, for checking analytical and other instruments. This should be further considered, since CRM's are sometimes more suitable than direct measurement of an instrument's performance characteristics.

During visits to the BCS laboratories, and subsequently, a number of calibration and other problems connected with the testing equipment were discussed and solutions suggested. From these discussions it was apparent that, although many of the staff lacked experience in the field, they were keen to learn and improve their methods and facilities. Purpose-built laboratories should prove a considerable boost to morale and efficiency.

Of some 500 Sri Lanka Standards published, most of the tests called for in about 200 can be carried out by the laboratories, also some tests to international (IEC and ISO) and national (e.g. BS, ASTM) standards. A breakdown by field is given:

Laboratory	Number of standards		
	Can be fully tested	Can be partly tested	Insufficient facilities for useful tests
Textile	79	8	-
Electrical	10	11	4
Analytical	n/a	n/a	n/a
Mechanical	94		2
TOTALS	202		6

The above standards include those specifying methods of test as well as product standards but exclude codes of practice and the like. They also exclude food standards. While the figures appear to show fairly wide coverage, it must be borne in mind that Sri Lanka Standards published to date represent only a small fraction of those applicable to the whole range of national products, many of which have yet to be prepared and published. In developed countries the number of established standards may exceed 10 000, so the scope for future expansion of both standards and means for testing materials and products in conformance with the standards is considerable.

Sub-contracted testing

At present, some tests are sub-contracted to other institutes, e.g. CSIR, for lack of facilities in BCS. In a country lacking in technical resources this is of course a sensible and economic way to proceed. However, this delegation of responsibility has no formal basis, so that BCS does not control the testing and the presentation of results even though any subsequent certification, i.e. the award of the SLS mark for a product, remains a BCS responsibility. These arrangements sould be formalized by the establishment of a testing laboratory accreditation scheme operated by BCS. Such a scheme should follow the guidelines in ISO Guide 25 and command official recognition by the Sri Lanka Government. Sub-contracting of testing should be limited to those laboratories which had been assessed and found to meet the relevant criteria. A corollary is that BCS laboratories should themselves meet the same criteria.

A number of countries already have such accreditation schemes in operation, many of them on a national basis. In some of these countries they provide a suitable means of discharging governmental responsibilities for safety, consumer protection, protection of the environment as well as demonstrating conformance to standards. Such a scheme would also help in meeting the requirements of the GATT Standards Code. It is therefore suggested that a broad-based national scheme should be considered, serving all these needs. However, a scheme to cover BCS sub-contracting is essential in any case even if a national scheme is deferred.

BCS staff are already giving consideration to an accreditation scheme, how it might be administered and organized, and to the basic criteria which laboratories assessed under the scheme should be required to meet. Attention has been drawn to certain other schemes with a view to adapting their methodology to BCS needs. These are:

a) The National Association of Testing Authorities (NATA) - Australia.

b) The Testing Laboratory Registration Council (TELARC) of New Zealand.

c) The National Testing Laboratory Accreditation Scheme (NATLAS) - UK.

To extend its knowledge of such schemes, and to develop contacts with those concerned in other countries, the BCS should be represented at the specialized annual conference, the International Laboratory Accreditation Conference (ILAC). ILAC 84 is to be held in London (UK) in October 1984.

Findings and Recommendations

Although handicapped by unsuitable accommodation, inadequate equipment and too few experienced staff, the Laboratory Services Division of the BCS is active and the staff are keen to develop its work on a sound technological base.

Given technical help and encouragement, and adequate funding, the Division could meet many of the testing needs for product certification and become a centre of expertise in testing and calibration of considerable help to Sri Lankan industry.

Although BCS sub-contracts some testing to other organizations, no formal basis has yet been established; consequently, technical control is lacking thus hazarding the reliability and credibility of the tests.

A scheme for the accreditation of testing laboratories should be established to formalize and control the arrangements under which BCS sub-contracts testing (or calibration) work to other organizations. This scheme should follow guidelines already established (K6) and use methodology based on that adopted by such schemes in other countries, e.g. NATA (Australia), TELARC (New Zealand), NATLAS (UK). When implemented, it could be extended to place additional testing (and hence certification) facilities at the disposal of BCS.

The above-mentioned accreditation scheme for testing laboratories should be considered by the Sri Lanka Government as the potential basis of a national scheme which could secure international acceptance within the framework of the GATT Standards Code and the recommendations developed by ILAC and ISO so as to enhance the export potential of Sri Lankan industry by diminishing barriers to trade connected with product testing and its acceptability. Arrangements should be made for Sri Lanka to participate in the annual ILAC meetings.

B. The Metrology Section of BCS

1. Purpose

The Metrology Section to be established within the BCS Laboratory Services Division should have the following objectives:

a) To provide general measurement support and advice to the Laboratory Services Division and, when called upon, to other Divisions of BCS;

b) To establish and maintain reference standards for all measurements carried out within BCS;

c) To set up and operate a calibration system that will ensure that all measurements made in the course of tests or in the metrology laboratory are reliable, of known accuracy, and traceable to national or international standards;

d) In appropriate cases, to utilize certified reference materials for the verification of the performance of testing equipment and methods that cannot readily be calibrated by objective measurements;

e) To provide a calibration service to industrial and other users of measuring instruments, issuing calibration certificates, and advising on industrial measuring problems;

f) To co-operate with other institutes providing measurement services, particularly the Measurement Standards and Services Division of the Department of Internal Trade;

g) As appropriate, and in liaison with MSS, to co-operate with metrological institutes in other countries in the region, particularly in the maintenance of standards, their intercomparison, and in the training of metrologists;

h) To prepare, maintain, and publish in appropriate form, a schedule of measurements, with ranges and accuracy, that can be made by the Metrology Section.

In furtherance of (a) above, the Metrology Section should assist in the selection and monitoring of sub-contractors who test on behalf of BCS, and in the assessment of their measurement capability under a formal laboratory accreditation scheme, if and when established.

It is suggested that the calibration system, (c) above, should follow the guidelines in BS 5781, Parts 1 and 2, (K15) interpreted to suit Sri Lanka conditions.

In providing an external calibration service, (e) above, care should be taken to ensure that only instruments in proper working condition are accepted for calibration, that they are properly stored, handled and packed for return after calibration, having regard to their vulnerability. Thus appropriate administrative arrangements and storage accommodation are required for this service, whereas the calibration of equipment used in BCS laboratories (located in the same building) will not generate the same requirements for storage, etc.

2. Scope

Having regard to the respective needs of the BCS testing laboratories and of industry, it is possible to specify in general terms the range of measurements for which the Metrology Section should possess facilities and skills, and to outline the additional measurement needs which may arise in future. The following are those measurements for which the metrology laboratory should be equipped initially:

a) Electrical measurements at dc and at low frequencies (up to about 1 kHz);

b) Mechanical measurements, viz dimensions, angle, form, surface finish, hardness, force, pressure;

c) Temperature measurements over the range $-40^{\circ}C$ to $+1500^{\circ}C$, but excluding radiometry;

d) Photometry - total light output of tungsten filament lamps and illumination levels only;

e) Reference materials - utilizing certified reference materials to check spectrophotometers, viscometers, hardness testing machines, pH meters, etc.

The detailed equipment requirements are dealt with later in this section of the report.

A number of other fields of measurement are not considered essential at present but should be considered from time to time for extending the scope of the Metrology Section. These fields arelisted below, with comments:

a) Electrical measurements at high frequencies, also pulse measurements. These arise principally in telecommuncations and broadcasting (sound and television), but also in radar, navigation, timekeeping, computers, digital electronics, some medical equipment and also in the measurement of electrical interference.

b) Acoustic measurements and vibration. These arise in telecommunications, broadcasting, medical audiometry, environmental noise measurement, the measurement of acceleration and impact, seismology, and in the monitoring of machine performance and in the tracing of defects.

c) The generation of forces by force standard machines. These machines, which may be dead-weight machines (i.e. operated by known masses) or lever or hydraulic machines, are necessary if load cells or proving rings are to be calibrated. However, these are expensive, requiring considerable space. Until they can be provided, it will be necessary for force measuring devices used for calibrating testing machines to be recalibrated at national laboratories in other countries (e.g. NPL (India), NPL (UK), NML (Australia)).

d) Radiometry, e.g. optical pyrometry. Few optical pyrometers are at present used by Sri Lankan industry, reliance for the measurement of furnace temperatures being placed on thermocouples. However, optical pyrometers have distinct advantages for some purposes, particularly because they provide a non-contact method and can be used to measure temperature distributions; their use can therefore be expected to grow as industry develops.

e) Photometry of fluorescent lamps. While the light output of tungsten filament lamps can be measured with relatively compact apparatus, i.e. in an integrating sphere of about 1m diameter, larger facilities are necessary for fluorescent lamps which may be up to 2.5m long (nominal 80 W lamp). At present these lamps are not manufactured in Sri Lanka.

f) Measurements on optical systems, e.g. lenses, filters. Optical components are not manufactured in Sri Lanka; moreover, MSS and CSIR both possess optical benches and should be able to undertake some measurements. The more sophisticated measurements, e.g. of optical transfer function, require very costly apparatus.

g) Colorimetry. In a well-developed textile industry, as well as in the manufacture of dyes, paints, wall tiles, etc., the measurement of colour is of considerable importance in maintaining consistency and quality. At present, these industries in Sri Lanka make little use of colour measurement, limiting this in most cases to subjective visual matching of samples to a reference specimen. Good colour measurement equipment, and reference standards, is costly but should be a priority area for extension of BCS facilities.

h) Measurements of mass, volume and density. Measurements of mass and volume are pre-eminent in legal metrology. MSS and its subsidiary district offices are well equipped for these and should be capable of meeting industry's needs as well as those necessary for consumer protection. Density measurements are less commonly necessary in legal metrology but are usually carried out by hydrostatic weighing or the use of hydrometers, density bottles and calibrated floats, all of which can be calibrated by weighing methods. Because of the availability of MSS facilities, such measurements within BCS and in industry can be related to MSS standards and calibrations and the BCS Metrology Section need not provide these facilities although it should organize and oversee the calibration arrangements for BCS equipment.

j) Flow measurements. These are currently necessary in industry but the provision of calibration facilities to cover a wide range of flow rates and fluids is costly and requires considerable space. To some extent, flow meters can be calibrated by the use of weighing methods and calibrated tanks and timing devices. Needs in this area should be kept under close review.

k) Measurements of time and frequency. Relatively inaccurate measurements of these are commonly required in the course of tests; for this purpose ordinary watches or quartz clocks are generally adequate. A check should be maintained on the need for more precise measurements. It may be noted that MSS has facilities for receiving standard frequency transmissions and time signals which could be used to calibrate digital frequency meters and electronic timers.

3. Environment

The environmental requirements for the metrology laboratory are determined by the nature and accuracy of measurements to be made, as set out above. Close control of temperature is particularly necessary for dimensional and electrical measurements, and stable temperatures for most other measurements envisaged. Control of humidity is also necessary, but principally as protection for the equipment employed and to provide comfortable working conditions. Cleanliness is especially important for dimensional measurements, and for some others, necessitating filtering of incoming air as well as the adoption of interior surfaces and finishes for the laboratory that would avoid trapping dust.

The choice of temperature for the laboratory has to be a compromise. A choice close to ambient would require least energy for the air conditioning plant; slightly higher than ambient, requiring heating of incoming air, is cheaper than a temperature a similar amount below ambient, which requires cooling (using more energy because cooling plant is less efficient). A temperature close to or a little below ambient is likely to be more comfortable for staff than one above ambient or well below. On the other hand, established practice in other countries is based on 20°C for dimensional measurements (ISO Recommendation) and on 20°C or 23°C for electrical measurements (e.g. UK and USA practice respectively). Thus instruments calibrated in other countries are likely to be calibrated at these temperatures and ought therefore to be used at the temperature of calibration. However, measuring instruments calibrated for other organizations in Sri Lanka, and for the BCS testing laboratories, are likely to be used in ambient temperatures of around 27 to 30°C, and ought to be calibrated at the temperature of intended use.

Having regard to technical requirements and cost implications, a draft specification (Annex C) was prepared; reference was made to a number of documents for guidance (K16 to K24). It will be noted that the chosen temperature is 27°C, close to ambient in Colombo and to ambient temperatures elsewhere in Sri Lanka, with the exception of the central massif (the Hill Country) which contains little industry apart from the cultivation of tea and other agricultural products. Account has been taken in the specification of the proposed layout (see below) and partitioning of the laboratory area.

4. Facilities

Certain metrological equipment that the laboratory will use is sensitive to vibration and should therefore be isolated from the building or floor. This requirement has been included in Annex C and the particular equipment concerned is identified in Annex E.

For the temperature measurement facilities, water supplies and drainage will be necessary, also possibly a compressed air supply for the ice-making equipment. Because of thermal effects, these facilities should be separated from those for other measurements. Any compressor for supplying compressed air, and the ice-making equipment, should be located outside the laboratory area, to avoid contaminating the laboratory atmosphere with oil vapour or dust.

The electrical measuring equipment, and electrical apparatus used for other measurements, may be susceptible to electrical interference. Sources of such interference (e.g. commutator motors, electric welding equipment) should be remote from the metrology laboratory. Checks should be made to ensure that interference is not affecting measurements. Certain electrical instruments should be supplied from voltage-stabilized mains. Stabilizers for this purpose should not be of the step type, as they are often ineffective for this purpose and may themselves generate interference. The mains supply voltage should be monitored. Although fluorescent lamps are recommended for general lighting, care should be taken to check that they do not produce electrical interference. If so, an earthed wire gauze screen surrounding the light fitting may eliminate this although of course this will reduce illumination also. An earth connection, separate from that associated with the electrical power system, should be provided for the electrical measurement area and care should be taken to avoid earth circuit loops which may introduce interference or power frequency voltages through circulating currents.

