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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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DP/BRA/82/020

A QUALITY MANUAL FOR THE CENTRE FOR SCIENTIFIC AND INDUSTRIAL METROLOGY, XERÉM-RJ, BRAZIL

Dr. J.H. Buckingham
UNIDO Consultant in National Calibration Services

August 1986

SUMMARY

Brazil's National Institute for Metrology, Standardization and Industrial Quality (INMETRO) has delegated its responsibility for maintaining the national standards of measurement to its Centre for Scientific and Industrial Metrology (CEMCI). CEMCI wishes to establish a quality manual to cover its various calibration and testing activities. This is to promote the standardization of its metrological procedures, and to ensure that all measurements made at the Centre can be traced to national and international standards of measurement.

The quality manual should itemise the calibrations and tests which are within the competence of CEMCI to perform. It should include details of the organisation of the Centre, together with the staff and equipment necessary for obtaining prescribed levels of accuracy in the measurements. It is believed that, in the first instance, the quality manual should represent the present capability of CEMCI, and not that which may be attained if certain increases in staffing levels, facilities, and equipment purchases eventuate. These increases are likely to result from CEMCI utilising an anticipated World Bank loan. Therefore, it is suggested that the quality manual be amended (if necessary) after the expenditure of that loan, if this results in a significant increase in the measurement capability of the laboratories at CEMCI.

[illegible] should be considered only on an annual basis. Otherwise, staff will have no time left to perform the calibration and testing work! Also, the manual should be as brief as possible. No useful purpose will be

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served by a manual which is too long to read!

However, it must contain sufficient information to be easily understood by staff of varying degrees of competence. In other words, it will only be of value if it can be used as a training guide for the raw recruit as well as a reference for experienced staff.

It is believed that the manual should be in two parts if it is to be a "manageable" document.

The first part should contain a general overview of the CEMCI organisation, together with brief details of the services it can perform and the levels of accuracy considered attainable. Such information is very important to potential clients and should always be available to staff so that they can respond to telephone enquiries and letters. This first part could also include the routine procedural information which is common to all Sections at CEMCI, whether these be length, mass, temperature, electrical, acoustics etc.

Examples of such information are:

- General housekeeping procedures,
- Security and confidentiality of clients' information,
- Methods of handling inwards and outwards correspondence and associated filing,
- Methods of job costing for subsequent invoicing purposes,
- Procedures for handling inwards and outwards items for calibration or test,
- Recording of measurement data,
- Checking of calculations and data transpositions,
- Reporting of calibration or test results,
- Withdrawal or re-issue of calibration or test reports,
- [illegible] of [illegible] of [illegible] and other [illegible]; [illegible].

Appended to this first part of the manual should be a list or organisation chart showing the current holders of senior positions at CEMCI (for example, director and section leaders), together with any academic qualifications they may possess.

The second part of the quality manual should contain all the technical and other information required for the satisfactory operation of a particular section at CEMCI (for example, mass calibration). This information would be unique to the section concerned, and would differ in technical content from the "part 2" held by another section (for example, Temperature Measurement).

Examples of information which could be contained in this specialised part 2 are:

- Job descriptions of staff in a particular section,
- Any staff training and evaluation programmes,
- Major items of equipment held by the section,
- The calibration schedule for that equipment, and any calibratio reminder system,
- Limitations to be placed on the use of reference equipment,
- Procedures for routine checking the accuracy of everyday equipment,
- Periodic maintenance of equipment,
- Replacement and/or repair of damaged and worn equipment,
- Precautions against contamination, corrosion, and other damage to items submitted for calibration or test,
- Laboratory accommodation, services, and any environmental controls,
- Procedures for monitoring ambient temperature and humidity

In short, everything that is required to assure the quality of the services performed by the section.

Appended to part 2 should be details of the present section staff, their main responsibilities, and any academic qualifications they possess, and a floor plan of the laboratory space showing the locations of major items of equipment.

Associated with the quality manual (that is, in the same physical location), there must be all the technical manuals detailing the measurement procedures used by the section. Since these, themselves, are often complex documents it is not considered feasible that they become part of the quality manual as such. It is suggested that the appropriate technical manual be used in conjunction with the quality manual when any calibration or test work is undertaken.

A QUALITY MANUAL FOR CEMCI

Contents | Page

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INTRODUCTION

My experience of quality manuals has been primarily of those developed at the Physics and Engineering Laboratory (PEL) of the Department of Scientific and Industrial Research (DSIR) in New Zealand. They are specific to the operations of PEL and are not necessarily applicable to the situation in Brazil, or indeed to that at other institutions in New Zealand.

Therefore, it is not my intention to write such a manual for CEMCI since it would be impertinent of me to attempt to impose PEL procedures on CEMCI operations. My input to the CEMCI quality manual should be limited to a discussion of items which might be suitable for inclusion. The detailed preparation must be done by the staff concerned. They must decide for themselves the contents and arrangement best suited to their operations.

In this connection, I cannot emphasize too strongly that the successful implementation of a quality manual depends entirely on the enthusiasm and good will of the staff concerned. A genuine desire to develop a quality operation must exist right at the start. It is much more difficult to "build-in" this desire at a later stage.

This report consists of two kinds of information:

That which might be of general use to all aspects of CEMCI's operations, and that which might be useful to a specific area of measurement. In discussing these aspects, I hope to demonstrate the possible consequences of not developing a set of operating procedures. In many cases I have drawn from personal experience to illustrate the problems which can, and do, arise. That these are frequently amusing is not intended to diminish their importance, but rather to produce a more lively and interesting text.

GENERAL PROCEDURES: THE QUALITY MANUAL, PART 1

1.1 - General Overview of the Organisation

Any quality manual should commence with a statement of the aims, responsibilities, and operations of the organisation. An excellent overview of the activities of CEMCI is contained in the publication

"INMETRO, Institutional View, Brasil 1984", pages 7-9. It is recommended this summary form the basis of the general description of CEMCI to be reproduced at the beginning of the quality manual. Very little editing would be required, although it would be useful to add descriptions of the proposed Optics group and the more "non-technical" groups like COTEC and DATAD. Some indication of present and proposed staffing levels in all CEMCI groups should be given.

1.2 - Measurement Capability of CEMCI

The tables presented on pages 9-11 of "Institutional View" could be reproduced in the manual after appropriate updating. These, together with the operational summary, provide a very clear picture of the present situation at CEMCI and will be valuable training aids for new members of staff.

The data given in the tables should be checked carefully. In my English language version, I noticed some numbers which were obviously incorrect, but these may have resulted during translation from the original. Also, staff may care to re-appraise the accuracies quoted for certain measurements. In general, it is better to understate the capability of an organisation rather than to overstate it.

My own institution has been embarrassed on occasion when it has been unable to meet the accuracy required by a client, even though we had stated previously that such accuracy was possible.

Some years ago, a private laboratory in New Zealand sought registration under the Australian accreditation scheme, NATA. I happened to be present in the NATA office when the managing director of the parent company of the laboratory presented a beautifully printed brochure of the laboratory's "capability" in support of the application. The brochure contained details of a very large range of calibrations and tests which the laboratory claimed it could perform. When asked how many staff were available to do the work, the managing director said there were 3 full-time staff and that some of the 40-strong parent company could help out on a part-time basis when required. I pointed out that PEL with a full-time staff of 200 would be prepared to undertake only 10% of the tests detailed in the brochure!

1.3 - General Housekeeping

In metrology laboratories, cleanliness is synonymous with "Godliness"! Good housekeeping procedures are essential to preserve a clean laboratory environment for measurements of great accuracy. Consequently, it is not always good practice to permit access by contract cleaning staff since they are unlikely to be experienced in the care of precision measuring equipment. Unintentional or rough handling of certain instruments can ruin their calibration, reduce their potential accuracy, and cause contamination.

For instance, the presence of just one fingerprint on a mass standard can increase its weight by several microgrammes. In addition, the sweat associated with a fingerprint is very corrosive and can cause rusting of steel equipment in a few days.

Therefore, it may be necessary for staff in some laboratories to undertake their own cleaning and other housekeeping. Provided the laboratory air-conditioning system works effectively, cleaning can be confined usually to a daily dust and mop with damp cloths. For steel and other oxidisable surfaces, and electrical equipment, the cloth should be wetted with benzene or other organic solvent, never water! The wearing of protective rubber gloves is recommended during this operation since contact with organic solvents can destroy skin lipids and cause dermatitis.

Placement of antistatic mats at entrances to laboratories, and the wearing of cotton overshoes or other indoor footware, considerably reduces the transfer of dust or dirt from outside. Equipment should always be put away after use, glassware cleaned, and any used chemicals disposed of. Otherwise, sooner or later, something will get knocked over, and valuable equipment damaged or measurement records spoiled. Once each week (preferably Friday afternoon), time should be allowed for a general tidy-up of the laboratory.

In addition to normal housekeeping, it is good practice to discourage smoking and the consumption of food or beverages in laboratory areas.

Food crumbs can ruin a mechanical measurement; fruit and beverages can cause corrosion and other contamination of equipment. In my own institution, I can remember an occasion when a speck of food on some measurement results was subsequently transcribed as a decimal point!

Tobacco smoke can have disasterous effects on measurement accuracy, and smokers should be permitted breaks away from the laboratory. This is particularly so in density or viscosity measurements, where the surface tension is required to be known (and constant). Tars and other hydrocarbons in the smoke are surface active agents, and will condense on most solid and liquid surfaces. One result is to reduce the measured surface tension of water by between 5% and 10%.

In my own laboratory I have measured the effect of just one puff of smoke on surface tension. Clean water exhibits a surface tension of 72.75 mN m^{-1} at 20°C. After contamination, this figure can drop below 69 mN m^{-1}. There are two reasons for this. One is the effect on the water surface itself. The other is the effect on the measuring device (in my case, a glass Wilhelmy plate). Smoke renders an otherwise clean glass surface slightly hydrophobic. Hence the contact angle between water and glass departs from the ideal zero. It then must be measured and allowed for in subsequent calculations.