Proper storage facilities are essential for equipment not in current use, especially for standards. Cupboards are better than open shelves. Unprotected steel items such as gauges should be wrapped in protective paper. Delicate items should normally be stored in foam-lined boxes. Good storage facilities are also necessary for equipment awaiting calibration or despatch after calibration.

The laboratory should be equipped with sufficient solid benches with working surfaces covered with melamine sheet for cleanliness. Paperwork, apart from the actual recording of results, should be done outside the laboratory, as paper lint and debris are undesirable in the laboratory. Similarly, food and drink should not be introduced into the laboratory; there should be no smoking. Entry to the laboratory should be via an airlock, and access restricted to the laboratory staff, the door being locked when they are not present. Visitors and cleaners should be strictly supervised to protect the integrity of apparatus and to ensure cleanliness of the environment. A so-called "tacky" doormat at the entrance, to remove dust from the soles of shoes, is advantageous, as is also the routine use of laboratory coats of lint-free material.

5. Layout

The laboratory layout proposed in the building plans appears well-chosen; a sketch is included in Annex C, showing how the area should be sub-divided. The possible need for space for future expansion was discussed with Dr. G.M.S. de Silva (as, of course, were most of the details discussed in this section of the report). It is possible that adjoining accommodation might be taken over for less accurate work, retaining the initial accommodation for more precise requirements.

To ensure that the most demanding measurements, i.e. dimensional and some electrical measurements, are provided with a suitable environment, including the lower temperatures (20°C or 23°C) which are the international norm, an inner laboratory, separated by a light, thermally-insulated, partition from the main laboratory, is proposed. Similarly, the area to be used for temperature work, where a fair amount of heat may be generated, should be partitioned off.

The proposed entrance lobby provides an air lock for access, and storage accommodation for equipment and records. The inner and outer doors should not be open simultaneously to avoid ingress of dirt or disturbing temperature control.

6. Staff

The work-load for the Metrology Section is not easy to forecast. The staff will need to possess a wide range of skills and each person will need to specialize in a particular area. In terms of man-hours, it is probable that 2 people would suffice for calibration of BCS testing equipment, but the spread of skills requires 3 or 4 people. The proposed calibration service will, if successful, grow gradually from a very low work-load (apart from marketing effort) to occupy perhaps 6 or more people. On average, each could calibrate upwards of 100 instruments a year.

An initial 4 staff, including the Head of the Section, is recommended. Relevant specializations are:

a) Electrical measurement

b) Dimensional measurements

c) Temperature measurement

Given appropriate academic ability, and with suitable practical training, they could be expected to cover the range of measurements suggested in the first paragraph of sub-section 2 (Scope), above. The Head of the Section, and at least one other, should be graduates of some years' relevant post-graduate experience. In addition to these 4 people, a laboratory attendant, responsible for the care and cleaning of the laboratory and its equipment, would be desirable.

7. Equipment

a) Electrical measurements:

The metrology laboratory needs reference standards for voltage, resistance and reactance together with apparatus for the calibration of measuring instruments, and suitable power supplies. Outline specifications for procurement are given in Annex D (items 1 to 18), which also includes a list of equipment already held, or on order, which should be transferred to the Metrology Section (items 19 to 25).

b) Mechanical measurements:

BCS already possesses a wide range of ordinary micrometers and gauges of various types. These will need to be added to from time to time as new requirements arise. However, the recommendations made here do not include these and are confined to major items. A list is given in Annex E.

Two surface plates are included; the cast iron plate received damaged and awaiting repair or replacement is of lower grade and could be retained for general use in the mechanical testing laboratory, as will most of the micrometers and gauges. However, the sine bar and precision rollers, also received damaged, should be held by the Metrology Section after replacement.

Delivery of all the items listed in Annex E should be deferred until after the new laboratory has been completed and has been in use for at least 2 months so that any teething troubles with the accommodation or air conditioning have been cured before the equipment is unpacked. This suggestion is made because of the susceptibility of many items to corrosion if the relative humidity rises above 65%, and the ease with which working surfaces etc., can be damaged by dust or careless handling. On present assumptions, delivery should be scheduled for the first quarter of 1985.

Suggested suppliers are given (addresses being omitted for brevity) for most items. The recommendations are based on a technical report (K24) of British origin and partly on a BIML publication (K32). There are many standards (e.g. ISO, BS) relevant to mechanical measurements which should be studied by the staff of the Metrology Section; some other useful references are given (K25 to K31).

Apparatus for the assessment of hardness and for the measurement of force, pressure and some other measurands occasionally regarded as "mechanical" is dealt with at d) below and is listed in Annex G.

c) Thermal measurements:

At present, BCS has no temperature standards although temperature measurements are necessary in almost every test carried out in the Laboratory Services Division. Some of the thermometers at present in use are not sufficiently accurate. The list of standards and other equipment recommended (Annex F) therefore includes at item 1 a range of suitable thermometers for general use. However, at least one of each (i.e. those independently calibrated) should be retained in the metrology laboratory for use as working standards. Any lost or damaged should be promptly replaced (liquid-in-glass thermometers have to be considered expendable) and the range should be extended to match needs.

Thermocouples recommended (item 2) have been limited to Type B as Types K and T are already on order for BCS. Because it is advantageous to reduce variety as far as possible, the digital voltmeters (item 5) could be identical to that specified at Annex D item 13 except for the improved accuracy specified. However, for thermocouple calibration only dc measurements are necessary, so suitable instruments may be available at lower cost.

The multi-point recorders are intended for use, primarily as environmental monitors, throughout the testing laboratories. One will be required in the metrology laboratory, one should be kept as a spare, the other four being deployed elsewhere. It would be advantageous if these can be operated with humidity probes also, thus permitting recording of both relative humidity and temperature on the same instrument.

On the present assumption that the new laboratory building will be ready for occupation (including all services, laboratory furniture, etc.) in December 1984, it would be wise to schedule delivery of all the above items for the last quarter (October-December) of 1984, or even the first quarter of 1985. This will avoid unnecessary storage, unpacking, repacking and removal of the equipment, some of which is easily damaged,and ensure that any guarantee (warranty) period does not commence before the equipment can be put into use.

Suggested suppliers, with addresses, are given for most items in Annex F. The equipment recommendations, and the suppliers suggested, are largely based on a technical report (K33) of British origin. For most items there will of course be suitable suppliers in countries other than UK.

The same report (K33) also contains a useful bibliography; the more important, which should be accessible to the staff of the Metrology Section, are listed (K34 to K42). In addition, there are a number of highly relevant ISO, British and American (ASTM) standards which are relevant.

d) Other measurements:

Force: While it is considered too costly, both in equipment and accommodation, to provide means for the generation of accurately known forces, there is a widespread need in industry, as well as within BCS, for the calibration of testing machines. Equipment is therefore recommended (Annex G) for such measurements; re-calibration every two years in a national measurement laboratory (e.g. NPL (UK)) will be necessary (K43 and K44).

Pressure: In general, current needs for pressure measurement in Sri Lanka do not demand great accuracy, and are mainly limited to pressures less than 1MPa (= 10 bar) in air, water or oil. Barometric pressures are mainly of interest to meteorologists and those concerned with pressure-operated altimeters. There is only a minor requirement for calibration of industrial vacuum gauges. Recommended equipment is listed in Annex G; it should be noted that the calibration of a dead-weight tester is dependent on the local value of g (the acceleration due to gravity) which should be quoted when ordering. The pressure test bench will require a supply of dry nitrogen for flushing pressure systems; distilled or de-ionized water will also be required (also required for ice-making and water baths for temperature calibrations - see Annex F).

Hardness: For reliable tests on metals, it is desirable to replace the existing Frank hardness tester in the BCS mechanical testing laboratory with a modern one of improved performance. It should cover Brinell, Rockwell B & C and Vickers HV30 scales, and be supported by a good range of hardness test blocks (BCS already has a small range). Relevant standards for hardness tests, which should be carefully studied, are listed in Annex K (K45 to K50). An outline specification for the replacement machine, which should be capable of making tests in accordance with these standards, is given in Annex G. The existing machine can be retained for routine test work in the mechanical testing laboratory, subject to regular checks on its performance. These can be made using hardness test blocks; additional blocks are recommended in Annex G. The independently certified blocks should be reserved for use in checking the new hardness machine once of twice a year, the others being used for intercomparisons with the Frank machine and with other machines in industry.

The existing Leitz microhardness machine is adequate, but consideration should be given to extending the range of test blocks available.

The hardness of rubbers and plastics is a basic parameter. Even if the BCS does not undertake a comprehensive range of tests on rubber and plastics products (K57 to K60), it should be equipped for hardness tests (K51 to K56) as components of these materials occur frequently in other products (e.g. electrical accessories, packaging). For reliability, a deadweight tester is essential, together with a range of hardness test blocks; these could be used to calibrate industrial instruments. Outline specifications are given in Annex G.

Quality control investigations on rubber products may necessitate the measurement of microhardness. If such equipment is procured, it also should be of the deadweight type, and be supported by microhardness reference blocks.

Photometry: The main requirement is for the measurement of the light output of tungsten filament lamps. For this an integrating sphere (1m dia. should cover domestic lamps up to 150W), standard lamps and a photometer of good discrimination and linearity with appropriate spectral response are necessary, together with suitable power supplies and electrical measuring instruments. A secondary requirement is for the measurement of illuminance (i.e. luminous flux) for the evaluation of lighting systems.

The standard lamps required are costly, and of course require certification by a national laboratory to provide traceability of measurements. To prolong their useful life, it is essential that they are operated from a suitably stabilized constant-current power supply, and that routine calibration work is done using selected lamps of local manufacture as working standards. Selection should be on the basis of stability and reproducibility. The standards recommended are rated at 40W and 100W, but the range could be extended by the addition of 60W and 150W lamps. It should be noted that these lamps will deteriorate in use (at best by 1% reduction in output per 100 hours use) and will need replacing every few years.

Viscometry: The Metrology Section should procure and maintain a selection of CRMs for checking viscometers. These may be selected from catalogues published by reliable sources of CRM's (K61 to K66). As the life of hydrocarbon CRM's is limited (e.g. NPL states that certification is valid for four months), these CRM's should be re-ordered on a regular basis, timed to suit scheduled re-calibration dates. If calibration work on viscometers increases BCS should consider purchase of reference viscometers of the glass capillary (BS/IP/SL) type; 3 full sets would be required. A suggested supplier is:

Poulten, Selfe & Lee Ltd., Russell Gardens, Wickford,
Essex, SS11 8BJ, UK (attention of Mr David Gosling)

from whom full details may be obtained. It should be borne in mind that viscometry is highly temperature sensitive, and that temperature control to ± 10mK may be necessary. The water baths for temperature calibration work (see Annex F) may be suitable as temperature controlled enclosures. It is recommended that viscometer calibrations should be made at 27°C, the normal temperature of use, and that CRMs purchased should be certified at this temperature. Temperature coefficients will also be required. Publications of the Institute of Petroleum (UK), the American Petroleum Institute (USA) and by ASTM (K67) may be useful.

Polarimetry and Refractometry: Instruments for these measurements should be calibrated using CRMs of a form to suit the individual instrument. In some cases these will be solid test-pieces of stable refractive index, in others liquids in suitable enclosures. The angular scales can of course be checked by conventional mechanical metrology. For the Schmidt & Haensch polarimeter used in the BCS analytical laboratory, a quartz plate should be obtained (see Annex G item 20). The Bellingham & Stanley Refractometer already has a reference plate of silica, although it would be desirable if this were independently certified.

pH measurements: In general, pH meters can be checked by the use of carefully prepared buffer solutions of known composition. However, an independent check giving international traceability can be provided by the use of CRMs (K68) for the preparation of these. These CRMs are obtainable from NBS (K61) and other sources.

Spectrophotometry: Spectrophotometers are best checked by the use of CRMs in the form of filters. These can be either metal film or absorbing glass types. Those supplied by NPL (UK) are described in a paper (K69). Those supplied by NBS are described in other publications (K70 to K74). CRMs of known composition can also be used to make up solutions for test.

For checking the spectrophotometers used by BCS, a set of 5 absorbing glass filters (Annex G item 21) should be satisfactory. It is assumed that the spectrophotometers will accept rectangular 10mm cuvette holders to BS 3875: 1965, into which the recommended filters are designed to fit. These filters are suitable for the range 400nm to 800nm; if shorter wavelengths are significant in BCS test work, then metal film filters will be needed in addition, certified at wavelengths below 400nm.

8. Organizational arrangements

The management of the Metrology Section involves a number of diverse tasks in order to achieve the objectives set out in sub-section III.B.1 above. These tasks may be summarized as:

a) internal housekeeping, maintaining the laboratory's facilities, equipment, standards and records in good order;

b) establishing and controlling routine arrangements for the calibration of all testing and measuring equipment used by BCS, and keeping records accordingly;

c) marketing and operating an external calibration service;

d) training the staff of the Metrology Section, and assisting in training other BCS staff, in the necessary procedures and helping them to acquire new skills as necessary;

e) reporting to senior management, identifying future metrological needs for BCS and for the support of industry, and recommending how these needs should be met.

A quality control handbook should be written, and kept up-to-date, setting out the prcedures to be followed in the laboratory's work.

Each item of laboratory equipment should be uniquely identified and records maintained of specification, performance, accessories, details and dates of maintenance and calibration, including identification of the relevant written technical procedure for its calibration and adjustment. A library of procedures, especially written or tailored to the laboratory's specific needs, should be established, each document being identified and dated. Amendments should be recorded, with dates. Each procedure should identify equipment used, details of method and presentation of results, and a section setting out the uncertainty of measurement achieved by the use of the procedure.

Each item of equipment in other BCS laboratories should also be on record, with similar data including identification of the relevant calibration procedure, with results and dates of calibration. A recall system should be established to ensure that each item is re-calibrated at the right time. The equipment should be labelled to show when calibration is due, or if overdue; a supply of standard labels is useful for this.

Similar arrangements, particularly concerning calibration procedures and results, are necessary for the external calibration service. For this service suitable estimating, receiving, despatch and costing arrangements are required. Consideration should be given to establishing a standard fee structure for the more common instruments, with time-related charges for others. Marketing the service will require considerable effort, by advertisements, direct mail, personal contact and by publication of a schedule of measurement services offered. A calibration certificate should be designed and printed.

Records of the laboratory environment (i.e. temperature, relative humidity, cleanliness) should be kept and arrangements made to protect equipment in the event of a breakdown of the air conditioning system. A particular hazard is relative humidity above 65/70%, causing rusting. Emergency heating to raise the temperature above ambient, with suitable ventilation, can help to prevent this, although at the expense of uncomfortably high temperatures.

9. Summary of findings and recommendations

The BCS metrology laboratory should be equipped and staffed to provide certain measurement facilities to match the needs both of BCS and of Sri Lankan industry. Extension of these facilities should be kept under review. Greater detail is given in sub-section III.B.2 above.

With layout, facilities and environmental control set out in sub-sections III.B.3, 4 and 5 above, the planned provision of a metrology laboratory of a nominal gross area of 128m^2 should proceed as planned.

The laboratory should have an initial staff of four.

The measuring and other equipment specified in Annexes D, E, F and G should be procured and commissioned.

Some existing metrology equipment, as well as some proposed for procurement, should be calibrated, and certified, to provide traceability to internationally recognized measurement standards. Other equipment should be regularly calibrated.

Some metrology equipment deliveries should be phased so as to match the availability of the new laboratory building.

Consideration should be given to the use of certified reference materials, under the supervision and control of the Metrology Section.

The present capability of the BCS to calibrate industrial instruments, as well as its facilities for products and materials testing, should be published and widely distributed in Sri Lankan industry and research institutes. As the services develop, this information should be frequently updated through a mailing list and other means.

IV. TRAINING AND TECHNICAL ASSISTANCE

A. Seminar on measurement in industry

With the dual objectives of providing some basic instruction in the principles of metrology, and demonstrating the intended role of BCS in meeting industrial measurement needs, a two-day seminar was planned and held in the Bureau's training section lecture room on 24/25 November 1983. The seminar programme is in Annex H.

The Minister of Industries and Scientific Affairs, the Hon. C. Cyril Mathew, opened the seminar. There were 42 participants, 29 from industry and 13 members of BCS staff. The participants were asked to comment on the seminar by use of a questionnaire. Most were satisfied with the value and quality of material but some 38% thought the level of treatment too simple and 33% mentioned gaps in coverage of the subject. Nevertheless, 79% considered the programme well integrated. 95% of respondents to the questionnaire said they would be interested in attending a more advanced course.

Opportunities were given during and after the various lectures for questions and discussion, but few contributed. Even so, 33% of those answering the questionnaire thought that more time was needed for this.

BCS management considered the seminar highly successful, especially in terms of participant numbers. It may be concluded that further seminars, generally focussing on a particular aspect of measurement so as to allow greater depth of treatment, should be organized. It should be possible to call upon Sri Lankan lecturers from universities and scientific institutions to avoid dependence on visiting experts. A useful by-product will be the greater visibility of BCS and its services. Such seminars should typically be of half- or one-day duration.

B. Training of BCS staff

Metrology Section staff

The designated Head of Laboratory (HoL), Mr D.D. Kodagoda, has undergone training at the National Research Laboratory for Metrology, Japan. As the exact content of his training course was not known at the time of the mission, the course being then in progress, it is not practicable to make further recommendations for his technical training. However, he would no doubt benefit from opportunities to visit calibration laboratories elsewhere, particularly any engaged in providing a national calibration service (e.g. the British Calibration Service based on NPL (UK)). In any event, he should familiarize himself with the national measurement facilities of other countries in the region with a view to possible co-operation in the maintenance and intercomparison of measurement standards. Liaison with MSS should prove helpful in this, since MSS has contacts with such laboratories under the auspices of the CSC Asia/Pacific Metrology Programme (K75).

The HoL should be well fitted to take the lead in providing on-the-job training for his staff, as and when the requisite equipment becomes available. Off-the-job training should be possible by arrangement with other institutions having relevant facilities:

e.g. CISIR - electrical measurements;
MSS - weighing, electrical, mechanical, thermal measurements;
Universities - according to facilities.

Training requirements not met by this means may be met at other institutes in the region such as SIRIM and SISIR (K76), also NML (Australia) and NPL (India). Allowance should therefore be made for three UNIDO Fellowships to be awarded under this project; these should be of around 2 months' duration each.

One of the areas in which training will be required is in temperature measurement, a new field for BCS. If it is necessary to go further afield for this, NPL (UK), BSI and British Calibration Service laboratories are suitable places.

A further need is for training in photometry. This could take in not only the testing of lamps but also the calibration of photometers, measurements on luminaires, and colorimetry, the latter two subjects with an eye to the future. Suitable places for such training are NPL (UK), BSI, and the Shirley Institute (UK) for colour measurement applied to textiles. It is unlikely that suitable training could be provided in the SE Asia region.

The third fellowship envisaged should be in force/pressure measurements, both new fields for BCS. NPL (UK) would be a suitable institute.

Other BCS staff

During the mission the training needs of staff engaged on product testing was discussed with BCS management. Preliminary enquiries were made for the training of two people at the Laboratory of the Government Chemist, London, UK. Other needs in electrical product testing were also considered and suggestions made.

Since measurement plays an important part in testing, it is desirable that an in-house training programme should be planned. This should ensure that BCS testing staff have a proper grounding in the selection and use of measuring instruments and in the possible causes of uncertainty in a measurement. Such training might conveniently be combined with the industrial seminars recommended in Section A above. For new entrants, however, more extensive basic training may be necessary; this could perhaps be given in the metrology laboratory.

Summary

A summary of fellowship proposals is in Annex J.

C. Assistance by outside consultants

Metrology Section

Until the new laboratory is operational, and the recommended equipment available, there is little benefit to be obtained from further missions by experts in metrology. However, once that stage has been reached, possibly in early 1985, it is suggested that three short (1 to 2 months) visits by UNIDO appointed metrology experts would be helpful. These would have the following objectives:

a) Assisting BCS management, and the HoL in particular, to set up an effective system of calibration control, identifying measurement procedures to be written, and advising on the marketing, administrative and technical aspects of the external calibration service.

b) Assisting the Metrology Section staff to commission the temperature measurement facility, and training the staff in the relevant techniques.

c) Providing on-the-job training in dimensional measurement, also measurement of form, angle, surface texture and hardness.

The three experts should be qualified, respectively, in:

a) Management of measurement laboratories and calibration services.

b) Temperature measurement, particularly in resistance thermometry and the calibration of thermocouples and liquid-in-glass thermometers.

c) Engineering metrology, i.e. dimensional metrology and related measurements.

Other requirements

If the recommendation (section III.A) to establish a laboratory accreditation scheme is accepted, it would be helpful to BCS to have the assistance of a consultant experienced in the operation of such schemes. His duties would include:

a) assisting BCS staff to formulate rules and criteria, and to set up the necessary administrative arrangements;

b) designing a training course for technical assessors who would visit and report on laboratories seeking accreditation;

c) advising the BCS how to ensure that its own testing laboratories could meet the criteria for the scheme, thus demonstrating its own commitment to the scheme.

The duration of the consultant's mission could be any period from two to six months, depending on the extent of assistance sought by BCS. It is possible that the same person could have the necessary background to cover the first of the three short assignments suggested in the preceding subsection "Metrology Section".

There are already plans under this project for missions by outside consultants in relation to the quality assurance, certification and information programmes of BCS. No comment on these is called for here.

D. The new laboratory building

Progress made in constructing the new building has proved much slower than was expected when this project was launched. BCS management now hope to have the building ready for occupation by the end of 1984. While this might be a practicable target for a general purpose office or factory building, the special requirements for laboratories, particularly air conditioning and other services, will demand special efforts. Moreover, the problems of transferring equipment and staff from the present laboratories to the new building need good planning and liaison if unacceptable delays and interruption to testing programmes are to be avoided. There is little local experience in Sri Lanka of such matters.

It is therefore recommended that consideration should be given to the appointment by BCS of a member of the project team whose full-time duties would be:

a) to effect the necessary liaison between those who will manage and staff the laboratories and those responsible for design, erection and the provision of building services and furnishings;

b) to monitor the progress made with the aforementioned work, and report regularly (say, monthly) to BCS management and to the project management;

c) to plan in detail the removal of the present laboratory facilities to the new premises, and their successful installation, so as to minimise damage to and loss of use of these facilities, extending the plan to embrace new equipment being provided.

Unless such an appointment is made, there is some danger that the availability of the new laboratories could be further delayed. In any event, it will call for special effort by all concerned to avoid the completion date slipping further.

E. Other assistance programmes

There are a number of organizations active in the region whose programmes include improvement of metrological andtesting facilities. For example, the Commonwealth Science Council has had an ongoing programme since 1977: The CSC Asia/Pacific Metrology Programme. That programme has been linked to Sri Lankan needs through MSS, and BCS has had little part in it so far. Other programmes are proposed or operated by ROSTSCA, ESCAP, ASCA and FEISAP. There are a number of international organizations primarily concerned with metrology, viz BIPM, OIML, IMEKO (particularly Technical Committee 8). Contact with these bodies, in liaison with MSS, could be helpful to BCS in building up its metrological services on sound lines, and might lead to opportunities for training or co-operative activities which would benefit BCS.

It is recommended, therefore, that BCS should actively seek and increase its metrological contacts and co-operation with other organizations in Sri Lanka and overseas, as well as with other national metrological institutes.

In addition, there are a number of overseas organizations, particularly in the more developed countries, which could provide technical assistance in metrology or the testing of materials or products. BCS already has established co-operative arrangements with ASTM and Underwriters' Laboratories Inc. Other possibilities include the Instrument Society of America, IMEKO TC8 (mentioned above), and various research institutes such as RAPRA in the UK. It is recommended that BCS should consider seeking corporate membership, or individual membership for a number of its staff, of such organizations.

F. Acknowledgements

The author of this report wishes to record his appreciation of the considerable help and co-operation afforded him during his mission by many people, particularly:

Dr G M S de Silva) Bureau of Ceylon Standards
Mr G Ganegoda)
Dr J Mattsson, UNIDO office, Colombo
Staff of the National Physical Laboratory, UK, for invaluable assistance by correspondence
Miss Sally Follett, who typed the report

and, not least, his wife Jane and their children for their company and support during his mission, and for their forebearance during the preparation of this report.

ANNEX A: INTERNATIONAL AND COUNTERPART STAFF

For UNDP

Mr. N. Bradshaw - Resident Representative, Colombo.

For UNIDO

Ms E. Taitt - Institutional Infrastructure Branch, Vienna.

Dr. J. Mattsson - UNIDO office, Colombo.

Mr. D.P. Thurnell-Read (UK) - Consultant in metrology.

For the Bureau of Ceylon Standards

Prof. P.A. de Silva - Director and Project Director.

Dr. G.M.S. de Silva - Assistant Director (Laboratory Services) and Project Executive Secretary.

Mr. D.D. Kodagoda - designated Head of Metrology Laboratory.

Mr. G. Ganegoda - Head of Electrical Testing Laboratory.

Mr. D.S.S. Liyanaarachchi - Head of Textiles Testing Laboratory.

Mrs S. Peiris - Head of Analytical Laboratory.

ANNEX B: ORGANIZATIONS VISITED

1. Ceylon Petroleum Corporation — 4 October 1983

Petroleum Refinery, PO Box 11 Kelaniya

Non-destructive testing laboratory (Mr. Sapugaskanda):

a) Tensile tests to 11 kN for weld strength, Vega Enterprises Inc (USA) A2.
b) Densitometer for radiography, Sakura PDA-81.
c) Radioactive sources for radiography of welds and pipeline tracing.
d) Ultrasonic surveying of pressure vessels.
e) Portable hardness tester, CV Instruments (UK) no 1 MK V.
f) Paint thickness tester, Elcometer.

Instrument maintenance section:

g) Pressure testing bench.

Findings: No calibration system or reference standards.

2. National Paper Corporation — 6/7 October 1983

Embilipitiya (Mr. M.A. Justin, Mills Manager)

Paper mill converting rice straw with added (imported) wood pulp. Capacity 50 t/day. Average output about 25 t/day. Recovery plant for caustic soda. Energy (electricity, fuel oil) costs account for 35% of production costs. Plant established with German technical help - most machinery and instrumentation of German manufacture.

QC laboratory: fairly well equipped but no calibration system.

Instrument repair section: has pressure testing bench but no other calibration facilities.

Problems: Low output, marginal quality, inefficient recovery process, high energy costs, high transport costs, high turnover of technical staff, fluctuating supply of principal raw material (rice straw).

Findings: First stage of process (cooking of rice straw with steam under pressure) not efficient, causing production losses, due to batches not being weighed and having high, unmeasured, water content.

Quality control reports not always acted upon.

High uptake of silica by rice crop (14/15%) causes clogging by calcium silicate precipitated in the recovery process.

Electricity board's meters read higher by 14% than plant's check meters causing dispute over charges.

Boiler efficiency in doubt due to lack of calibration facilities for instruments (mass flow, flue gases).

Ceylon Standards for paper not used by QC laboratory.

3. Kelani Cables Ltd. 10 October 1983
Kelaniya (Mr. W.J.L.J. Wijayaweera, Works Manager)

Makes electric cable to Ceylon Standards, holds SLS mark, also makes enamelled wire, some cadmium-copper wire. Uses enamelling (400° C) and annealing (vacuum) furnaces.