Again, smoke from a non critical area can be transmitted to a critical one via the laboratory air-conditioning system. If laboratories are equipped with smoke detectors for fire alarm purposes, this can have interesting results. A few months ago, one of my staff was assembling an electronic circuit in the laboratory. Smoke from his soldering iron activated a highly sensitive detector and resulted in an unwelcome visit from the local fire brigade! Needless to say, we reduced the sensitivity of the detectors after that.

1.4 - Security and Confidentiality of Information

The security and confidentiality of information obtained during the course of a programme of work for a particular client should be maintained at all times. Clients' work which is not currently under test should be kept in a closed cabinet. Discretion should be exercised with regard to clients' work under test when visitors are admitted to the laboratory.

The reason for this is that the information obtained during the calibration or test belongs to the client, who is often paying for the service provided by the laboratory.

In my own country, there have been cases of attempted industrial espionage during such work, usually in the area of product testing rather than instrument calibration. It should always be remembered that the client comes to the laboratory because he relies on the quality of the service provided. Part of that quality assurance is the understanding that the measurement results have not been given to anyone else.

The only possible exception in New Zealand is where testing is required for a process of litigation. In this case, we undertake such work after the client has agreed that the results be made available to all parties before the court hearing. Otherwise the results could be classified as unfair evidence in a court of law, and possibly ruled as inadmissible.

Occasionally, my staff desire to publish clients' test data in the scientific journals. In such cases, they must first obtain permission to do so from their client(s).

In New Zealand, public servants must sign a written undertaking (the Official Secrets Act) never to disclose information obtained during the course of their official duties unless permission to do so is first obtained from their supervisor. This is almost always given when the information is not for a specific client and is not of a sensitive or strategic nature. Occasionally, however, certain (usually younger) members of staff feel that even this minor restriction is unnecessary and that scientific information should be freely given to everybody.

In such cases, I remind them of a situation which arose at PEL some years ago. A certain member of our staff was "moonlighting", that is working after hours as a "private" consultant. He released official information to his "client" which subsequently was proved to be in error. The client then sued PEL believing, wrongly, that the staff member was acting in his official PEL capacity. Needless to say, we disciplined that officer. He was given the choice of immediate resignation or public dismissal. Had the information been of strategic importance, he would have been liable also to a court fine, a prison term, or both.

I once heard the Chief Scientist for ICI state, during a lecture on quality assurance, that information comes in one of three categories. It is either useful, in which case money is made out of it; or it is interesting, so it is published; or it is funny, in which case one laughs at it! I think that sums up the subject very well.

1.5 - Correspondence and Associated Filing

CEMCI will have its own well-established procedures regarding the handling of inwards and outgoing correspondence and associated filing. It is worth including those procedures in the Quality Manual as resource material for new staff.

It is often useful for an officer receiving or originating correspondence to maintain his/her own filing system in addition to that of the central registry. This provides a rapid referral system and is valuable during subsequent correspondence or telephone conversations regarding a particular job. In such cases, the original letter should be copied for the officer's own file before being returned to the registry.

1.6 - Job Costing for Estimating and Invoicing

With increasing emphasis on "accountability" in the Public Service, job costing is becoming usual practice in the central measurement laboratories of many countries, New Zealand's included. Governments are committed to reducing the level of public expenditure. Consequently, at PEL for example, the level of government funding in 5 years time will be less than 70% of that for 1986. Therefore it is becoming essential for us to make up the balance by charging for work done for our clients. Otherwise, those government funds will be steadily eaten away by service work to the detriment of other activities like maintenance of the national standards.

Even if such policies have not been initiated in Brazil, proper job costing is still good practice for a highly professional organisation like CEMCI. It is a sad but true fact that the quality of a product is often measured in terms of its cost. Human psychology is such that, if something appears to cost too little, then it is believed there must be something wrong with it! In the past, there have been occasions at PEL where potential customers have lost interest because our services were too cheap. They have then gone to a private organisation and paid two or three times as much for an inferior product. While this may have reduced our calibration and testing load, it did our reputation no good at all!

Therefore, it is important to derive the true cost of a job (but not to overcharge for it). Several factors need to be taken into account:

a) The cost of the person doing the work. In New Zealand, this is estimated on an hourly or daily basis by taking the officer's rate of pay and multiplying by the factor 2.5. Looked at another way, the daily rate will be annual salary divided by 100 assuming an average of 250 working days a year. This multiplier is used to account for "invisible" costs such as pension schemes, annual leave, sick leave, etc., plus overheads like administration, electricity and other utilities, and maintenance of buildings.

   It should be remembered that the time taken to do the job is not just that for the actual measurements. In addition, there is the time associated with any specimen or equipment preparation, working out results of a measurement, checking those results, and preparing the report. Some of my own staff have found that, when they have assessed these additional factors, the total time for the calibration or test can be up to three times as long as their estimate for the measurement alone!

b) The replacement cost of any equipment used for the measurement. In my own laboratory, we use a formula based on 20 cents per $ 1000 of replacement cost per hour of use. In this way, the charge for equipment costing $ 100,000 would be $ 20 per hour.

c) The cost of any special jigs or fittings that need to be made for a particular job.

d) The cost of any raw materials used during the job, such as sheet metal, chemicals, photographic paper etc.

e) The cost of transport. If a job is required to be done away from the laboratory, the cost of getting to and from the measurement site should be assessed together with the travelling time of the officer involved.

f) The cost of typing the measurement report and any associated correspondence.

I must confess that it is only during the last 6 months that PEL has been attempting to assess all these factors in preparing estimates for work done for our clients, so we are still on our own "learning curve" in this respect.

Having gone through this initial estimation process, the various components should be summed and the client advised of the likely cost of the work. If, at this stage, the client wishes the work to proceed, his acceptance of the quote should be in writing and should include an order number against which the work can be charged. This will help subsequent invoicing when the job is complete.

It is very important to obtain this written confirmation. At PEL, there have been a number of occasions when this was overlooked. The result was that clients later denied they had requested the work to be done, or stated they were given to understand there would be no charge. In one instance, the client was a major government department, and a large amount of correspondence about the misunderstanding was generated! After two years, PEL decided the expenditure on this clerical effort was greater than the cost of the original job. In such cases, it is prudent to "write-off" the cost against experience!

In general, it is considered unprofessional to quote one fee, and then attempt to recover another (higher) sum if the estimate was in error. Experience helps to overcome this problem.

However, there will be occasions when staff are asked to quote for work of a complex or long term nature in which the various cost components are more difficult to assess. In such cases, PEL obtains the client's prior agreement that work only up to a certain value will be undertaken. If this is insufficient to complete the job, the client is then given the option of accepting any interim results or of providing additional finance to enable satisfactory completion.

Associated with this "professional" approach to estimating the cost of a job is the need to provide an itemised invoice when that job is complete. Clients are often required to pay a considerable amount for a high quality calibration or test. Therefore, they are entitled to know exactly how that money has been spent. A simple statement of the total fee due is insufficient. In all cases, the various components in the total should be detailed. In other words, the invoice should be of the same quality as the job!

1.7 - Care of Items Submitted for Calibration or Test

Clearly, it is the client's responsibility to adequately pack any instruments or test samples before they are sent to the laboratory. However, on arrival, these should be checked for damage which may have occurred in transit, and the customer advised of any unserviceable items. At PEL, we occasionally repair the damage but, more usually, return unserviceable items and reduce our charges accordingly. We do not charge for work which cannot be done!

Serviceable items are then allocated to the appropriate officer for calibration or testing. At this stage, a uniquely identifiable job number should be allocated to the work. CEMCI will have its own procedures for doing this. Where a job consists of many similar components, such as calibration of a batch of thermometers, each item should be identified.

The serial number of the item is sufficient for this identification. However, if there is no serial number, a suitable mark or number should be etched or engraved on it before measurement. If permanent marking is inappropriate, a tie-on or adhesive label can be used as a last resort.

When it is not possible for the work to proceed immediately, the job plus any associated paperwork should be carefully and securely stored until the work can proceed. Although laboratories frequently disclaim responsibility for any loss or damage which might occur during the time items remain in their care, it is clearly undesirable to gain a reputation for careless handling!

Once the job is due to commence, any necessary cleaning, degreasing, or other preparation prior to measurement should be undertaken with great care. Steel items should be regreased immediately after measurement to preclude any rusting.

Once the work is complete, the item(s) should be retained by the laboratory until the calibration or test report has been written and checked for accuracy. It is very bad practice to release items and then to have to recall them because the measurements were later found to be in error. This is likely to attract the dissatisfaction of the client, especially if he needs the items to continue his operations!

Prior to despatch, completed items should be repacked carefully to avoid any damage on the return journey to the client.

1.8 - Recording of Measurement Data

Originally, many measurement laboratories recorded their test data in numbered, hard-covered work books which were retained by the section doing the work. There is nothing wrong with this practice since it provides a permanent, readily available record which is often needed for reference purposes at a later date.

However, with the present trend to electronic data capture and processing, and associated computer printout, the information can now be stored more easily on floppy discs. At the same time, it is prudent to maintain any worksheets and computer printouts with a copy of the final report on an appropriate laboratory file. This insures against any loss of electronically stored data because of some malfunction in the computer or word-processing system. A friend of mine in another DSIR division once spent two years painstakingly compiling an inventory of New Zealand native flora. All the information was stored on a VAX 11/780 computer. There was a "disc crash" and he lost everything, and had to start his work all over again!