QC laboratory:

a) Tensile testing to 1000 kgf (i.e. 10 kN approx.).
b) Furnaces to 240° C.
c) High voltage testing to 1500 V (proof) and to 15 kV (spark test).
d) Resistance bridge, no standards.
e) Micrometers intercompared, but no standards.
f) Two 400° liquid-in-glass thermometers.

Problems: Better calibration of instruments, especially enamelling furnace thermocouples (NiCr/Ni) and vacuum gauges (to -0.9 bar), is needed.

Findings: Management is conscious of need for regular calibration, keen to maintain and improve quality but unaware of current resources of BCS for calibration of instruments (e.g. resistance bridge, micrometers).

4. Veyangoda Textile Mill 13 October 1983

Veyangoda (Mr. E.D. Duffin (UK), Resident Mill Manager; Mr. W.O.H. Meththananda, QC Manager)

Managed by Tootal (UK). Some new machinery for cloth finishing and printing but quality sufficient only for the domestic market despite an apparently well-organized QC laboratory. No colour measurement facilities.

Problems: Investment in modern machinery, training and supervision of production staff, working conditions (noise, heat, safety).

Findings: Good productivity, could compete internationally if quality can be raised by improved cotton supplies (currently Indian) and more modern machinery.

5. Moratuwa University 17 October 1983

Moratuwa

A primarily technical university (709 undergraduates in 1979) a few km south of Colombo.

Structures laboratory:

a) 200 tf Amsler lever force machine (1970).
b) Amsler box (load cell) (1970).
c) Kyowa load cell 10 tf (1972).
d) Various Soiltest Inc (USA) proving rings.

Soil Testing laboratory:

e) Wykeham Farrance Ltd. 5000 kgf compression testing machine.
f) Various proving rings (e.g. 2 kN, 2 kgf).
g) Budenberg "standard test gauge" for pressure to 12 bar.

Public Health (microbiology) laboratory - conducts diploma course :

h) pH meter, Philips PW9409.

j) Spectrophotometer, Cecil Instruments (UK) CE 373.

k) Balance, Mettler H30.

l) Dissolved Oxygen Meter, EIL 1510.

m) Turbidimeter, Hach Chemical Co. (USA) 2100A.

Metrology laboratory:

Under the Production Engineering department. Some good equipment but mounted on wooden tables:

n) SIP, Societé Genevoise.

p) Universal (2-axis) measuring machine.

q) Projector.

r) Gauge blocks (appeared in poor condition).

s) Auto collimator, inadequate mounting.

Department of Textiles (Dr. Lakdas Fernando, Head):

A range of textile fibre and fabric testing equipment, some quite old, less comprehensive than BCS facilities. Provides a testing service to industry. Fees charged.

Findings: On the whole, mediocre equipment barely adequate for teaching. Metrology laboratory resources are insufficiently utilized for lack of proper organization and environment. No evident of calibration, regular or irregular, or appreciation of the need. Some equipment had been provided with UN funding.

6. Ceylon Steel Corporation 18 October 1983

Athurugiriya (Mr. Ranjith Wijewardana, Chief Metallurgist)

Converts imported billets and scrap, produces reinforcement bars, etc. Capacity 150 000 t/year. Established with Russian technical advice. Much of original measuring and testing equipment of Russian origin, but some since replaced.

Principal equipment noted:

a) Hardness (standardizing) machine, ESE model SPVR 2M about 3 years old. Measurements are Vickers to 900, Rockwell C to 60, Brinell to 400.

c) - do - for Brinell tests.

d) Microhardness tester, Russian made but similar to Leitz but without turntable. Replacement being sought, also certified microhardness standard blocks.

e) Universal testing machine 50 t capacity, a robust hydraulic machine of Russian origin.

f) Tensometer 20 kN, Monsanto W, about 3 years old.

g) Atomic Absorption Spectrophotometer, Varian AA875 about 3 years old. Electronics alleged unreliable and servicing difficult.

h) Spectrophotometer for silicon analysis, Bausch and Lomb Spectronic 20.

j) On order - Bausch and Lomb Spectrograph at cost of SLR 3m.

k) Temperature of molten steel (1700° C) measured by "disposable" Pt/Rh thermocouples.

l) Pressure measurement to 250 kgf/sq.cm. required for hydraulic systems, but no calibration facilities available.

Findings: QC activities appeared well organized, and finance for essential equipment available. Help needed in making choice, and for ensuring regular calibration. CRM's could be useful.

7. Lever Bros (Ceylon) Ltd. 19 October 1983
Colombo (Mr. C. Tissaratchy, Assistant QC Manager)

Wholly-owned subsidiary of UK firm making soap, washing powder, shampoo, toothpaste, and a bread release compound (an emulsion of water and coconut oil). Chairman and Marketing Director are both from UK, remainder of staff Sri Lankan. Labour intensive, even packing.

Findings: QC laboratory and associated microbiology laboratory appeared well organized. Little need for calibration of instruments as process and hence QC fairly simple.

8. Lanka Walltiles Ltd. 20 October 1983
Balangoda (Mr. Ranjith Munamalpe, Production and Development Manager)

Owned jointly by Ceylon Ceramics Corporation and Japanese firm Danto who gave technical advice when established. Makes plain and decorative ceramic walltiles to the Japanese company's standards but has met and passed overseas national standards, e.g. BS, also ASTM except for water absorption. Output 1200 t/month of which 90% exported under brandname Danto Tile (DK brand). Dropping Japanese connection except for shareholding from April 1984 and marketing as LKL brand. 20% of raw material is local, 30% from Kalutura, 20% from Nathandia, balance 30% imported via Colombo. Firm makes own refractories also.

Production appeared well-organized with effective QC though inspection for glaze defects is purely visual. The Production Manager has his desk in the QC area where QC charts were well in evidence.

Critical in-process measurements are of kiln temperature (max. 1080° C) and of the viscosity of the glaze (range 100-300 cP). QC instruments included a Colour and Colour Difference Meter (Nippon Denshoku Kogyo Co. Ltd. ND-K6B) and a reflectance meter.

Findings: A progressive firm with an established QC activity - a good example of management at its best, ready and able to invest in quality as the road to success.

9. Rubber Technology Laboratory, Industrial Development Board (IDB) Peliyagoda — 24 October 1983

Recently established by the IDB (a Government agency) to assist the rubber processing industry, particularly small producers. Has facilities for mixing and rolling the raw material with various additives to provide the required physical characteristics. The laboratories are new, most of the equipment being still in crates. From a list, there appeared to be a reasonable range for the purpose, but providing only a limited analytical capability. In discussion it was said that the IDB aimed to increase the export of rubber-based products (as distinct from raw rubber) by some 3 times over the next 5 years. This is expected to be possible merely by increasing volume (and presumably raising quality) without extending the range.

Findings: The apparent overlap between the roles of the Rubber Research Institute, the IDB, and BCS needs to be examined further and co-operative policies developed to ensure optimum use of resources. The aim of increasing exports substantially by volume increase alone seems optimistic.

10. Ceylon Ceramics Corporation 25 October 1983
Negombo (Mr. Nihal Dissanayake, Factory Manager)

Manufactures popular tableware using both wheel and slip-casting, slip-cast sanitary ware (mainly Eastern style pans), electrical insulators by pressing and turning, and pressed refractories for its own use and for another plant in the same group. Although it had set up the necessary electrical testing equipment, there is currently no production of insulators for lack of orders despite a substantial national programme for rural electrification and an obvious need for improvement of the telephone service. Competition from cheap imports was alleged. The factory had lost its export business for almost all its products, and had experienced a reduction in domestic orders.

The production processes were highly labour intensive. The tableware was double fired, first unglazed for 36 hour cycle in an oil-fired kiln. The kiln temperature was measured on one side only using Pt/Rh thermocouples which were never re-calibrated and were replaced only when they failed. A visual colour match, without instruments, was used to check the temperature on the other side of the kiln.

The second (glazing) firing was for a 12 hour cycle in an electric kiln. Tableware decoration was by transfer, silk screen printed on the premises by quite old equipment, although some of the designs were attractive. This facility brought some orders for specials for hotels, clubs, etc. - minimum order size 1000.

The QC laboratory hardly merited the name, possessing few facilities. The critical measurement for the slip casting process, ie.e. viscosity of the slip, relied on a 15 year-old torsion viscometer showing repeatability as large as 10^0 despite control limits of 320^0 (minimum) and 340^0 (maximum). Funds for replacement were said to have been refused by management.

Findings: Despite loss of markets, there were no indications that investment in modern production methods was contemplated, nor was QC anything more than notional. Without proper attention to these matters, the business is likely to continue to decline, losing customers and money. Much could be learned from the Lanka Walltile Co. in which the Ceylon Ceramics Corporation has a majority shareholding.

11. Applied Physics and Electronics Section, Ceylon Institute of Scientific and Industrial Research — 26 October 1983
Colombo (Dr. S. Gnanalingam, Head of Section, and Dr. P.A.J. Ratnasiri, Senior Research Officer)

This was the only visit to CSIR although it is active in a number of industrial fields including rubber testing. The section visited had made an international reputation some years ago for its work on ionospheric propagation of radio waves, its sounding data being recognized as definitive for the tropics. This work and the calibration of electrical equipment for industry are its principal activities.

The section possesses good electrical standards, e.g. Guildline standard cells, AC/DC transfer instrument (Fluke 540 B), a digital wattmeter. It also has a 0.6m diameter photometric integrating sphere (Macam) with photometer, and is obtaining GEC lamps for use as standards. The latter were certified only by the maker, and there had been difficulties in supply. Following complaint by Dr. Ratnasiri that GEC had misled him in their literature, and hence had supplied unsuitable lamps, the supplier had apologized and generously offered to supply the correct (specially selected) lamps free of charge.

Similar difficulties with the supplier of the sphere had met with a stony response. Among the projects in hand was an attempt to repair two chart recorders (making one out of two) for an industrial customer. This had proved unsuccessful for lack of replacement parts, the recorders being no longer in production.

Problems: Supply of the correct equipment is not easily secured by distant customers such as CSIR despite their technical competence. Their trust is sometimes abused. A more far-reaching problem is the almost total lack of staff in the section, despite its good facilities and evident demand from Sri Lankan industry for technical help. Low rates of pay appear to be the primary cause.

Findings: A well-established and surprisingly well-equipped electrical measurement laboratory, which included a separate air-conditioned area for the best standards. There should be close collaboration between CSIR and BCS (and MSS also); good relations exist already which provide a basis on which a co-operative policy could be built.

12. Measurement Standards and Services Division (MSS), Department of Internal Trade — 22 September 1983 and 9 November 1983
Colombo (Mr. H.L.R.W. Mandanayake, Deputy Warden of Standards, and Mr. U. Senaratne, Assistant Commissioner of Internal Trade)

These laboratories, under the direction of Mr. Mandanayake, provide the technical facilities for legal metrology in Sri Lanka, and are also charged with holding the national standards of measurement. However, the smallness of the staff and limitations of accommodation evidently prevent MSS making the contribution to meeting the national measurement needs that it could.

As might be expected, there are some good balances and adequate standards. In the electrical field, the equipment was less modern than that at CSIR, although of good quality. The dimensional equipment included a large granite surface table and an autocollimator without stand; it seems the stand was deleted from the order by an administrator without reference back to the laboratory to check how essential it was!

The optical laboratory was in some disarray. As well as an optical bench, there were 0.5m and 1m spheres, standard lamps and a power supply of Indian origin, some damaged and unserviceable although nominally new.

The laboratory complement was stated to be 5 scientists of whom one was currently attending a M.Sc. course in the UK at the University of Manchester Institute of Science and Technology.

Findings: The staff complement is remarkably small for the leading legal metrology laboratory in a country the size and population of Sri Lanka, particularly considering its pivotal role in the national measurement system as custodian of national standards. With the exception of photometry, the laboratory was moderately well equipped, though it was not possible to judge whether all the staff had sufficient competence and experience. The reliance that BCS and other technical organizations, and Sri Lankan industry at large, must place on this laboratory for ensuring traceability of measurements argues for some increase in its resources and for a review of the adequacy of its accommodation, staff and equipment. The laboratory has participated in the Commonwealth Science Council's regional metrology programme, although this provides little direct support by way of help in improving facilities. Co-operation between BCS and MSS is likely to be facilitated by the good relations between Dr. G.M.S. de Silva and Mr. Mandanayake.

13. Exporters' Forum, Export Development Board (EDB) Colombo — 11 November 1983

This was one of a series of meetings between Government officials, usually led by the Minister of Trade, and people from the exporting firms and agencies. Dr. G.M.S. de Silva and Mr. D.P. Thurnell-Read attended to assess its appropriateness for propagating the significance of quality to exports, and the BCS role in this. The proceedings dealt first with progress on matters raised at previous meetings (these are generally held every 2 months) and later with new items. Although many matters raised were of the nature of complaints that one might have expected to be resolved in the course of everyday contacts between industry and officials, some were of greater significance.

Two concerned metrological matters, but none appeared to be focussed on quality issues or the availability, relevance or use of standards (i.e. standard specifications). The first item involving measurements concerned a dispute between a commercial producer and the (state) marketing agency about the weight of product that had passed from the producer via the agency to the ship on which it was to leave Colombo. It seemed probably that, although neither party had appreciated the point, the dispute had arisen through one party relying on weighing and the other merely on counting bags of a nominal weight. This led to false accounting. Moreover, as the product was hygroscopic, its weight could change in transit if imperfectly stored.

The second matter concerned a dispute about electricity charges by a local authority (as distributor of electrical power) to an industrialist, based on a notional assessment of peak load. This dispute would not have arisen if the local authority had employed appropriate metering methods; its spokesman seemed unfamiliar with the technical aspects of electricity distribution.

Findings: The principal value of the Forum in relation to quality is the range of industrial contacts in the export field which it can provide; these are perhaps best utilized through use of the EDB's address list. The particular meeting attended also showed the rather low level of basic measurement knowledge available to exporters, thus demonstrating the potential value of a technical consultancy service as envisaged under this UNDP/UNIDO project.

14. St. Anthony's Bolts and Nuts Industries 14 November 1983
Colombo (Mr. Athula Perera, Factory Manager)

This firm, part of the St. Anthony's group, had just resumed production following damage inflicted during the riots of July 1983. Some buildings, vehicles and equipment had been destroyed by fire and damaged or stolen by rioters. Fortunately, some expensive equipment, including a jig borer, a grinder and a spark erosion machine, had escaped. The firm's business was the manufacture of bolts and other turned parts for which wire was drawn using tools and dies made on the premises.

Findings: Although this firm would in normal times need to rely on properly calibrated measuring instruments for measurement of dimension, angle and form the disruption prevented the exact needs being evaluated. However, if its products are to conform to recognized standards, calibration support would be necessary. It is presumed that manufacture was aimed at the domestic market only.

15. Mouldex Ltd. 15 November 1983
Ratmalana (Mr. R.R. Karunaratne, Manager)

This plastics moulding firm manufactures its own tools and dies. Mouldings are in polyethylene, polyvinyl chloride, polypropylene and ABS, using blow-, injection- and extrusion- moulding techniques. There is no QC laboratory as such, but there appeared to be an adequate range of measuring equipment in the tool room, although not in the best condition. However, no hardness measuring machine was available but purchase was contemplated. During a tour of the production facilities it was observed that moulding quality from one machine was poor (serious sinkings) apparently due to excessive mould temperature. The whole place bustled with activity unlike most organizations visited.

Problems: New machinery, with better prospects of quality, is desirable; Mr. Karunaratne intended travelling to Europe in search of this. Advice was required on the machining of hard metals, and on the design of moulds. Quality was presumably acceptable for the domestic market, but was a long way below the norm in developed countries; no QC statistics were seen.

Findings: An energetic firm, member of a private group, which recognized the need to invest in improved methods. With advice on QC, probably has potential to supply a larger market and to export. BCS calibration facilities and QC consultancy could help here.

16. Lanka Hiqu Ltd. 16 November 1983

Investment Promotion Zone (IPZ), Katunayaka
(Mr. Lanil Gunasekara, Managing Director)

This subsidiary of a West German firm makes magnetic recording heads and other small wound components and lead assemblies. Methods include turns counting during winding, using self-bonding enamelled wire, control of wire tension, grinding of ferro-ceramics, dimensional checks, adhesive bonding of small parts. The impedance of wound components was measured by comparison bridge, and a coercivity meter (away for repair) was used to check pole-piece characteristics. No QC function in evidence. Labour almost wholly female.

Problems: Although air-conditioning plant was provided, humidity was rather high, causing some rusting of precision jigs and machines. Mr. Gunasekara said that original low temperature had provided drier air, but workers complained of headaches and temperature had been raised nearer to outside ambient (typically 27 to 30° C) to reduce absenteeism. He hoped to reduce temperature in stages. In the meantime a drier is needed but is not available. A lathe used for dressing grinding wheels was in a partitioned-off area but there were no dust removal facilities, presenting a potential quality hazard.

Difficulties experienced during winding require checks on the wire enamel, and also on the temperature of hot air used for bonding. Turns-counting winding machines sometimes gave false counts for unknown reasons - the counters were electronic and could be suffering from electrical interference.

The factory was operating well below capacity, apparently due to product cost and quality problems and related training needs. Female workers were recruited on the basis of science qualifications despite the repetitious nature of the work. Good vision is essential; although the workpieces were each well illuminated by a ring light surrounding a magnifier; the general illumination was low providing undue contrast. This may have contributed to the headaches reported.

Findings: This firm, the only one visited in the IPZ, has good potential; all its output is exported to sister companies. Better attention to working conditions, especially psychological factors, should pay dividends in output and quality. If recruitment criteria were matched to the work, i.e. manual dexterity, visual acuity and good colour vision, an adequate supply of good workers should be available without drawing on a scarce resource, i.e. those with scientific ability. Calibration needs could be met, some now, some later, by BCS. It was unclear how committed the German parent was to the development of this firm, since the various problems observed should have been resolved with their advice.

17. Meter Calibration Laboratory, 17 November 1983
Ceylon Electricity Board (CEB)
Colombo (Mr. P.N.S.K. Boteju, Engineer in the Regional Maintenance Branch)

This is the sole laboratory in Sri Lanka for the calibration of electricity meters and associated instrument transformers. It should, therefore, have facilities for the measurement of current, voltage and power up to quite high levels and thus complement the facilities of MSS, CSIR and BCS.

The laboratory had at one time been well-equipped, but much of the equipment is now inoperative and obsolescent. Indeed, one or two items could well find a place in a museum! In consequence, it is at present only able to calibrate a limited range of meters and in insufficient quantities. Calibration of voltage and current transformers is not possible at present. No basic electrical standards such as standard cells, potentiometer, standard resistors were to be seen. The engineer in charge, who had only taken charge a few weeks earlier, was as yet unable to gain access to locked cabinets containing records and handbooks for the testing equipment.

The equipment seen included

a) A very old standard wattmeter of the electrodynamic type with mirror and scale (Cambridge Instrument Co. L 373205 with volt/ampere/watt adaptor box).

b) Standard 3 phase kWh meter (Chamberlain and Hookham Ltd. (Birmingham, UK) type FST4 No 5302035, rated at 3 x 5 A, 3 x 230 V, 50 Hz, 200 kWh and marked "Precision Grade").

c) Test benches for series/parallel connection of meters under test.

d) An inoperative instrument transformer test bench (Foster Transformer Co, UK).

Problems: Because of insufficient storage elsewhere, the laboratory contained large piles of electricity meters awaiting calibration, many of them damaged and in need of repair. It was said that many meters were damaged or interfered with by consumers, under the pressure of steep increases in electricity supply prices in recent years. Apart from pushing in or breaking the glass window (apparently a frequent occurrence), entry was obtained by breaking the lead seals and resealing them after interfering with the mechanism. The seals showed large voids and appeared to be of unsuitable material to take a proper impression from the sealing pliers. Some of the latter were worn but even those that were not could not perform satisfactorily on the seal material. In consequence, consumer interference was not obvious on inspection.

A further problem mentioned was that responsibility for electricity distribution outside the CEB's own areas was shortly to be transferred from local authorities to the CEB. This would increase the calibration and repair load; it seems that the local authorities make no arrangements for meter calibration.

Findings: The CEB's meter testing facilities are quite inadequate to meet demand because of inoperative equipment and poor organization. There is no effective traceability for measurements made. There are no calibration facilities for instrument transformers, implying that metering of supplies to industrial and commercial consumers cannot be verified (vidé 2 above).

A major overhaul of facilities is necessary, with training of staff. Technical advice is required on procurement specifications for electricity meters with a particular eye to their susceptibility to fraud. It was noted that current procurement and testing is to a British Standard now superseded (in the UK) by a new Standard. Attention needs to be paid to the design and specification of seals and their materials.

Not discussed during the visit were questions of legally enforcable regulations, the contractual obligations of consumers, and the arrangements for enforcement, monitoring and penalization for infringements and damage to meters. Any project dealing with the technical facilities should cover these matters also.

ANNEX C: SPECIFICATION FOR THE ENVIRONMENT
AND RECOMMENDED LAYOUT OF THE METROLOGY LABORATORY

1. The laboratory shall comprise a total area of approximately $128m^2$ divided into four areas:

   a) An entrance lobby ($16m^2$). This should include storage for laboratory records, equipment handbooks, etc., and for incoming/outgoing equipment;

   b) An inner laboratory ($32m^2$) for electrical and dimensional measurements, with temperature control separate from the main laboratory;

   c) A main laboratory ($64m^2$) for less accurate electrical measurements, photometry, other physical and mechanical measurements, storage of laboratory equipment and of CRMs;

   d) A thermal laboratory ($16m^2$) for baths and furnaces used for temperature calibrations, sharing temperature control with the main laboratory;

2. a) Target temperature $27^{\circ}C$; permitted tolerance on average temperature (averaged over the laboratory volume and during one month) is $\pm 1^{\circ}C$ max.;

   b) In any period of 4 hours after stable conditions are reached, temperature fluctuations at any one point to remain within a total range of 1 K (= $1^{\circ}C$);

   c) At any instant the temperature difference between any two points in the laboratory shall not exceed 2 K;

   d) The temperature limits given above shall be achieved with equipment power dissipation in the main laboratory and thermal laboratory combined anywhere in the range 0 to 3 kW;

e) Temperature controls shall be located within the main laboratory.

3. It shall be possible to depress the temperature of the inner laboratory to any desired temperature in the range 20°C to 27°C, controlled to ± 1°C, with equipment power dissipation in this area anywhere in the range 0 to 1 kW. When the temperature of this area is depressed, no air should be drawn directly from the main laboratory.

4. a) Target relative humidity 55%; applies to main and inner laboratory;

   b) Permitted tolerance ± 5%.

5. Air changes should be variable (under the control of the occupants) from 2 to 5 per hour whilst maintaining control of temperature and humidity; inlets and outlets shall be of large area to avoid producing high velocity flows within the laboratory. Air distribution should be as even as possible throughout the laboratory with inlets not more than 4m apart. No air inlet is necessary for the entrance lobby which can be supplied by air exhaust from the laboratory (see 7 below).

6. Incoming air to be filtered for cleanliness so as to provide less than 2×10^6 particles (of size over 1μm) per cubic metre (to be demonstrated by sampling). The inlet air to the air conditioning plant should be ducted and filtered. To avoid rapid clogging of the fine-particle filter, it may be necessary to pre-filter outside the building to eliminate coarse particles; it may also be desirable to wash the inlet air.

7. Part of the air exhaust shall be via the entrance lobby, thus providing some control of temperature in that area and discouraging the entrance of dust via the door. The air pressures in each laboratory and in the entrance lobby shall be slightly higher than ambient when the doors are closed.

8. Lighting should provide illuminance of a horizontal surface at 1m above floor level of not less than 800 lux (1 lux = 1 lumen/m^2). Sufficient light sources shall be used and spaced so as to avoid serious shadows.

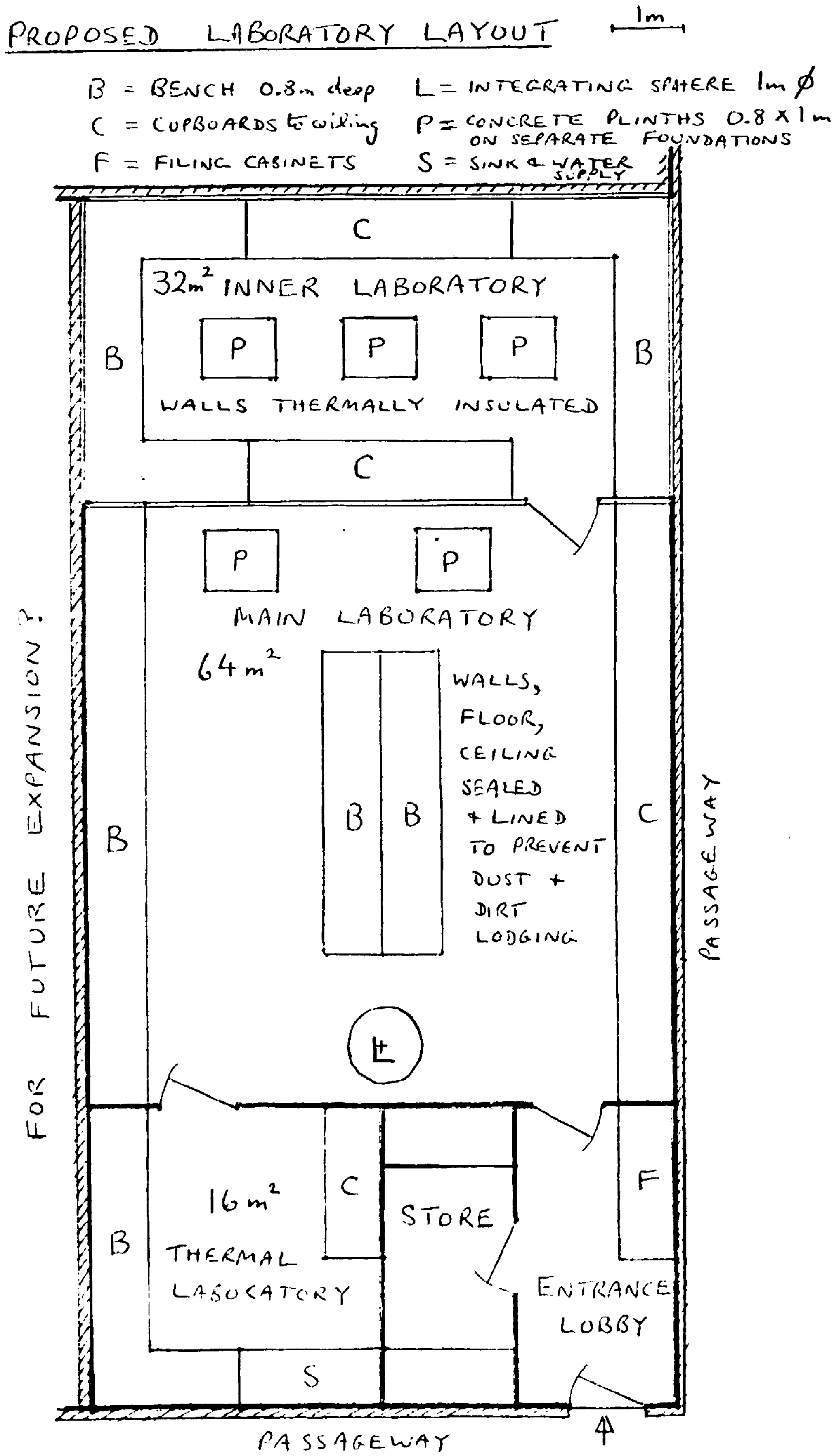
This general lighting should preferably be by fluorescent lamps embedded in the ceiling, which could be a false ceiling used as a plenum. It is recommended that the heat dissipated by these lamps be carried away in the air exhaust flow.