In all cases, the results should be identified by the job number, serial number (or other identification) of the item(s) under test, the date when the work was done and by whom. Worksheets should be single sided and numbered. Manual recording of test data must be in permanent form, that is ballpoint pen or ink, never pencil. Corrections should be made by crossing out incorrect data and the corrected figures written along side, above, or below the crossed-out data. Each sheet and any corrections should be initialled by the officer doing the work.

In addition, it is good practice to maintain a register of all work carried out by the section. This is a useful cross reference. This register should contain the following information about each job:

- the CEMCI job number, or other number uniquely identifying the work,
- date the work was done,
- customer's name, address, and order number,
- details of item(s) tested, together with the serial number(s) or other identification,
- brief description of work done,
- work book or worksheet identification,
- time taken and charge for the work,
- number of registry file containing copy of final report,
- name of officer who carried out the work

This register should be kept permanently by the section.

1.9 - Checking of Calculations and Data Transpositions

Having obtained all the measurement data necessary for working out the results, and assuming the measurements have been made correctly, there is still the possibility of errors being made during subsequent calculations.

Therefore, the person carrying out the work should perform each calculation at least twice (and on different occasions). Selective checks should be made by another officer, and the appropriate worksheets initialled by him/her to show this has been done. All data transpositions should be checked by the person concerned and another officer. Similarly, the final report should be checked over by the other officer and each page initialled by him/her before the report is signed by the person who did the work. A further check on the report should be made by the countersigning officer, who is usually the director or a senior member of the laboratory.

In other words, the Japanese principle of "quality circles" should be applied to the calculation of results and their subsequent presentation in a calibration certificate or test report. After all, that document is supposed to be the quality end-product of all the QA procedures used in the laboratory!

Of course, even with all these safety checks, it is still possible for something to go wrong. On one occasion at PEL, we were rather embarrassed when a client pointed out that our calibration certificate for the $6\frac{1}{2}$ digit DVM he had submitted stated one range in MV not mV. A simple typographical error, but it made all the difference in the world!

On another occasion, fortunately before the report was sent to the client, I managed to spot that one of my staff had listed the calibration of an anemometer in units of metres per second instead of metres per minute. I asked her how she had obtained these figures since we did not possess a supersonic wind tunnel!

Fortunately, however, good checking procedures make such occurrances the exception rather than the rule.

1.10- Reporting of Calibrations and Tests

Measurement results should be reported in writing always.

Oral reporting is discouraged because there is a much greater chance of error. In addition, any ambiguities in conversation can cause the client to misunderstand, or wrongly interpret, the results. On one occasion at PEL, a very senior officer (who should have known better!) advised a client by telephone that his scale was readable to plus or minus one tenth of the interval between small divisions. The client confused readability with accuracy when, in fact, the scale had a cumulative error in excess of two small divisions over its entire length. That the client subsequently won a contract on the basis of the supposed accuracy of his measuring equipment made the situation all the more embarrassing!

If, for reasons of urgency, the client insists on an oral report, it must be emphasized to him/her that the information is given "without prejudice", that it is not official, and that it will be confirmed later in writing. No staff member should ever communicate results orally without the prior consent of a senior officer.

Preparation of the written report should be done by the officer who carried out the measurements. Normally, a handwritten draft will be submitted for typing. The typed draft is then checked by the originator and another officer. Because written reports are legal documents, transcription errors cannot be amended by "whiting out" and typing over. Consequently, even one small error will require a complete retype of that page of the report. This puts great strain on the typist: knowing that you must not make a mistake invariably means that you will make at least one! With some of PEL's more complex reports, our typists used to become quite paranoid on occasion. One of them, after six false starts, finally had to take 5 days leave before being able to produce a "clean" original!

Fortunately, word processors have now removed this problem. In addition, the report can be stored on floppy disc so that, if the client ever loses the original, a replacement can be produced quickly. This is especially important where a report is required in a legal action, since the courts generally do not accept xerox copies.

Once a satisfactory report has been typed, and the required number of xerox copies made for filing purposes, everything should be initialled and/or signed as suggested in section 1.9, or as laid down in CEMCI's procedures. The quality of presentation of information in reports should pay due regard to any typing or word-processing guidelines adopted by CEMCI, but it is most important that the reports should display all the attributes of good reporting practice. That is, they must be understandable to the end-user, they must be concise, and they must be unambiguous. That they must also be correct goes without saying!

Considering the report in its final form, the following should apply.

The front page of the report should be typed on official letter head paper or format sheet similar to that already used by the Rede Nacional de Calibração, RNC (see page 24 of the RNC manual, published by INMETRO, 1984). It should bear a unique report number and any relevant CEMCI file number. The report number, page number, and date of issue should be typed on each page of the report. A suitable format for continuation sheets is shown on page 25 of the RNC manual. Page numbers should be expressed as "page... of...".

Also on page one, the title of the report should be given. At PEL, we use the words "Report of Examination of....", where the name (and quantity) of the item(s) examined is inserted in place of "...".

The reports should continue as follows, preferably but not necessarily in the order given:

- customer identification; that is, the client's name, address, and order number.
- description of the article(s) examined, together with existing identification marks or serial numbers. In addition, with the client's permission, PEL often adds its own identifying number (usually the report number) to the article(s). In such cases, our reports include the statement: "the... has(have) been marked with the number(s)... in reference to this report". When several articles are tested under the same report number, each is marked with that number followed by (1), (2), (3) etc as appropriate. When adhesive or tie-on labels have to be used, our reports state: "Samples are not permanently identified. It is the customer's responsibility to ensure continued identification".
- examination carried out. Brief details of the client's requirements and the test method used should be given. Major items of equipment used for the measurements should be included.
- results of examination. This part of the report should provide the detailed results in the form required by the client. This may be tabular, graphical, or both. In appropriate instances, the results of any visual examination might be mentioned, and reference make to conformation (or otherwise!) with a specification. However, care should be taken to state only factual information. Opinions should not be expressed in the report, but may be contained in a covering letter. In all reports, the appropriate SI units of measurement must be stated.
- uncertainty of measurement. No measurement is ever exact. Therefore an associated uncertainty must be quoted in all cases, together with the appropriate confidence level. Normally, in standards laboratories, the 99.9% (3σ) confidence level is used, but there will be occasions when 95% (2σ) or even 70% (1σ) is appropriate. This is quite acceptable so long as it is stated.
- environmental conditions. The ambient temperature and, where applicable, pressure and humidity applying at the time of

test should be stated in all cases. Where results have been corrected to standard conditions (for example, 20°C), this should also be stated. In certain force, pressure, and vibration calibrations, the value of "g" (gravitational acceleration) is required to be known. In such cases, it is useful to include a formula embodying "g", so that the client can use the value for his "local gravity" (if known).

- date of examination. The date(s) of examination should be recorded in all cases, together with when the item was previously tested at CEMCI. With items each as sets of masses or gauge blocks, multi-range voltmeters, etc, these may need to be calibrated over a period extending to several weeks. In such cases, PEL states "the examination was carried out between ..., 19.. and..., 19..".

- certifying signatures. As mentioned in section 1.9, PEL reports bear two signatures on the final page: that of the officer who performed the measurements and that of the countersigning officer. The initials of the third party who checked the report are also included. All three officers usually initial any other pages (without signature). I note that the otherwise admirable RNC report forms appear to make provision for only one signature (Assinatura Autorizada). It is suggested these be suitably amended since, at present, they contain no proof that multiple checking of their contents has been undertaken.

- conditions against mis-use of report details. I am impressed by the conditions stated at the bottom of the RNC report forms. Only occasionally does PEL state that the results apply only to the particular item(s) under test. Again, RNC goes further than PEL by insisting that "... reproduction in total or in part requires the previous authorization of RNC". By comparison, PEL permits reproduction in total, but not in part without the permission of the director. PEL can profit from RNC procedures in this respect.

Clearly, restriction must be placed on the use of report information. Twenty years ago, PEL was testing aluminium ladders for a local manufacturer. The tests were undertaken in accordance with a recently published New Zealand standard specification. One week later, the manufacturer advertised in the newspapers that his ladders were the only ones tested to the new specification. However, he omitted to state that his ladders had failed! Needless to say, we invited him to withdraw the advertisement or face court action. The advertisement did not appear again! But without that printed condition on our report, we would have been powerless.

I have gone into some detail about the format and contents of the "ideal" report. However, as I have already said, this is the end product of a laboratory's quality management programme. The laboratory's reputation ultimately depends on the quality of its reporting procedures. Therefore, these must be correct, invariable, and completely reliable.

1.11- Withdrawal and Reissue of Reports

Even with the most rigorous of checking procedures, mistakes will still occur, and reports containing errors released occasionally. The errors usually arise in one of two ways.

The first is when mistakes occur in transposition or calculation from the original data, or when the wording of the report is ambiguous (and can cause errors in interpretation). In other words, the error is confined to the report itself and does not arise from incorrect measurement.

In such cases, the client should be advised of the error and requested to return the report. On its receipt, it and all copies held by CEMCI should be destroyed and a new (correct) report issued.

The second situation is when subsequent work or discussion reveals a mistake that was made during the original examination of the item(s) under test. In such cases, the client should be requested to return the report and the item(s) for re-examination. Again, all copies of that report should be destroyed, the work repeated, and a correct report issued.

In all situations requiring this kind of remedial action, the cost of the "remedy" should be borne by CEMCI. Remember also that it is no disgrace to admit to error. It is just one more demonstration of the importance placed on quality by the laboratory (provided, of course, the mistakes do not become too numerous!). In fact, institutions who claim to never make mistakes are either dishonest or unaware of their errors. It is wise to beware of such institutions!

1.12- Retention and Disposal of Records

Records of all measurement results, reports, associated correspondence etc should be retained by CEMCI for at least 10 years, and preferably for ever.