9. The internal surfaces of the laboratory (viz ceiling, walls, floor, partitions) shall be smooth and free of crevices and projecting ledges so as not to form dust traps,and be painted with an anti-static paint. The light fittings should blend smoothly with the ceiling, and be easily cleaned.

10. Vibration of the floor must be kept to the lowest possible level. Certain items of equipment will require large concrete pedestals which should be supported on foundations separate from those supporting the building and floor, so as to improve isolation from disturbances. Concrete surfaces must be sealed to prevent the dispersion of dust.

11. All temperature and humidity measurements necessary to demonstrate conformance to this specification shall be made at least 10cm from vertical surfaces (i.e. walls, partitions) and between 70cm and 210cm above floor level.

PROPOSED LABORATORY LAYOUT



ANNEX D: EQUIPMENT REQUIRED FOR ELECTRICAL MEASUREMENTS

1. One bank of 4 standard cells in a temperature-controlled enclosure (to be used as the laboratory reference standard):
   Long-term stability of voltage better than 10μV per year;
   Controlled temperature should not be less than 30°C (will be used in an ambient temperature between 19°C and 28°C);
   Monitoring thermometer to be included;
   Automatic changeover from line(mains) power to battery operation should be possible;
   Power supply: 230V ± 10%,50Hz;
   Battery to be supplied - rechargeable nickel-cadmium cells preferred;
   Calibration certificate required (see note 4 below).

2. Two standard cells, each in its own enclosure (to be used as working standards):
   Provided with terminals and provision for measuring cell temperature;
   These cells will normally be used in ambient temperatures of 20°C to 30°C (corrections for temperature will be made);

3. One standard cell in enclosure, for use as a travelling standard (may be identical with cells at 2 above if sufficiently robust).

4. One precision potentiometer:
   Range: not less than 1.1V;
   Limits of error: ± 0.01% of reading down to 10mV without applying calibration corrections (± 0.005% if corrections applied);
   Calibration certificate required (see note 4 below).

5. One power supply for item 4:
   Mains (230V ± 10%, 50Hz) or battery operated, electronically stabilized;
   Stability of output better than 10ppm for 10% change in mains voltage;
   Drift not to exceed 1ppm per hour after warm-up.

6. One voltage ratio box for extending the range of item 4 up to 1000V:
   Limits of error: ± 0.005%;
   Calibration certificate required (see note 4 below).

7. Two electronic null detectors for use with items 1 to 4:
   Sensitivity: ± 1µV fsd, with sensitivity range-switched over at least 6 decades (i.e. to ± 1V);
   Input impedance: not less than 10k ohm;
   Zero drift: less than 0.1µV over 1 hour;
   less than 0.1µV per °C change in ambient temperature;
   Common mode rejection: better than 120dB at dc or 50Hz;
   Preferably mains (230V ± 10%, 50Hz) and battery operated.

8. One continuously variable ac power supply:
   Voltage output: up to 300V, 50Hz, single phase;
   Voltage stability: stable at any setting to 0.05% over 1 hour, or for 10% change in supply voltage;
   Frequency: 50Hz ± 0.1Hz.
   Total harmonic distortion: less than 0.1%;
   Output current: from 0 up to at least 1A;
   Power supply: 230V ± 10%, 50Hz.

9. One set of standard resistors (2-terminal) comprising:
   a) 10k ohm ± 0.002%
   b) 1k ohm ± 0.002%
   c) 100 ohm ± 0.002%
   Calibration certificate required (see note 4 below).

10. One set of standard resistors (4-terminal) comprising:
   a) 10 ohm ± 0.002%
   b) 1 ohm ± 0.01% 1A
   c) 100m ohm ± 0.01% 3A
   d) 10m ohm ± 0.02% 10A
   e) 1m ohm ± 0.05% 30A
   f) 0.5m ohm ± 0.1% 50A
   Current ratings as shown above;
   Calibration certificate required (see note 4 below).

11. One resistance bridge (Wheatstone type):
    Range: 100ohm to 1Mohm;
    Limits of error: ± 0.005% over full range;
    Calibration certificate required (see note 4 below).

12. One electronic null detector for use with item 11 (preferably similar to item 7):
    Sensitivity: to detect imbalance of 0.001% over full range of bridge;
    Preferably mains (230V ± 10%, 50Hz) and battery operated.

13. One digital voltmeter for ac and dc voltage measurements:
    dc voltage:
        up to 1000V, with resolution of 1μV on lowest range;
        limits of error ± 0.1% of reading above 10mV; ± 10μV below 10mV (both over ambient temperature range 20°C to 30°C and during 6 months following calibration);
    ac voltage:
        up to 1000V, true rms sensing, true rms indicating, with resolution of 10μV on lowest range;
        limits of error ± 0.5% of reading above 100mV; ± 0.5mV below 100mV (both over ambient temperature range 20°C to 30°C, frequency 50Hz to 1kHz, and during 6 months following calibration);
    Auto-ranging;
    Input impedance: not less than 10Mohm;
    Power supply: 230V ± 10%, 50 Hz;
    Calibration certificate required (see note 4 below);
    See also note 6 below.

14. One general-purpose dc power supply:
    Output: constant-current, adjustable from 0 up to 30A into load developing up to 10V;
    Stability: better than ± 0.05% over 1 hour, or for 10% power supply voltage change, or for 50% change in load resistance;
    Protection: automatic limitation of output voltage to 10V (or settable); output voltage and current displayed;
    Power supply: 230V ± 10%, 50Hz.

15. One general-purpose dc power supply:

Output: constant-voltage adjustable from 0 up to 300V at load currents up to 0.1A;

Stability: better than ± 0.05% over 1 hour, or for 10% power supply voltage change, or for 50% change in load current;

Protection: automatic limitation of output current to 0.1A (or settable); output voltage and current displayed;

Power supply: 230V ± 10%, 50Hz.

16. One general-purpose digital multimeter to measure ac and dc voltage and current, and resistance:

Ranges: dc voltage: 1V fsd to 1000V fsd;
current: 1mA fsd to 1A fsd;
ac voltage: 1V fsd to 1000V fsd;
current: 1mA fsd to 1A fsd;
resistance: 1ohm to 10Mohm;

Limits of error: ± 1% of reading above 100mV and above 100µA on voltage and current ranges (both over ambient temperature range 20°C to 30°C and during 6 months following calibration, and over 50Hz to 1kHz for ac ranges); ± 5% of reading for resistance;

Fully protected against overload;

Input impedance on voltage ranges; not less than 10Mohm;

Power supply: 230V ± 10%, 50Hz and/or battery.

17. One meter calibrator for dc, delivering calibrated voltage or current and indicating per cent deviation of output using manual incremental control:

Ranges: voltage 1mV to 1000V;
current 1mA to 1A;

Limits of error: ± 0.1% of output;

Deviation control range: ± 10%;

Power supply: 230V ± 10%, 50Hz;

Calibration certificate required (see note 4 below);

See also note 6 below.

18. One meter calibrator for ac, delivering calibrated voltage or current and indicating per cent deviation of output using manual incremental control:
Ranges: voltage 1mV to 300V;
current 1mA to 1A;
Limits of error: ± 0.1% of output;
Frequency: fixed at 50Hz ± 0.1Hz;
Deviation control range: ± 10%;
Power supply: 230V ± 10%, 50Hz;
Calibration certificate required (see note 4 below);
See also note 6 below.

General notes

1. Except where specified otherwise, normal operating temperature 25 ± 5°C, relative humidity up to 95% (allowing for possible use outside the laboratory), but equipment should be suitable for storage in tropical conditions (i.e. temperatures up to 50°C, relative humidity up to 95%) without damage or change of calibration.

2. Equipment should conform to recognized international or national standards applicable to the type of equipment. Tenderer to state standards complied with.

3. Equipment to be accompanied by full instructions for installation, operation, re-calibration and maintenance, including circuits, parts lists, diagrams and list of recommended spares, as appropriate, all in English.

4. Calibration certificates to be supplied where indicated. For UK suppliers, these should be British Calibration Service or National Physical Laboratory certificates. For other suppliers, the certifying authority should be an equivalent national calibration service or a national measurement laboratory. Tenderer to state proposed source of certification and temperature (27°C preferred).

5. Prices to be inclusive of tropical packing and delivery Colombo for both sea and air freight.

6. If funds available permit, it would be advantageous if items 13, 17 and 18 are provided with IEEE 488 (IEC 625) computer interfaces, to facilitate future automation of calibration activities.

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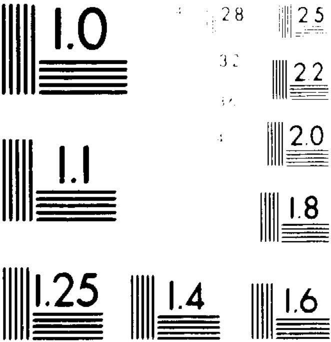

MICROCOPY RESOLUTION TEST CHART

Equipment already held or on order which should be allocated to the Metrology Section:

19. Resistance bridge, Kelvin type (Cropico KB5) for four-terminal resistance measurements.

20. Resistance standards:
    a) 100 ohm (Cropico RS1)
    b) 10 ohm (Cropico RS3)
    c) 1 ohm (Cropico RS3)

21. Wattmeter, air-cored dynamometer (Crompton 119):
    Ranges: 24/60/120/240 V at up to 5A.

22. Frequency meter/counter (Marconi Instruments 2432A):
    10Hz to 560MHz.

23. Distortion factor meter (Marconi Instruments 2331A):
    20Hz to 20kHz;
    Ranges: 0.1% to 100% fsd.

24. Decade resistance box (e.g. Gen-Rad 1433-9731):
    1Mohm in 0.1 ohm steps;
    Limits of error: ± 0.01%.

25. Decade capacitance box (e.g. Gen-Rad 1413-9700):
    Up to 1µF;
    Limits of error: ± 0.05%.

ANNEX E: EQUIPMENT REQUIRED FOR MECHANICAL MEASUREMENTS

1. One granite surface plate, 1000mm x 750mm, to BS 817 Grade A with adjustable feet for levelling:
   Calibration certificate required (see note 5 below).

2. One cast iron or steel surface plate, 600mm x 600m, to BS 817 Grade A with adjustable feet for levelling:
   Calibration certificate required (see note 5 below).

3. Two toolmakers' flats, steel, hardened and lapped, to BS 869:
   Suggested suppliers for above items:
   - Crown Windley Ltd. (UK);
   - Eley & Warren Precision Engineers Ltd. (UK);
   - C.E. Johansson Ltd. (UK and Sweden);
   - Keeling Metrology Ltd. (UK);
   - L.K. Tool Co Ltd. (UK and USA);
   - Rubert & Co Ltd. (UK);
   - L.S. Starrett Co Ltd. (UK and USA);
   - Mitutoyo Mfg Co Ltd. (Japan).

4. One autocollimator with stand and accessories:
   Discrimination: 0.5 seconds of arc;
   Suggested supplier:
   - Rank Taylor Hobson Ltd. (UK).

5. One toolmakers' microscope, 50 x 100mm or larger, with rotary table and illuminating facility:
   Suggested suppliers:
   - Keeling Metrology Ltd. (UK);
   - Precision Grinding Ltd. (UK);
   - T.G.M. Gauge Maintenance Ltd. (UK);
   - Vickers Instruments Ltd. (UK);
   - Leitz (FRG);
   - Mitutoyo (Japan).

6. One set of steel length bars (end gauges) to 500mm, inspection grade to BS 1790/BS 5317:

Calibration certificate required (see note 5 below);

Suggested suppliers:

Haycock Gauge & Tool Co Ltd. (UK);
Headland Gauges Ltd. (UK);
Moore & Wright Ltd. (UK);
Speedright Gauge & Tool Co (UK);
L.S. Starrett Co Ltd. (UK and USA);
T.I. Coventry Gauges Ltd. (UK);
C.E. Johansson Ltd. (UK and Sweden);
Lichfield Gauge & Precision Co Ltd. (UK);
Machsize Ltd. (UK);
Thomas Mercer Ltd. (UK);
Piccadilly Precision Engineering (UK);
Russell Gauges Ltd. (UK);
Sigma Ltd. (UK);
T.G.M. Gauge Maintenance Ltd. (UK);
Yorkshire Precision Gauges Ltd. (UK);
Hommelwerke GmbH (FRG);
Tsugami Corporation (Japan);
Cary (Switzerland).

7. One horizontal length measuring machine with internal standard and measuring microscope, for comparison of length bars and scales up to

Either a) 1000mm
or b) 500mm

with electronic comparator or digital indication;
Resolution: 0.1µm;
Overall uncertainty: 5µm;
Calibration certificate required (see note 5 below);
Suggested suppliers:

Leitz (FRG);
V.E.B. Carl Zeiss (GDR);
S.I.P. (Switzerland);
L.K. Tool Co Ltd. (UK);
Metronic Technology Ltd. (UK);
Sigma Ltd. (UK);
L.S. Starrett Co Ltd. (UK and USA).

8. One vertical comparator for gauge blocks with electronic indication:
Range: 100mm;
Discrimination: 0.1µm;
Suggested suppliers:

Carl Mahr (FRG);
Cary (Switzerland);
Tesa (Switzerland);
Rank Taylor Hobson (UK);
C.E. Johansson Ltd. (UK and Sweden);
Sigma Ltd. (UK);
L.S. Starrett Co Ltd. (UK and USA).