There are several reasons for this:

a) Records are essential to the resolution of any subsequent dispute between the laboratory and the client.

b) They provide a means of detecting errors in procedures, measurements, and calculations.

c) They comprise the behavioural history of items submitted for test. For instance, only by comparing previous calibration certificates for an instrument can its stability (or otherwise) be determined.

d) The records are necessary for any quality audit of a laboratory's staff and measurement procedures. They indicate the level of performance of the laboratory, and hence its ability to provide a reliable service. In the event that a laboratory accreditation scheme is introduced in Brazil, such records will form the basis of any assessment to determine the acceptability of a laboratory under the scheme.

e) The records represent the history of a measurement laboratory's operations and are useful in predicting how these operations might develop in the future.

As mentioned in section 1.11, the only occasion when records should be destroyed is when they are shown to be in error and need replacement by correct information.

Some years ago, a PEL clerk was asked by our administration officer to remove some out-of-date files from the registry in order to make room for the current ones. We have a stack room for archival material of this nature. Unfortunately, the clerk misunderstood the instruction and loaded the files on a truck to be taken to the local rubbish dump! Before we realised what had happened, all those files had been buried under 3 metres of rubbish by a bulldozer. Consequently, PEL has few detailed records of its activities prior to 1965. Fortunately, all the original calibration certificates for our instruments are retained in a fire- and blast-proof strong room. Otherwise the clerk would have had those as well!

CEMCI will have its own procedures for the copying, distribution, and retention of records. However, in the case of laboratory test reports, it is good practice to take three xerox copies before the original is sent to the client. At PEL, we generally advise the client to retain the original for at least five years. With the copies, one is retained by the PEL section which did the work, one is filed by the registry, and, of course, one is deposited in the strong room.

Apart from anything else, this procedure insures against loss or misplacement of the laboratory or file copies, and has saved PEL from some embarrassment on several occasions.

1.13- Details of Senior Personnel at CEMCI

In any organisation, it is important to know who to contact for advice regarding procedural matters, disputes, client requirements, and (especially) personal problems. After all, the quality of a job depends mainly on the performance of the staff doing the work. And performance depends on knowledge and personal well-being. Therefore, it is useful to include in the quality manual some details of the holders of senior positions in the organisation.

In the case of CEMCI, it is suggested that the names of the following senior staff should be included:

Director,
Technical Coordinator (COTEC),
RNC coordinator (CORNC),
Coordinator of Administration and Technical Support (DATAD),
Chief of Acoustics and Vibration,
Chief of Mechanical Measurements,
Chief of Electrical Measurements,
Chief of Heat and Temperature Measurements,

Coordinator for Optical Measurements.

This information could be given in either tabular form or a diagram in an appendix to part 1 of the manual.

SPECIFIC PROCEDURES: THE QUALITY MANUAL, PART 2

2.1 - Application to Metrology Operations

In the following sections, I attempt to develop those aspects of the Q.A. scheme which would be suitable for a specific area of measurement at CEMCI. However, although the scheme is centred around the present operations and procedures of the electrical measurement group, it is intended as a model upon which the quality manuals of all technical groups can be based.

During the preparation of these sections, I have relied heavily on information provided by my colleagues in the following CEMCI laboratories:

DC Voltage and Current (LATED)

Low Frequency Voltage and Current (LATEA)

Electrical Resistance (LARES)

Electrical Capacitance and Inductance (LACAP)

Current and Voltage Transformers (LATRA)

Electrical Power and Energy (LATENE)

I would like to express my gratitude to the staffs of those laboratories for their advice, constructive comments, and endless patience during this phase of my assignment.

2.2 - Job Descriptions of Staff

Before any quality management procedures can be introduced to the laboratory, the staff must have a clear picture of their place in the organisation, and of the measurements for which they are responsible. Otherwise, new members of staff will not know what they are supposed to be doing (or appreciate fully the implications of their work), and any attempt to develop staff training programmes will be unsuccessful. For experienced staff the existence of detailed job prescriptions makes it easier to move to different fields of measurement, or to assume positions of responsibility in the organisation.

The present staff ceiling of the electrical group is 17 full-time officers (7 professional and 10 technical), plus 1 part-time consultant. The following paragraphs attempt to detail their responsibilities:

a) Chief of Group: Responsible to the Director, CEMCI for all matters of policy and general management of the electrical group. He/She should act as quality manager, and be responsible for quality assurance and its proper maintenance within the electrical laboratories. The responsibilities should include:

- preparation and introduction of the Q.A. manual, part 2 (electrical),
- any subsequent amendments,
- guidance of staff in the implementation of the manual,
- conducting regular quality audits of the electrical laboratories, including the staff (staff evaluation).

b) Physicist, LATED: Deputy to Chief of Group. Also responsible for day-to-day running of LATED including:

- allocation of work and ensuring this is within the competence of the officer concerned,
- on-the-job training of new or inexperienced staff,
- authorisation of job opening and closure,
- maintaining a record of work completed,
- maintaining a record of LATED income and expenditure.

Technical responsibilities of this officer include:

- ensuring the international traceability of Brazil's primary standard of voltage via regular overseas calibration and intercomparison,
- ensuring corresponding traceability of reference and working standards of DC voltage,

- provision of associated calibration services,
- undertaking DC current and voltage calibrations and tests as required.

c) Technicians, LATED (2): Responsible for:

- maintenance of standard cells and their enclosures (technician 1)
- maintenance of associated measuring equipment (both technicians),
- measurements on DC current and voltage sources, voltmeters, potentiometers, and ammeters (both technicians),
- preparation of associated calibration or test reports.

d) Physicist/Engineer, LACAP: Responsible for day-to-day running of LACAP (see prescription for LATED, paragraph 2.2 (b)). Technical responsibilities include:

- ensuring the international traceability of Brazil's primary standards of capacitance and inductance via overseas calibrations and/or intercomparisons,
- ensuring corresponding traceability of reference and working impedance standards, maintenance of laboratory equipment,
- provision of associated calibration services,
- planning for measurement services for magnetic quantities,
- measurements of capacitors and inductors, impedance bridges, and other measuring instruments,
- preparation of associated reports.

e) Physicist, LACAP: Technical responsibilities as given in paragraph 2.2 (d).

f) Physicist, LARES: Responsible for day-to-day running of LARES (see paragraph 2.2 (b)). Technical responsibilities include:

- ensuring international traceability of Brazil's primary standard of resistance via overseas calibrations and/or intercomparisons,
- ensuring corresponding traceability of reference and working standards of resistance,
- provision of calibration services for resistance and conductance

measurements.

g) Technicians, LARES (3): Responsible for:

- maintenance of resistance standards and associated equipment (technicians 1 and 2),

- calibration of instruments and equipment such as resistance meters, meggers, decade resistance boxes, wheatstone bridges etc (all technicians),

- preparation of associated reports.

h) Engineer, LATEA: Responsible for day-to-day running of LATEA (see paragraph 2.2 (b)). Technical responsibilities include:

- maintenance of Fluke AC-DC transfer standards,

- Low frequency (60-400 Hz) current and voltage measurements, up to 1000 V,

- calibration of AC ammeters and voltmeters,

- associated report preparation.

i) Technician, LATEA: Technical responsibilities as per paragraph 2.2 (h) plus calibration of oscilloscopes and AC sources.

j) Physicist, LATRA: Responsible for day-to-day running of LATRA (see paragraph 2.2 (b)). Responsible for calibration and testing of measuring transformers.

k) Technical Officer, LAENE: Responsible for day-to-day running of LAENE (see paragraph 2.2 (b)). Responsible for calibration of energy and power meters, and for type approval testing.

l) Technicians, LAENE (3): Technical responsibilities include:

- maintenance of measuring equipment (technicians 1 and 2),

- calibration of energy and power meters (technician 1),

- prototype kWh and kVA meter type-approval testing (technician 2),

- user calibrations, assist technicians 1 and 2 (technician 3),

- preparation of associated reports (technicians 1 and 2).

m) Consultant: Former chief of electrical group, now retired. Works part-time as consultant to group and helps with calibration load when required.

It is suggested that each of the above personnel write their own detailed job descriptions based around my "Summaries". By sharing the load in this way, the job will be done quickly and will not be too onerous. Staff of other CEMCI groups should do likewise, using these electrical descriptions as guidelines.

2.3 - Staff Training and Evaluation

Many of the staff at CEMCI have undergone a post graduate course in general metrology. Some senior officers of the electrical measurements group have received additional training in the appropriate laboratories of NBS (USA), PTB (FRG), ETL (Japan), and elsewhere. These senior people can, and do, provide in-house training for new or inexperienced staff.

However, it is recommended that details of the techniques covered during this in-house training be documented in the quality manual, rather than taught on an "ad hoc" basis. This is to ensure the continued availability of the information in the event that the officer responsible for training in a particular topic is unavailable. Such training should always centre on the appropriate measurement procedures. For instance, in any discussion of measurement uncertainties, the source(s) of random and systematic errors in, say, resistance measurements will be different from those applying to the interferometric calibration of gauge blocks.

When such training is not given, or is not properly documented, things can go wrong. For instance, during a recent international intercomparison of 1 ohm resistance standards, both Australia (NML) and New Zealand (PEL) claimed that the travelling standards were unstable devices since they appeared to change their value with time. However, further measurements indicated this change was an artifact resulting from the particular method of measurement used at NML and PEL!

Both organisations are experienced in the use of Leeds and Northrup, and Thomas-type resistors. The travelling standards were Tinsley devices. When the latter were connected into the bridge in the normal or fully interchanged configuration, the results agreed to 1 part in 10^8. But when a partly interchanged configuration was used, the results were 3-4 ppm higher.

It is interesting that this property appears to be peculiar to the Tinsley design, and is not experienced with other devices. We believe it is due to the generation of a Seebeck emf in one of the internal lead wires of the Tinsley resistors. This emf appears to be induced by Peltier heating or cooling when current flows in a separate, but thermally coupled, lead wire.

Subtle problems of this nature (and some not so subtle!) will always arise through lack of experience. The first step towards gaining the necessary experience is a properly documented training programme.

Allied to this business of staff training is the need for well established staff evaluation procedures. Staff evaluation is the most important part of the quality audit process. It helps maintain a continued high level of performance by staff, and exposes any problems associated with inexperience or inadequate training. Clearly, the quality of performance of an organisation depends first on the quality of its staff. Without good staff, the organisation will fail, no matter how much money is poured into facilities and equipment.

Since INMETRO is currently devising a set of internal rules pertaining to the career structure of the organisation, staff promotion criteria etc, it is appropriate that some consideration be given by INMETRO to the most suitable method of staff evaluation. Any quality audit of staff within CEMCI will need to be arranged so as to complement, rather than conflict with, those internal rules.

The system used at PEL is far from ideal, but it does provide such evaluation at regular (2 years) intervals. Promotion within PEL (and DSIR generally) is by merit. So we have to rate our scientists and technicians according to several criteria, such as:

- scientific knowledge
- experience
- performance and output

- ability in problem solving
- significance of work done
- ability in supervision of staff
- client and staff relations etc.

The most important of these is undoubtedly performance. Here the emphasis is on quality, rather than quantity, of work completed during a 2 year period. However, it is always amusing to see the significant increase in output of some of our scientists as evaluation time approaches!

Having rated our scientists and technicians, we then must rank them by order of merit. We have 100 scientists at PEL and a similar number of technicians. To put those 100 scientists in the currect order of merit from the best to the worst is always a difficult, and often unpleasant, task. The promotion prospects, rate of promotion, and ultimate "career grade" of each one of those scientists depends solely on their position on the order of merit list. It is a time consuming process and not one to be undertaken lightly. It is always worth bearing in mind that an organisation's most precious resource is its human one. It is important that this resource be managed properly.

2.4 - Details of Equipment

Details of major instruments and equipment held by each laboratory should be included in the manual.

This is not merely for use by the staff. It is also one of the first things requested during any quality audit. For instance, it is an RNC requirement that such a list be available for inspection before any application for accreditation can be considered. CEMCI/RNC should not require of others what it is not prepared to do itself!

The list should provide the identity of each item, when last calibrated, and when due for recalibration. As a guide to what can be involved, pages 26-28 of the present document list the equipment of one of my laboratories at PEL. Using that model, I have included on pages 29-31 an incomplete list of LATED equipment. It is left to LATED staff to provide the missing details before this is used as an example throughout CEMCI.

Standards or Equipment		Calibration Status	Report or Certificate No.	Calibration Authority	Date of Last Calibration	Calibration Interval
__Gauge Blocks__						
Calibration grade	81A	due	S8513	PEL	Oct 1978	4 years
	81B	current		PEL	Nov 1982	4 years
	89A	due	79/A/194	PEL	May 1980	4 years
	89B	due				4 years
	4305	current		PEL	1981	
	1C12	current		PEL	1980	
Inspection grade	Y5775 (D99)	current	S20197	PEL	Mar 1984	2 years
	7736	current	S10999	PEL	Feb 1982	5 years
	4424	current	S20123	PEL	Nov 1983	2 years
	4425	current	S10338	PEL	Jan 1981	5 years
Workshop grade	27115	current	S10253	PEL	Mar 1981	5 years
	6650	current	S20132	PEL	Dec 1983	2 years
	5928	current	S10203	PEL	Apr 1981	5 years
	1315	current	S10326	PEL	May 1981	5 years
__Length Bars__						
447 Reference		due	M25699	NPL	1956	4 years
2236 Reference		due	M082680	NPL	1973	4 years
Inspection		due				4 years
Combination Angle Gauges		due	NPL B1946	NPL	1946	4 years
__Secondary Standards & Items of Equipment__						
Steel balls 445 -		current	MC 144/184	NPL	Jan 1977	8 years
Steel balls 838		current	S7773	PEL	Jul 1977	8 years
Steel balls 858		current	S7775	PEL	Jul 1977	8 years
Steel balls 868		current	S7774	PEL	Jul 1977	8 years
Steel balls 828		current	S7772	PEL	Jul 1977	8 years
Thread measuring cylinders S9471		current	S9471	PEL	Feb 1980	10 years
Thread measuring cylinders S9470		current	S9470	PEL	Feb 1980	10 years
Thread measuring cylinders (22 individual serial nos.)		current	S9262	PEL	Oct 1979	10 years
Cylindrical standards (15 individual serial nos.)		current	S9832	PEL	May 1980	6 years
Cylindrical standards A1-11		current	S9833	PEL	May 1980	6 years
Cylindrical standards (12 individual serial nos.)		current	S10205	PEL	Feb 1981	6 years

Standards or Equipment		Calibration Status	Report or Certificate No.	Calibration Authority	Date of Last Calibration	Calibration Interval
Cylindrical square 8A1		current	S10442	PEL	Sep 1981	8 years
Cylindrical square M36/1		current	S10443	PEL	Sep 1981	8 years
Cylindrical square 1071		current	S10038	PEL	Dec 1980	4 years
Engineer's square WaA53		current	S10437	PEL	Aug 1981	5 years
Engineer's square 54001		current	S10434	PEL	Aug 1981	5 years
Engineer's square 54201/2		current	S10435	PEL	Aug 1981	5 years
Engineer's square 54202		current	S10436	PEL	Aug 1981	5 years
Engineer's square 54201/6		current	S10433	PEL	Aug 1981	5 years
Precision Mandrels 7430		see note	S7430	PEL	Jul 1977	
Pitch reference standards QA1-12		see note	S7133	PEL	Feb 1976	
Pitch reference standards RA1-13		see note	S7133	PEL	Feb 1976	
Rollers 8A156		current	S7901	PEL	Aug 1977	8 years
Rollers A4157		current	S7902	PEL	Aug 1977	8 years
Rollers M160		current	S9853	PEL	Jun 1980	8 years
Roundness standards*	(4) (individual serial nos.)	current	NSL37469	NSL	May 1984	10 years
Roughness standard	2302	see note	S9778	PEL	Apr 1980	4 years
Setting standards	P242/073	current	S10206	PEL	Feb 1981	6 years
Straight edge	NPL46/86	current	S10812	PEL	Oct 1981	8 years
Straight edge	107	current	S10810	PEL	Oct 1981	8 years
Sine bar	P474	current	S10052	PEL	Nov 1981	8 years
Sine bar	9116	current	S10053	PEL	Nov 1981	8 years
Steel tape 10 metre	AP15392/2	current	83/A/115	PEL	Apr 1983	10 years
Vee pieces (4 pr)	(individual serial nos.)	current	08125	NPL	Feb 1977	10 years
Surface plate	K312 NPL43	current	S10974	PEL	Dec 1981	5 years
Surface plate	K313 NPL43	current	S10975	PEL	Dec 1981	5 years
Surface plate	2673	current	S20134	PEL	Jun 1984	4 years

Standards or Equipment	Calibration Status	Report or Certificate No.	Calibration Authority	Date of Last Calibration	Calibration Interval
Instrumentation					
Screw diameter measuring machine 136/43	current	S1101	PEL	Feb 1982	4 years
200 inch profile projector 105/10/7		S7187	PEL	Apr 1984	5 years
SIP profile projector AP/6/206	see note	79/A/171	PEL	May 1979	
Bench micrometer 27/41	see note	S6027	PEL	May 1975	
Electronic gauge 25255 Electronic gauge	see note				
Talysurf model 3 112/320/1110	see note				
Hardness tester 20/208	see note				
Talyrond model 51 112/843/375	see note				
Sears Roit comparator	see note				
Federal horizontal comparator	see note				
Federal gauge block comparator	see note				
SIP Trioptic 19	see note	79/A/170	PEL	Jun 1979	
Screw pitch measuring machine TS166	see note				
Leitz PMM866 measuring machine	see note		PEL		1 year

Note

Calibrations undertaken as and when required, usually when setting up instrumentation. Such calibration may take the form of checks against standards such as gauge blocks or dedicated standards, eg, surface roughness standard for Talysurf.

EQUIPMENT	SERIAL NUMBER	CALIBRATION STATUS	REPORT No. OR CERTIFICATE No.	CALIBRATED BY	DATE LAST CALIBRATION	CALIBRATION INTERVAL
Standard cells enclosure, Guildline (12+12 cells), 9152/12						
Standard cell oven, JRL (3 cells), SCO 106						
Standard cells (4), Eppley, 121						
Pico ampere source, Keithley, 261						
Nanovolt source, Keithley, 260						
DC current source, JRL, DCS 105						
DC voltage reference, PPM, 412 D						
DC power supply, Hewlett Packard, 8268 B						
Current shunt, Guildline, 9211 A						
Direct current comparator potentiometer Guildline, 9930						
DCC potentiometer system, Guildline, 9936						

EQUIPMENT	SERIAL NUMBER	CALIBRATION STATUS	REPORT No. OR CERTIFICATE No.	CALIBRATED BY	DATE LAST CALIBRATION	CALIBRATION INTERVAL
DC voltage calibrator, Fluke, 343 A						
DC voltage/current calibrator, Fluke, 382 A						
Programable constant current/ constant voltage calibrator, Fluke, 3.330 B						
Calibrator, Fluke, 5.100 B						
Meter calibrator, Fluke, 760 A						
Precision digital voltmeter, Guildline, 9577						
Digital voltmeter, Hewlett Packard, 3456 A						
Calibration system, Fluke, 7105 A						
-DC voltage standard, differential voltmeter, null detector, Fluke, 335 A						
-High impedance voltmeter, null detector, Fluke, 845 AR						
-Kelvin-Varley voltage divider, Fluke, 720 A						

EQUIPMENT	SERIAL NUMBER	CALIBRATION STATUS	REPORT No. OR CERTIFICATE No.	CALIBRATED BY	DATE LAST CALIBRATION	CALIBRATION INTERVAL
-Lead compensator, Fluke, 721 A						
-Reference divider, Fluke, 750 A						

2.5 - Equipment Calibration Schedules and Reminders

Each laboratory at CEMCI should keep a record of the calibration history of its instruments, together with some reminder system which indicates when recalibration is normally due. It is often convenient to incorporate the reminder in the equipment inventory as proposed in section 2.4-provided of course that this inventory is updated at regular intervals and not left to gather dust in somebody's desk drawer or filing cabinet!