9. One contact thermometer with electronic indication, for checking temperatures of gauge blocks, etc:

   Range: at least 18 to 30°C;

   Discrimination: 0.1°C or better;

   Power supply: either a) 230V ± 10%, 50Hz

   or b) rechargeable batteries (charger and spare set of batteries to be supplied).

10. One roundness measuring machine with electronic indicator and electrically-connected chart recorder:

    Workpiece capacity: at least 200mm dia., mass 20kg;

    Discrimination: better than 0.1μm;

    Suggested suppliers:

    Rank Taylor Hobson (UK);

    C.E. Johansson Ltd. (UK and Sweden);

    L.S. Starrett Co Ltd. (UK and USA);

    Mitutoyo (Japan).

11. One surface roughness measuring machine with electronic indicator and electrically-connected chart recorder:

    Preference given to equipment that will measure parameters to all common standards (e.g. rms, max height, quasi-peak, etc.);

    Stylus to be motor driven with variable speed;

    Certified reference specimens to be supplied (see note 5 below).

    Suggested suppliers:

    Rank Taylor Hobson (UK);

    Dr Perthen GmbH (FRG);

    Hommelwerke GmbH (FRG).

General notes

1. Except where otherwise specified, power supply 230V ± 10%, 50Hz.

2. Normal temperature for use 27 ± 1°C, relative humidity 50 to 65%, but equipment should be suitable for storage in tropical conditions (i.e. temperatures up to 50°C, relative humidity to 95%) when plain steel surfaces are suitably protected from corrosion, without damage or change of calibration.

3. Equipment should conform to recognized international (IEC of ISO) or national (e.g. BS) standards applicable to the type of equipment. Tenderer to state standards complied with.

4. Equipment to be accompanied by full instructions for installation, operation, re-calibration and maintenance, including parts lists and diagrams and list of recommended spares, as appropriate, all in English.

5. Calibration certificates to be supplied where indicated. For UK suppliers, these should be British Calibration Service or National Physical Laboratory certificates. For other suppliers, the certifying authority should be an equivalent national calibration service or national measurement laboratory. Calibration temperature 27 $\pm$ 1°C; where this is not possible, 20° $\pm$ 1°C is acceptable, with a statement of temperature coefficient over range 19 to 28°C. Tenderer to state temperature and proposed source of calibration.

6. Prices to be inclusive of tropical packing and delivery Colombo for both sea and air freight.

7. In addition to the equipment listed above, items such as squares, straightedges (rectangular section and toolmakers' knife-edge), vee-blocks, plain and cylindrical setting standards may be required if these are not already available in BCS.

ANNEX F: EQUIPMENT REQUIRED FOR THERMAL MEASUREMENTS

1. Liquid-in-glass "total immersion" solid-stem thermometers for precision use:

	Quantity required	Specification	Range °C	Scale Interval °C
a)	3	STL/0.1/-5/+25 to ISO653	-5 to +25	0.1
b)	6	STL/0.1/20/45 to ISO653	+20 to +45	0.1
c)	3	STL/0.1/40/65 to ISO653	+40 to +65	0.1
d)	3	STL/0.1/60/85 to ISO653	+60 to +85	0.1
e)	3	STL/0.1/80/105 to ISO653	+80 to +105	0.1
f)	3	STC/0.1/39/51 to ISO654	+39 to +51	0.1

Note: one of each of the above 6 types to be accompanied with a cali-certificate as specified below (note 4); for the remainder, certification by the manufacturer is acceptable.

g)	3	Series P to ISO1770	-35 to +50	1
h)	6	Series C to ISO1770	0 to +60	0.5
j)	6	Series D to ISO1770	0 to +100	1
k)	6	Series F to ISO1770	0 to +250	2

Note: for all of the above 4 types, the manufacturer's calibration certificate is required;

Suggested suppliers:

Corning Ltd., Stone, Staffordshire, UK;
H. Stout & Co Ltd., Holmethorpe, Redhill, Surrey, UK;
G.H. Zeal Ltd., Lombard Road, London, SW19, UK.

2. Six thermocouples type B (i.e. Pt 30% Rh/Pt 6% Rh) in hermetically sealed enclosures suitable for furnace temperature measurement:

Calibration certificates required (see note 4 below);

Suggested suppliers:

Engelhard Industries Ltd., St. Nicholas Road, Sutton, Surrey, UK;
Furnace Instruments Ltd., Harwood Street, Sheffield, S2 4SE, UK;
Johnson Matthey Metals Ltd., South Way, Exhibition Grounds, Wembley, HA9 OHW, UK.

3. Three secondary standard (100 ohm) platinum resistance thermometers for use over range -40°C to +630°C:
   Calibration certificates required (see note 4 below);
   Suggested suppliers:
   Rosemount Engineering Ltd., Heath Place, Bognor Regis, Sussex, UK;
   H. Tinsley & Co Ltd., Werndee Hall, South Norwood, London, SE25, UK.

4. One triple point of water cell:
   Calibration certificate required (see note 4 below);
   Supplier:
   National Physical Laboratory, Teddington, TW11 OLW, UK.

5. Two digital voltmeters for thermocouple emf measurement:
   Resolution: 1μV or better, 4 digit display (minimum);
   Limits of error: ± 5μV over range 20°C to 30°C;
   Power supply: 230V ± 10%, 50Hz;
   Calibration certificate required (see note 4 below);
   Suggested suppliers:
   Datron Ltd., Hurricane Way, Norwich Airport, Norwich, UK;
   Racal-Dana Ltd., Duke Street, Windsor, UK;
   Solartron Electronic Group, Farnborough, Hants, UK.

6. One resistance bridge for use with item 3 above:
   Limits of error 10ppm;
   Either a) complete with power supply and electronic balance indicator (preferably similar to Annex D item 7 or 11);
   or b) automatic and self-balancing, with digital indication and IEEE488 (IEC 625) computer interface;
   Power supply: 230V ± 10%, 50Hz;
   Suggested suppliers:
   Automatic Systems Laboratories, Construction House, Grovebury Road, Leighton Buzzard, UK;
   H. Tinsley & Co Ltd., Werndee Hall, South Norwood, London, SE25, UK.

7. Two resistance standards, for use with item 6, values as recommended by supplier of item 6:

Limits of error: 5ppm at 27°C;

Temperature coefficient: less than 5ppm/°C;

Calibration certificate required (see note 4 below);

Suggested suppliers:

Cropico Ltd., Hampton Road, Croydon, CR9 2RU, UK;

H. Tinsley & Co Ltd., Werndee Hall, South Norwood, London, SE25, UK.

8. One low thermal emf reversing/selector switch (or a multi-point scanner), for use with item 5 or with a precision potentiometer, when calibrating thermocouples:

Suggested suppliers:

P.P.M. Ltd., Hermitage Road, St. Johns, Woking, Surrey, UK;

also Automatic Systems Laboratories;

Cropico Ltd.;

Datron Ltd.;

H. Tinsley & Co Ltd.

(addresses above).

9. One pair of binoculars or a viewing lens, for reading scales on liquid-in-glass thermometers; with supporting stand:

Suggested supplier:

E.N. Irving, 258 Kingston Road, Teddington, Middlesex, UK.

10. Two stirred water baths for thermometer calibration work over the range 0 to +80°C:

Temperature stability: 10mK over 1 hour;

Temperature uniformity: better than 5mK between points 100mm apart;

Power supply: 230V ± 10%, 50Hz;

Suggested suppliers:

Grant Instruments Ltd., Barrington, Cambridge, UK;

H.N. Irving (address above);

Labapp, 177 Lockwood Road, Huddersfield, HD1 3TE, UK;

Townson & Mercer Ltd., 93/96 Chadwick Road, Astmoor, Runcorn, Cheshire, UK.

11. a) One fluidized alumina powder bath for thermometer calibration work over the range 80°C to 1000°C:

Temperature stability: 0.1°C over 1 hour;

Temperature uniformity: better than 0.1K over the working volume, at 200°C, and pro-rata to 1000°C;

With means to prevent scattering or spillage of powder when in use;

Power supply: 230V ± 10%. 50Hz.

b) Supply of pure alumina powder sufficient for 3 fillings of the bath:

Suggested suppliers:

Isothermal Technology Ltd., Pine Grove, Southport, Merseyside, UK;

Tekman Electronics Ltd., Unit B8, Telford Road, Bicester, OX6 OTZ, UK.

12. One tubular electric furnace suitable for comparison of thermocouples and/or resistance thermometers:

Range: 400°C to 1800°C;

Temperature stability: 2°C over 1 hour;

Temperature uniformity: better than 1K over the working volume;

Power Supply: 230V ± 10%, 50Hz;

Suggested suppliers:

The Amalgams Co Ltd., Tinsley Park Road, Sheffield, UK;

Carbolite Co Ltd., Bamford Mill, Bamford, Sheffield, UK;

Furnace Instruments Ltd., Harwood Street, Sheffield, S2 4SE, UK;

Johnson Matthey Metals Ltd., South Way, Exhibition Grounds, Wembley, HA9 OHW, UK;

Stanton-Redcroft Ltd., Coppermill Lane, London, SW17.

13. One reference temperature enclosure for thermocouple "cold" junctions, controlled at 0°C:

Power supply: 230V ± 10%, 50Hz;

Suggested suppliers:

Delristor Ltd., 21 Windsor Road, Uxbridge, Middlesex, UK;

Mectron (Frigistor) Ltd., 480 Bath Road, Slough, SL1 6BL, UK.

14. One set of icemaking equipment for the production of ice pellets and for shaving or crushing these to produce a fine slush for filling an ice/water bath (e.g. item 10 above). The equipment should include a de-ionizer and any necessary ancillary pumps or compressors. Tenderer to quote output capability in kg/hour and temperature of ice produced.

Ambient air temperature 30°C;

Water supply temperature 20°C;

Power supply: 230V ± 10%, 50Hz;

Suggested suppliers:

Hubbard Refrigeration Ltd., The Street, Martlesham, Woodbridge, Suffolk, UK;

H.N. Irving, 258 Kingston Road, Teddington, Middlesex, UK;

Prestcold Ltd., Theale, Reading, UK.

15. a) Six multi-point electronic temperature recorders, including transducers (probes), with individual adjustment of each probe channel for calibration purposes:

Number of probes per recorder: 6 minimum;

Lead length to probe: 20m minimum;

Temperature range: at least +15°C to +35°C;

Resolution: 0.2°C or better;

Drift: not to exceed 0.5°C during 6 months following calibration;

Power supply: 230V ± 10%, 50Hz;

Notes: Preference will be given to a recorder which can be used to record % relative humidity also, over at least the range 40 to 80% RH, with limits of error not exceeding ± 5%.

b) Sufficient charts, pens, spare probes (at least 2 per recorder) for maintenance of the above for a period of 2 years.

General notes

1. Normal operating temperature 25 ± 5°C, relative humidity up to 95%, but equipment should be suitable for storage in tropical conditions (i.e. temperatures up to 50°C, relative humidity to 95%) without damage or change of calibration.

2. Equipment should conform to recognized international (IEC or ISO) or national (e.g. BS) standards applicable to the type of equipment. Tenderer to state standards complied with.

3. Equipment to be accompanied by full instructions for installation, operation, re-calibration and maintenance, including parts lists and diagrams and lists of recommended spares, as appropriate, all in English.

4. Calibration certificates to be supplied where indicated. For UK suppliers, these should be British Calibration Service or National Physical Laboratory certificates. For other suppliers, the certifying authority should be an equivalent national calibration service or national measurement laboratory. Tenderer to state proposed source of certification.

5. Prices to be inclusive of tropical packing and delivery Colombo for both air and sea freight.

6. In addition to the equipment listed above, a supply of alumina tubes, drilled metal blocks and mounting clamps and supports for thermometers will be necessary. It is assumed that these will be purchased or manufactured locally as needed.

ANNEX G: EQUIPMENT REQUIRED FOR OTHER MEASUREMENTS

FORCE: 1 set of equipment comprising items 1 to 8:

1. One special low-profile load cell for verification of concrete testing machines (e.g. Avery-Denison model 7122):
   Range: 200kN to 2MN, compression only;
   Calibration certificate required to BS 1610 grade 1 (see note 4 below).

2. One sealed load cell, with tension fittings:
   Range: 50kN to 500kN, compression and tension;
   Calibration certificate required to BS 1610 grade 1 (see note 4 below).

3. One sealed load cell, with tension fittings:
   Range: 5kN to 50kN, compression and tension;
   Calibration certificate required to BS1610 grade 1 (see note 4 below).

4. One load cell, compact type, with tension fittings:
   Range: 2kN to 20kN, tension only;
   Length: 100mm max overall (excluding fittings);
   Calibration certificate required to BS 1610 grade 1 (see note 4 below).

5. One sealed load cell:
   Range: 500N to 5kN, compression only;
   Calibration certificate required to BS 1610 grade 1 (see note 4 below).

6. One sealed load cell, with tension fittings:
   Range: 50N to 500N, tension only;
   Calibration certificate required to BS 1610 grade 1 (see note 4 below).

7. One stabilized dc power supply for use with any of items 1 to 6 above:
   Power supply: 230V ± 10%, 50Hz.

8. One digital voltmeter or ratiometer for use with any of items 1 to 6 above:

Resolution: 1μV or better;

Limits of error: sufficiently low to enable BS 1610 grade 1 performance to be achieved when used with any of items 1 to 6 above from 10% to 100% of force range, over temperature range 20°C to 35°C, and during 6 months following calibration;

Power supply: 230V ± 10%, 50Hz;

Calibration certificate required (see note 4 below).

Supplier suggested for items 1 to 8:

National Physical Laboratory, Teddington, TW11 OLW, UK (for attention of Mr R F Jenkins).