It must be remembered that no instrument will remain "in calibration" for ever. Instruments in every day use normally require recalibration more frequently than will those used for reference purposes. However, since I am not conversant with the amount of use given to specific items of equipment at CEMCI, no firm rules can be given as to when a particular instrument should be recalibrated.

In general, any instrument which has required repair or routine maintenance should be recalibrated before being put back in service. Sometimes, the performance of an instrument will lead one to suspect its accuracy, in which case it should be recalibrated immediately. So it is always good practice to check that an instrument is operating satisfactorily before its use.

I have a colleague at PEL who, although an excellent research scientist, is extremely naive on matters of calibration and traceability.Last year, he did some work in Antarctica on the properties of sea ice. This work was highly relevant to the operations of the American Deep-Freeze program at McMurdo Sound where they have built a runway for C-130 aircraft on the ice. My friend took with him an uncalibrated thermometer. When he got to Antarctica, he measured the temperature of the ice as +6°C! Clearly impossible. The thermometer had a large zero error which he had not noticed before leaving New Zealand.

Another less amusing story concerns a colleague who calibrated some end bars for an Australian organisation. The accuracy he intended to quote in his report was higher than the certified accuracy of the standards he had used for the measurements. Moreover, those standards had not been calibrated for 12 years. Needless to say, I was able to impress upon him the seriousness of the situation and those standards were recalibrated imr . ately!

Different laboratories within CEMCI will have (or should have) their own programmes for instrument calibration. However, experience indicates that instruments used for measuring mechanical quantities are usually more stable than those for electrical or temperature measurements. So a calibration schedule for various instruments might be as follows (the intervals given are the maximum which should be contemplated):

QUANTITY	INSTRUMENT	RECALIBRATION INTERVAL
Mass	Primary Kilogramme	15 years
"	Reference standards	5 years
"	Working standards	2 years
Force	Elastic proving devices	2 years
Length	End gauges (calibration grade)	4 years
	" " (working grade)	2-4 years (depending on use)
"	Laser interferometer	1 year
Voltage	Standard Cells	3 years
	Digital voltmeters	1 year
Temperature	Thermometers:-Full calibration	1 year
	-ice-point check	before use

2.6 - Limitations on Use of Reference Equipment

Instruments and equipment constituting the primary or reference standards of measurement should be used only to assure the international traceability of secondary or working standards. They should never be used for routine calibrations of clients' measuring instruments.

Since the accuracy of all traceable measurements made within a country depends on the accuracy of the primary and reference standards, the latter should be treated with great care and used as little as possible. Otherwise, there is every chance that their accuracy will be significantly degraded before their next international calibration or intercomparison is due.

However, it should be remembered that it is just as futile to never use those standards as to use them too often. In one country I visited some years ago, its national measurement organisation possessed copies 1 and 2 of the international prototype Kilogramme. Those beautiful platinum-iridium standards had never been removed from their containers during the 80 years they had remained in the organisation. Occasionally, one or other was returned to France for recalibration against the prototype. Instead of using them to calibrate the national reference masses, the organisation regularly purchased sets of secondary standards from Germany and relied on the manufacturer's calibration. Whenever it was decided that a particular set was "out of calibration" (usually every 4 or 5 years), that set was retired and a new set purchased. That organisation sincerely believed that ownership of copies 1 and 2 conferred respectability on its operations!

This example illustrates the wrong way to effect traceability in measurement. Clearly, it is important to restrict the use of reference equipment, but not to ban its use entirely. The procedures developed by LATED illustrate the correct use of such equipment.

For instance, Brazil's volt is defined by means of two sets of standard cells (12 cells in each). One set (the reference) is used only to check the other (working) set. The reference set is itself calibrated against the PTB (FRG) volt via a 4-cell travelling standard. Once again, the only use of the travelling standard is to transfer the volt from PTB to CEMCI.

The working set of 12 cells is used to calibrate other voltage sources and precision potentiometers. LATED's Guildline 9936 potentiometer system is then used to calibrate its 9577 precision DVM which, in turn, is used for calibrating high quality equipment submitted by outside customers.

So it can be seen that there are varying degrees of use given to equipment throughout LATED's voltage measurement "chain". At the top end of the chain (primary and reference standards), use is very restricted, but at the bottom (lower accuracy) end there is more freedom.

In addition to limiting the amount of use given to certain equipment, LATED has defined who should use it. For instance, only the Physicist in charge of LATED is authorised to check the performance of the two sets of cells using the laboratory's Guildline 9930 potentiometer dedicated to that purpose. Again, only one of LATED's technicians has the responsibility to maintain the standard cell enclosures and ovens.

These kinds of procedures illustrate the precautions which must be taken to assure the satisfactory operation of reference equipment. The loan, or other unauthorised use of such equipment must never be contemplated if its continuing accuracy is to be beyond doubt.

Therefore, it is very important that all CEMCI laboratories fully document any restrictions on the use, and the users, of specific items of equipment. This should be done in the appropriate copy of the quality manual. Otherwise, sooner or later, misuse will occur, and the repercussions could be unfortunate for Brazil as a whole.

2.7 - Checks on New and Everyday Equipment

All new equipment should be thoroughly checked over and calibrated on its arrival at CEMCI. In New Zealand, we frequently take possession of equipment which is then found to be faulty. It is unfortunate when the fault is discovered after the guarantee has run out! The calibration is necessary because we have found it unwise to rely on the manufacturer's figures - they have been known to be wrong! It is recommended that CEMCI include some cautionary note to this effect in its quality manual.

I have already stated that the more frequently an instrument is used, the more rapidly it is likely to go out of calibration. Therefore, although recalibration of the reference standards might be at intervals of several years, some working standards may require recalibration every 6 months or sooner. Equipment in daily use should be checked even more often. In fact, it is good practice to check such equipment every time before use.

Such checks should take note of any warm-up time required for the instrument to reach an acceptable level of stability. Depending on the circumstances, it may then require complete or partial calibration, or spot checks according to the manufacturer's instructions (such as range and zero checks and adjustments). A laboratory's experience of its own equipment will enable the appropriate recommendations to be included in the quality manual. The idea here is prevent as far as possible any traps for the unwary!

2.8 - Periodic Maintenance of Equipment

No item of equipment will last for ever. Normally, its "working" life will be limited by the amount of use, but can be extended beyond normal expectations by careful handling and regular maintenance. Thus, routine maintenance of equipment is an essential part of a laboratory's operations, particularly where financial and geographic considerations preclude the rapid replacement of unserviceable items.

In the electrical area, such maintenance might consist of replacing the kerosene in temperature-controlled baths or enclosures, removing oxide layers from terminals, checking printed circuit boards, edge connectors, cord anchorages etc. In temperature measurement, the oil used in high temperature baths will oxidise and need quite frequent replacement; the windings on fixed point furnaces may need attention from time to time; and the metals of the fixed points themselves become contaminated with use.

In the mechanical area, the ever present menace of corrosion of gauge blocks and other steel instruments needs to be prevented by careful cleaning and regreasing. Any burrs or scratches on micrometer anvils will require removal by a mild abrasive. Large items like CEMCI's Zeiss coordinate measuring machine will require an annual check and recalibration of its scales - usually by the firm's representative.

Whatever maintenance is required, it should be documented, along with a timetable for the work. Nothing is more annoying than to find an instrument is unserviceable when needed - especially if the problem could have been solved with a little care and attention at the proper time.

Timetabling enables customer calibrations to be scheduled so as to not conflict with maintenance operations. This improves efficiency, customer relations, and the overall quality of the service. Remember, regular periods of maintenance can prevent the occurrance of major problems which might otherwise result in a complete shut-down of operations.

Each laboratory should detail its maintenance requirements and procedures in its copy of the quality manual.

2.9 - Replacement or Repair of Equipment

Even with the best maintenance procedures, there will be occasions when the replacement or major repair of equipment is necessary. Repair which can be performed "in-house" should be detailed in the quality manual. The real problems arise, however, when an outside agency is called upon to repair or replace unserviceable items

Knowing something of the inadequacy of manufacturers and service agencies in New Zealand, I can appreciate the difficulty in solving such problems in Brazil. Even so, these problems can be minimised by detailing the procedures to be followed in the event of a major breakdown of equipment. Knowing whom to approach for advice is the first step in solving a problem beyond the experience of laboratory staff. Often with the proper advice, the staff can then effect their own repairs.

In the distant past, when I imagined I had some ability for research, I was measuring the dynamic properties of protein monolayers at the air/water interface. Part of my apparatus consisted of an electronic microbalance of 500mg capacity. This developed a rather disturbing fault which manifested itself in the form of severe oscillations of the beam bearing the small weighing pans. Apart from making measurement impossible, the oscillation caused the beam to hit its end stops, and there was a distinct danger of distorting its light aluminium components.

I telephoned the local agent and requested the instrument be checked over. After 3 days of inactivity, I again telephoned the agent only to be told that they had no experience with my type of instrument. So I then telexed the UK manufacturer, described the fault, and requested a solution. The telex was sent one Friday morning, New Zealand time. The reply was sent that same Friday afternoon, UK time. It said "change amplifier A3". The fact that this particular integrated circuit had to be ordered through another agent, and took 2 weeks to be airmailed from the US, in no way detracted from that advice. When A3 was replaced, the problem was solved and the equipment worked perfectly for the next 2 years.

The fact that I had documented that train of events enabled a colleague who continued my work to solve the problem very rapidly when it occurred again.

With certain types of equipment (for example, standard cells and laser tubes), it is possible to predict their useful lifespan. In such cases, this should be documented so that re-ordering can be arranged well in advance of the anticipated demise of the instrument or component. It is always much more convenient to have the replacement waiting on the shelf than to have to cease operations for a time.

Again, the continuity and reliability of your services, together with customer satisfaction, are the reasons for such documentation.

2.10- Precautions Against Damage of Equipment

I have already mentioned (section 1.7) that it is important to take great care of items submitted for calibration or test. Nothing is more embarrassing than to have to return instruments in a worse condition than when they were received. After all, there really is no excuse for careless handling by an organisation committed to good quality management procedures.

Of course, occasional accidents will happen no matter how much care is taken. Sometimes this is simply because somebody has forgotten a trivial detail, such as reading the instructions relating to an item's use. Last year at PEL, we were asked to perform some photometric tests on a very special lamp. When the (usually meticulous) officer went to do the tests, he did not check that the lamp was intended for use at 110 V, and so applied 230 V to it. In trying to dissipate more than 4 times the maximum rated energy, the filament glowed briefly like the mid-day sun before eternal darkness set in!

In such circumstances, broken or damaged items should be replaced wherever possible - even though the laboratory may be under no obligation to do so. This is to preserve both a good QA image and cordial relations with the customer. Therefore, there should be some procedure whereby any associated expenditure can be authorised.

However, it is more important for each laboratory to document its handling procedures so as to minimise the risk of accidental damage to both its own and other people's equipment. For instance, in dimensional metrology, I have already mentioned the need to protect against corrosion of steel samples. Such samples should always be protected with a suitable grease while awaiting test. They should be cleaned with a solvent such as X55 immediately before, and again after, use. Finally they should be regreased or dipped in a rust inhibiting solution before their return to the client.

With sets of masses, these cannot be greased. So they should be stored in the dry environment of the calibration laboratory. This is good practice from the point of view of the calibration itself since if will reduce the "soaking" time required for the masses to come to the temperature of their surroundings. It is obvious that masses must always be handled with tongs or a chamois leather glove to prevent contamination.

Volumetric glassware and liquid-in-glass thermometers always present problems. The fragile nature of instruments like pipettes, hydrometers and pycnometers requires very delicate cleaning and handling procedures. They should always be supported at two points along their length during cleaning, and no undue load should be applied to them during their calibration or use.

With thermometers, breaks can occur in the column. Although gas filling helps minimise column breaks, it also makes it more difficult to rejoin them when they do occur. Conversely, a thermometer with a vacuum space will have its mercury column easily broken, but very easily rejoined. Also with thermometers, the accuracy of the calibration depends to a large part on the way the instrument is handled. The main cause of instability (apart from dropping!) arises from the thermometer bulb. Since this contains about 6000 scale degrees of mercury, and glass is very elastic, small changes in bulb volume can cause significant changes in the calibration. For instance, a volume change of 1 part in 10^5 will cause the calibration to change by 0.05°C.

As illustrated by my example, it is very important in the electrical area to check an instrument's operating conditions (voltage, current, and frequency rating, source impedance etc). Also, that it is protected from moisture and extremes of temperature during any storage, and that it has adequate ventilation during use. Standard cell containers must be stored the correct way up, otherwise the calibration will be worthless. Electronic instruments and components should be protected from stray electrostatic or RF fields. Consequently if any maintenance or circuit modifications are required, these should always be done while wearing an earthing wristband.

Clearly, each laboratory will have a number of handling problems which are unique to a specific field of measurement. These problems and their means of prevention should be documented.

2.11- Laboratory Accommodation

The amount of space allocated to each laboratory should be noted together with details of special facilities like anechoic or reverberation rooms, Faraday cages, environmental chambers etc. The floor plan of each laboratory showing the physical location of equipment and facilities should be included as an appendix. Apart from enabling new staff to familiarise themselves with the accommodation, such details provide essential planning aids when extensions to laboratories and/or facilities are contemplated. As a general rule of thumb, each officer needs a minimum of 25 m^2 of laboratory space (otherwise people bump into each other!) and about 10 m^2 of office accommodation.

In addition to this information, any environmental details should be listed. The following are examples of those for PEL's length standards laboratory:

- Temperature: 20 ± 0.5°C
- Humidity : 50 ± 10% RH

- Dust levels : "Good housekeeping" standards only. Cleanliness provided by filtered and overpressured air, air lock to laboratory, antistatic mats.

- Lighting level: 500 lux

- Water : filtered and deionised, pressure 150 kPa (gauge)

- Power Supply : 400 V 3 phase, 230 V single phase.

2.12- Monitoring of Ambient Conditions

All measurements are affected by changes in ambient temperature, pressure, and humidity. Therefore, it is essential that these parameters be monitored throughout the duration of a measurement -using instruments which are themselves in calibration!

Some years ago, PEL developed a prototype gauge block calibration system based on our HP laser interferometer. For some time we were puzzled over one serious source of error in the results. This was finally tracked down to changes in temperature as small as 1 mK. We therefore concluded that the apparatus was a very sensitive thermometer and that some re-design was necessary!

On another occasion, I was preparing for a mass calibration when I began to feel uncomfortable. A glance at the thermometer showed the room temperature was 28°C. A logic fault had occurred in the temperature control system such that, although it was calling for cool air, the heaters were operating at full power.

CEMCI will have its own procedures for monitoring the environment but the details pertaining to various types of calibration should be noted. For instance, although an instrument of the "thermohygrograph" type is adequate as a rough measure of the temperature and humidity, and provides a complete week of recordings, it is not adequate for precision work. For instance, a thermometer reading to better than 0.01°C is required to monitor temperature during interferometric calibration of gauge blocks. Where a piece of complex measuring equipment is in operation, it may be necessary to monitor the temperature at several points simultaneously using quartz or platinum resistance thermometers coupled to the electronic data processing system.

Remember also, that it is the temperature <u>at the point of measurement</u>, and not that at the other side of the room, which is important. For this reason, whenever one of PEL's officers has to leave any equipment for a while, we replace him/her with a 100 W lamp so that the temperature does not change significantly during that break. This is particularly important during mass calibrations where the operator is often close to the balance and acts as a reasonably efficient radiator!

Of course, the same kind of "hyperfine" variations do not occur with pressure or humidity. So a central measuring point for those parameters is usually sufficient.

2.13- Staff Lists

Having documented the various general and technical procedures which constitute the quality manual (and, by now, wishing you had never started!), there remains one final task before the document can be considered complete. That is a list of present staff in a particular area of measurement. This serves two purposes. It is an essential aid to staff evaluation, and it also provides a useful guide as to the qualities to be looked for in potential members of staff.

The biographical details can be quite short, and I have developed a list for the staff of the electrical group by way of example:

- <u>Electrical Measurements Group</u>

Chief:	Sebastião	(physicist): BS, PTB (FRG) training (6 months), 25 years metrology experience.
LATED:	Vinge	(physicist): BS, post graduate course in general metrology (1 year), PTB (FRG) training (1 year), 10 years metrology experience.
	Victor	(technician): electronics, 5 years metrology experience.

	Luis	(technician): BE, 5 years metrology experience.
LACAP:	Mauro	(physicist and electronics engineer): BS, BE, post graduate course in general metrology (1 year), PTB (FRG) training (15 months), 10 years metrology experience.
	Dulce	(physicist): BS, post graduate course in general metrology (part-complete), 5 years metrology experience.
LARES:	Macoto	(physicist): BS, post graduate course in general metrology (1 year), LCIE (France) training (1 year), 10 years metrology experience.
	Angelica	(technician): 3 year diploma in digital electronics, will have training at LCIE in 1987 (6 months), 12 years metrology experience.
	Ricardo	(technician): electronics, studying for BE in electronic engineering, 5 years metrology experience.
	Janice	(technician): electronics, studying for BS in physics, 2 years metrology experience.
LATEA:	Joana	(electronic engineer): BE, post graduate course in general metrology (1 year), ETL (Japan) training (6 months), studying for ME, 12 years experience.
	Edson	(physicist and electronics technician): BS, 3 years experience at CEPEL, 2 years metrology experience.
LATRA:	Walmir	(physicist): BS, post graduate course in general metrology (1 year), PTB (FRG) training (1 year), 11 years metrology experience.

LAENE: Ivan (technical officer): 3 year electronics diploma, Landsgyr (Switzerland) training (2 months), 13 years metrology experience.

Roberto (technician): electronics, studying for BE in electronic engineering, 2 years metrology experience.

Paulo (technician): electrical, studying for BS in physics, 8 years metrology experience.

Amaral (technical assistant): electrical, ex-driver at INMETRO, 3 years metrology experience.

Consultant: Isabel (physicist): BS, training at NPL (UK) NBS (USA) and PTB (FRG), retired chief of electrical group, 30 years metrology experience.

As for the job descriptions (section 2.2), it is suggested each staff member supply his/her own biographical details to supplement these summaries.

CONCLUDING REMARKS

It is clear from the contents of this document that there is nothing highly technical or innovative about a quality manual. Most of the information will be obvious to all who read it. Many will realise they have been performing the various operations for years (albeit, perhaps unconsciously). The important things to remember with any quality assurance operation are:

a) Nothing should be left to chance,

b) Everything should be performed the same way on each occasion.