PRESSURE

9. One portable rotating piston dead-weight pressure gauge tester (calibrator), complete in transportable box:

Range: 20kPa to 1MPa (0.2 to 10 bar);

Limits of error: 0.1% over full range, and over temperature range 20°C to 35°C (with temperature corrections, if necessary);

Construction: preferably stainless steel throughout;

Weights: stainless steel, individually marked with identification;

Accessories: set of adaptors to following pipe threads, in transportable box:

BSP $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$ inch

M10 x 1, M12 x 1.5 and M20 x 1.5

NPT $\frac{1}{8}$-27, $\frac{1}{4}$-18, $\frac{1}{2}$-14

sufficient gaskets for two years' use

note: BSP = British Standard Pipe (Whitworth)

M = metric thread to ISO standards

NPT = American standard taper pipe thread

Calibration certificate required, including masses of individual weight-pieces (see note 4 below);

Suggested suppliers:

Budenberg Gauge Co Ltd. (UK);

CEC Consolidated Electrodynamics (USA);

Ruska Instrument Corporation (USA);

Desgranges et Huot (France);

Maihak AG (FRG)

VEB Messgerätewerk Beierfeld (GDR).

10. One self-contained pressure test bench for the calibration of industrial pressure gauges to 1MPa (10 bar) using air, water or hydrocarbon fluids, complete with all interconnections, stop cocks, filters, separators and set of adaptors to all pipe threads listed above under item 9; electronic digital indication preferred:

Limits of error: 1% over range 20kPa to 1MPa over temperature range 20°C to 35°C;

Compressor: manual or motor driven;

Power supply: 230V ± 10%, 50Hz;

Note: Tenderer to specify suitable hydrocarbon fluids, quantity recommended for 2 years' use, and identify suitable sources of supply;

Suggested suppliers: as for item 9 above.

HARDNESS

11. One hardness testing machine for Brinell (5mm) ball, Rockwell B & C and Vickers HV30 scales:

Automatic loading and timing, otherwise manual operation is acceptable;

Preference given to a simple machine that can be relied upon to maintain its calibration for at least 5 years without servicing other than routine maintenance;

Two indenters of each type to be supplied;

Operating temperature will be 27 ± 1°C;

Certificate of verification by intercomparison with a master machine to be provided, together with evidence that the master machine is accepted by a national measurement laboratory as reproducing the relevant national hardness scales;

The geometrical form of each indenter supplied is to be certified (see note 4 below);

Power supply: 230V ± 10%, 50Hz;

Suggested suppliers:

Avery-Denison Ltd. (UK);
Engineering & Scientific Equipment Ltd. (UK);
Vickers Ltd. (UK);
Hardness Control Instruments Ltd. (UK);
Rockwell (USA);
Indentec Hardness Testing Machines Ltd. (UK)
Frank (FRG).

12. One set of hardness test blocks:

a) Two blocks between 100 and 200 HB;

b) Two blocks between 250 and 350 HB;

c) Two blocks between 40 and 60 HRB;

d) Two blocks between 60 and 80 HRB;

e) Two blocks between 20 and 30 HRC;

f) Two blocks between 30 and 40 HRC;

g) Three blocks between 40 and 50 HRC;

h) Three blocks between 50 and 60 HRC;

j) Two blocks between 60 and 70 HRC;

k) Three blocks between 100 and 200 HV30;

l) Three blocks between 250 and 350 HV30;

m) Three blocks between 600 and 750 HV30;

Calibration certificates required for at least one of each type of block (see note 4 below); for the remainder the manufacturers' certificate is acceptable;

Suggested suppliers:

National Institute of Metrology, POB 2112, Beijing, China;

also, those for item 11 above.

13. One deadweight hardness testing machine for rubber in accordance with ISO 48, 1400, 1818, ASTM D1415, BS 903 Part A26 methods H, L, N, DIN 53519:

Range: 10-100 IHRD;

Accessories: complete with ball indenters 1mm, 2.5mm, 5mm dia. and fittings to permit tests to methods CH, CL, CN to BS 903 Part A26;

Power supply: 230V ± 10%, 50Hz;

Calibration certificate required for dimensions of indenters, foot, and forces applied (see note 4 below);

Suggested suppliers:

H.W. Wallace & Co Ltd., (UK) (e.g. type H1);

also, others listed in BS 2719.

14. One set of rubber hardness calibration blocks covering the range 10-100 IHRD, for intercomparisons between pocket-type testers and item 13 above:

Calibration certificate required for hardness at 27°C (see note 4 below);

Suggested suppliers:

RAPRA (UK);

also, suppliers of item 13 above.

PHOTOMETRY:

15. Six (three of each rating) secondary standard lamps for photometry, coiled tungsten filament type, selected and aged:

Ratings:

a) 40W, 220V nominal;

b) 100W, 210V nominal;

Cap: bayonet cap (B22d);

Power supply: for constant current (dc) operation;

Calibration certificate required (see note 4 below);

Recommended supplier:

National Physical Laboratory (UK)

(for the attention of Dr M.E. Peover).

Note: order from NPL, but specify GEC type LF to drawing no. T73-804, 805.

16. One integrating sphere (to BS 354 or similar), for lamp photometry, complete with all fittings, necessary plugs and sockets (with mating components to match), to suit lamps specified below:

Nominal diameter: 1m;

Internal coating: white reflecting, suitable for tropical use;

To be fully fitted with directly interchangeable lampholders (using no tools) to suit the following lamps, with means to centre these:

a) GEC secondary standard lamp type LF, 40 or 60 or 100W to drawing no. T73-804, 805, cap bayonet B22d, mounted cap up;

b) GEC secondary standard lamp type LF, 150W to drawing no. 73-801, 803, cap bayonet B22d, mounted cap up;

c) Tungsten filament general service electrical lamps to Ceylon Standard 61 (1969), rated at 25 or 40 or 60 or 75 or 100 or 150W, bayonet cap, mounted cap up;

To accept the photometer specified at item 17 below.

Suggested suppliers:

Schmidt & Haensch GmbH (FRG);

Institut für Lichttechnik, Berlin;

Macam Photometrics Ltd. (UK);

Alexander Wright & Co Ltd. (UK);

Note: order should be accompanied by CS 61 and by the GEC drawings specified, as well as details of item 17.

17. <u>One</u> multi-range V(λ) corrected silicon cell photometer for use with item 16 above:

Digital indication;

Preferably suitable also for portable use for the measurement of illuminance in the range 100 to 2000 lux, with filters or corrections to suit:

a) tungsten filament light sources;
b) fluorescent lamp sources;
c) daylight (not direct sunlight);

Power supply: 230V ± 10%, 50Hz <u>or</u> (if used as a portable instrument) dry batteries (preferably re-chargeable cells);

Calibration certificate required for spectral response (see note 4 below);

Suggested suppliers:

National Physical Laboratory (UK) (for the attention of Dr. M.E. Peover);
Lichtmesstechnik, Berlin (FRG);
Optronik, Berlin;
Osram GmbH, Berlin or Munich (FRG);

also, suppliers for item 16 above.

18. (Only required if item 17 not suitable for portable use).

<u>One</u> portable photometer (to BS 667 or similar), V(λ) corrected, for the measurement of illuminance, with filters or corrections to suit:

a) tungsten filament light sources;
b) fluorescent lamp light sources;
c) daylight (not direct sunlight);

Range: 100 to 2000 lux;

Limits of error: 5% of reading;

Power supply: dry batteries (preferably re-chargeable cells);

Calibration certificate required for spectral response and illuminance (see note 4 below);

Suggested suppliers:

as for item 17, excluding National Physical Laboratory (UK);

(there will be a number of others).

19. One stabilized dc power supply for use with secondary standard lamps (item 15 above) and also with lamps under test:

Output current (stabilized): variable from 0.08A to 0.9A;

Output voltage: 180V to 270V nominal;

Stability of output current; better than 0.05% over 1 hour, or for 10% change in supply voltage;

Settability: output current adjustable in steps (or continuously) not greater than 0.01%;

Power supply: 230V ± 10%, 50Hz;

Suggested suppliers:

Vinculum Services Ltd. (UK);
Farrell Instruments Ltd. (UK);
Kingshill Electronic Products Ltd. (UK);
Pierre Fontaine Electronique (France);
Lambda Electronique S.A. (USA and France);
Hewlett-Packard Co (USA);
Philips (Netherlands);

also, suppliers of power supplies in Annex D.

CERTIFIED REFERENCE MATERIALS:

20. One quartz control plate to suit Schmidt & Haensch Lippich Polarimeter model 14170:

Calibration certificate required for sodium yellow line (see note 4 below);

Suggested suppliers:

Optical Activity Ltd., Industrial Estate, Bury Road, Ramsey, Huntingdon, Cambridgeshire, PE17 1NA, UK;
Bellingham & Stanley Ltd., Polyfract Works, Longfield Road, Tunbridge Wells, Kent, UK;
Schmidt & Haensch GmbH, Naumannstrasse 33, 1000 Berlin 62, FRG.

21. One set of absorbing glass filters for checking spectrophotometers, mounted in special frames (Pye Unicam Ltd. registered design 969423) and supplied in a wooden box:

Nominal densities:

a) 0.15;
b) 0.5;
c) 1.0;
d) 2.0;
e) 3.0;

Calibration certificates required covering the wavelength range 400 to 800nm (see note 4 below);

Recommended supplier:

National Physical Laboratory, UK
(for the attention of Dr. M.E. Peover).

General notes

1. Unless specified otherwise, normal operating temperature is 25 $\pm$ 5°C, relative humidity up to 95% (allowing for possible use outside the laboratory). However, all equipment should be suitable for storage in tropical conditions (i.e. temperatures up to 50°C, relative humidity up to 95%), subject to protection of uncoated steel surfaces (items 11 & 12), without damage or change of calibration.

2. Equipment should conform to recognized international or national standards applicable to the type of equipment. Tenderer to state standards complied with.

3. Equipment to be accompanied by full instructions for installation, operation, re-calibration and maintenance, including circuits, parts lists, diagrams and list of recommended spares, as appropriate, all in English.

4. Calibration certificates to be supplied where indicated. For UK suppliers, these should be British Calibration Service or National Physical Laboratory certificates. For other suppliers, the certifying authority should be an equivalent national calibration service or a national measurement laboratory. Tenderer to state proposed

source of certification and temperature (27°C preferred).

5. Prices to be inclusive of tropical packing and delivery Colombo for both sea and air freight.

6. If funds available permit, it would be advantageous if items 8, 17 and 19 are provided with IEEE 488 (IEC 625) computer interfaces, to facilitate future automation of calibration activities.

ANNEX H: PROGRAMME FOR SEMINAR ON MEASUREMENT IN INDUSTRY

Organized by the Bureau of Ceylon Standards with the sponsorship of the United Nations Industrial Development Organization.

24 and 25 November 1983

<u>Thursday 24 November</u>

	0900	Opening ceremony
	0930	Tea
DPT-R	1000	Units of measurment, standards, reference materials and traceability
	1200	Lunch
DPT-R	1330	Accuracy, error, uncertainty
	1500	Tea
DPT-R	1530	Calibration of instruments, laboratory records
	1700	Close

<u>Friday 25 November</u>

GMSdeS	0900	Development of the Bureau's technical services
	1000	Tea
DPT-R	1030	Process control instrumentation
GMSdeS	1130	Visit to Bureau Laboratories, Colpetty & Wellawatta
	1300 approx.	Lunch
HLRWM	1400	Engineering measurements
	1515	Tea
DPT-R	1530	Electrical measurements
	1630/1700	Close.

HLRWM = Mr H.L.R.W. Madanayake, Deputy Warden of Standards, Department of Internal Trade

GMSdeS = Dr G.M.S. de Silva, Assistant Director, Bureau of Ceylon Standards

DPT-R = Mr D.P. Thurnell-Read, UNIDO Consultant in Metrology and Calibration

ANNEX J: FELLOWSHIPS RECOMMENDED

Subject	Duration	Location	Year
METROLOGY			
Temperature measurement	2 months	UK	late
— resistance thermometry		e.g.NPL,	1984
— calibration of liquid-in-glass thermometers		BSI, BCS*	
— calibration of thermocouples			
— pyrometry			
Photometry	2 months	UK	1984/5
— testing of lamps		e.g.NPL,	
— calibration of photometers		BSI,	
— testing of luminaires		the Shirley	
— colorimetry		Institute ø	
Force and pressure	2 months	UK	1984
— calibration of materials testing machines		e.g.NPL, Instron,	
— calibration of pressure gauges		BCS*	
— calibration of vacuum gauges			

*BCS (in this context) = laboratories of the British Calibration Service.

ø for colorimetry applied to textiles.

ANNEX K: REFERENCES

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3 Sri Lanka Standards Institution Act (drafted in 1981, enactment expected in 1984)

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79 Units of measurement (ISO Standards Handbook 2), pub. ISO, second edition 1982

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ANNEX L: SUGGESTED DISTRIBUTION OF REPORT

SRI LANKA:

Sri Lanka Government (Ministry of Industries and Scientific Affairs) — 15 copies

Bureau of Ceylon Standards — 10 copies

Ceylon Institute for Scientific and Industrial Research — 1 copy

Measurement Standards and Services Division, Department of Internal Trade — 1 copy.

UNITED NATIONS:

UNIDO — 10 copies

UNDP headquarters — 5 copies

Office of the Resident Representative, Sri Lanka — 2 copies

UNESCO Regional Office for Science and Technology for South East Asia (attention Mr. U.S. Kuruppu) — 1 copy

UNESCO Regional Co-ordinator for the Asia Pacific Metrology Programme (Dr. K. Chandra, Deputy Director, National Physical Laboratory, Hillside Road, New Delhi, 110012 India) — 1 copy

UN Headquarters Library — 2 copies

UN Library, Geneva — 1 copy

Dr. A. Geneidy (consultant) — 1 copy

Mr. D.P. Thurnell-Read (author) — 1 copy.

INTERNATIONAL:

Bureau International de Métrologie Légale — 1 copy

Commonwealth Science Council (attention Dr. M.G.A. Khan) — 1 copy.