If the documented procedures in the CEMCI quality manual are complete and correct, and the staff adhere to them 100% of the time, a high quality operation is assured. Being a very imperfect "expert", I am sure there are aspects of CEMCI's operations which I have omitted to cover. The staff will be in a better position than I to determine what these are, and to include them in the manual.

The term "quality assurance" is accepted world w as being synonymous with reliability. The success of Japan's industries is due entirely to their very effective quality assurance procedures. The purchaser of goods and services is no longer satisfied with having faults fixed under guarantee, and will always look for the supplier most likely to provide the quality in the first place.

Because of this, the so-called consultants in quality management sustems are in great demand at the present time. But there is nothing they might propose which is other than common sense. It can be argued that the main purpose of such consultants is to open management's eyes and to teach it how to think!

Therefore, it is open to debate whether such consultants are really worth the high fees they can command. After all, even Duran and Demming built up their impressive reputations by advocating procedures which they had found successful in their own operations. So it is worth remembering that anyone can do it, given the will to do so. I wish CEMCI every success in this task.

ACKNOWLEDGEMENTS

I am grateful to CEMCI director Dr. Alexandre and his staff for transforming an anticipated difficult task into a most pleasurable and satisfying one. My particular thanks must go to Graça for her incredibly accurate typing of the manuscript from my incomprehensible notes. That there were so few breakdowns in communication says much for her tranquility, and her patience with my difficult English and almost non-existent Portuguese.

Comments on the Study Report:

DISSEMINATION OF TIME AND STANDARD FREQUENCIES IN BRAZIL

Dr. J. H. Buckingham
UNIDO Consultant in National Calibration Services

13 August 1986

1 - As it stands, the report is based on the premise that there are potential users of time and frequency information of higher accuracy than is currently available. This may be correct but, unfortunately, there is no information in the report which demonstrates that such a need for higher accuracy and better coverage exists. The report will stand or fall on this point.

2 - The following questions need to be addressed:

- Are the "potential users" referred to in the report likely to eventuate? That is, has there been an actual survey of the needs of "real" and "potential" users?

- How many existing users are dissatisfied with the present accuracy of dissemination?

- Would actual and potential users be prepared to contribute to the annual operating cost of the proposed installation at Brasilia? Does this estimated cost include the salaries of all staff required to man the station?

- Has the cost of ongoing maintenance and replacement of equipment been allowed for in the estimates?

- Is it considered likely that users (and potential users) requiring the highest accuracy would establish operations in areas of poor radio reception? If they were unwise enough to do so, presumably they would maintain their own caesium or rubidium vapour standards which are more accurate than broadcast frequencies.

3 - If satisfactory answers to the above questions can be obtained, then the proposal to establish the Brasilia station is probably

reasonable. From my limited experience of time and frequency measurements, the technical content of the report appears quite satisfactory. However, perhaps more emphasis could be placed on extending existing calibration services for frequency generating and measuring equipment.

4 - I agree that the accessibility of certain space platforms can be a problem. However with GPS, for example, receivers are readily available at a cost of about US$ 30,000 each. I understand also that the United States Naval Observatory (USNO) is prepared to make available the GPS receiver design data to many organisations wishing to construct their own.

5 - Brazil's present methods of disseminating standard time and frequency appear identical with, but more developed than, those of New Zealand.

MEASUREMENT TRACEABILITY IN BRAZIL: FIRST IMPRESSIONS

Dr. J.H. Buckingham
UNIDO Consultant in National Calibration Services

06 August 1986

SUMMARY

This report to UNIDO/UNDP represents my initial impressions of Brazil's measurement infrastructure after the first 10 days of my assignment with the National Institute of Metrology, Standardization, and Industrial Quality (INMETRO). It details the present method of assuring the accuracy of the national standards of measurement maintained by the Centre for Scientific and Industrial Metrology (CEMCI) at Xerém. It cautions against the introduction of research programmes in state-of-the-art metrology, but suggests developmental work which may be necessary to cope with an increasing number of calibration requests received by CEMCI. It comments on the desirability of developing a quality manual covering CEMCI's operations and concludes with a recommendation that all branches of INMETRO arrange traceability to the national standards of measurement. Appended to this report are my comments on 2 papers about metrology in Brazil which were written by Dr. K.G. Kessler of the United States' National Bureau of Standards.

INTRODUCTION

Measurement traceability is a process whereby the accuracy of a measuring instrument is assures through a hierarchy of calibrations against acceptable standards of measurement. It is the first step in the process of industrial quality assurance, and is as important for consumer protection as it is for the economic health of a nation.

Brazil became a signatory of the "Convention du Mètre" in 1875. Since then, her measurement infrastructure has envolved with the intention that all industrial and scientific measurements made in Brazil be traceable to the national standards of measurement. Currently CEMCI has responsibility for maintaining the standards for all physical quantities except time interval and ionizing radiation.

I understand that, at present, very few laboratories throughout Brazil can claim that the measurements they make are traceable to the national standards. These laboratories form the core of a National Calibration Network (RNC), which is organised by CEMCI. A similar network covering those laboratories concerned with industrial product testing is in the process of being implemented. I have been advised that an Australian expert is due to arrive during August, and that he will assist in developing this scheme. I anticipate that he and I will be working together to introduce laboratory accreditation procedures for testing organisations.

As far as I am aware, there is as yet no formal requirement that the reference standards of Brazil's legal metrology system be traceable to the national standards of measurement. I hope to be able to demonstrate the desirability of such an arrangement during the course of my assignment.

Traceability of Measurement Standards

Kessler (1985) considers that Brazil is an industrialized, not a developing, country. I agree. Brazil's present level of industrialization is similar to, and in some areas greater than, that of Australia or New Zealand. Consequently, the international traceability of industrial measurements is necessarv if Brazilian products are to have access to world markets. This is particularly so in cases where Brazilian firms might undertake contract work on behalf of overseas companies. Only by means of international traceability can it be ensured that components made in different countries fit when they meet for assembly.

CEMCI has gone about achieving such traceability for its operations in an eminently sensible manner. The regular calibration of Brazil's national standards by overseas organisations, like the US National Bureau of Standards and Germany's Physikalisch Technische Bundesanstalt, ensures their continued accuracy.

Until Brazil's industries develop to the point where they are in competition with overseas firms in very "high tech" areas (such as aerospace, or advanced electronics and communications), there appears to be no need to establish "absolute" standards, which are of the highest possible accuracy and independent of overseas calibration. Any proposal to establish such standards in Brazil should be viewed with great caution. Providing the accuracy of a standard is sufficient to ensure a required level of accuracy in measurements at the work face, the method by which this is achieved is largely irrelevant.

In most cases, the ultimate accuracy of these absolute standards is far greater than that necessary to assure the quality of industrial measurements in even the most industrialized of nations. That such standards have been developed at all has been due partly to a desire to advance the science of measurement for its own sake, partly to intellectually challenge the more innovative of standards scientists, and partly to enhance the international reputation of their parent organisations. Only in a few instances is calibration against these new devices more convenient than by traditional methods. For instance it is simpler to calibrate a laser measurement system by means of a stabilised laser than by using end-, or line-standards. In general, however, it would be true to say that few of the recent advances in standards science have been because of demands from industry for greater accuracy.

Consequently, a very careful cost-benefit analysis should be undertaken before Brazil considers embarking on such research activities.

Of greater importance at the present time is the need to arrange traceable calibration of all the secondary standards of measurement deployed throughout Brazil. Since this will mean an ever increasing work load for CEMCI, that organisation could profit from the current trend towards automation in measurement techniques. Not only does automation speed up the calibration process and make working conditions more tolerable for the calibration staff, but also it frequently removes the greatest potential source of error in the measurement - man himself.

For example, in my own laboratory, my staff have automated their technique for calibrating linear scales (Hurst and Sutton, 1982). Our laser measurement system is now under computer control, and can calibrate all divisions on a scale in under 2 minutes. It used to take an observer several hours to calibrate only 10% of those divisions. Thus, throughput is increased, staff no longer suffer from eyestrain and, because the computer also prints the calibration certificate, there is no possibility of transcription errors.

One further advantage of developmental work of this nature is that it (like work on basic standards) is intellectually challenging. Therefore, it contributes to the retention of the brightest staff, who otherwise might be tempted to seek employment elsewhere. Such activities could increase the attraction of working at CEMCI, while, at the same time, being inherently useful to the centre's operations.

Quality Manuals

One of the main terms of reference of my assignment is to assist with the preparation of a quality manual for CEMCI. Such a manual is an integral part of any reliable calibration activity. However, it must be stressed that the manual must detail the system which works for CEMCI. There is little point in an outside "expert" attempting to impose procedures familiar to him if these are inappropriate to CEMCI's operations.

The case for quality manuals is being promoted in many countries since it is considered that such a manual is a guarantee of the quality of a process. Nothing could be further from the truth! Given that the manual is correct, and appropriate to the operation in hand, it can only achive the desired result if staff adhere to it 100% of the time. Therefore, if the scientists and technicians who perform the calibrations are to fully support the manual, they must be consulted at every step in its preparation. A system which is imposed on staff by an insensitive or autocratic management is doomed to failure.

Also, the preparation of a quality manual is a laborious and complex process, involving all concerned in a great deal of work. So it is important to ensure as far as possible that the first draft is not too different from the final version. This requires careful planning.

My own organisation is well aware of this and, only now, is it commencing work on a document which details its overall activities. So far, individual sections of my laboratory have developed quality manuals covering their own specialised fields of calibration. Two examples will be passed to CEMCI's director, Dr. Alexandre Sette Camara. I stress that they are intended as illustrations only, and should not be construed as ideal formats for CEMCI's operations. At best, they will serve to indicate the type and range of information that quality manuals should contain.

In general, a quality manual should detail such things as:

- the measurements, calibrations, or tests which are within the competence of a laboratory,
- distribution of staff throughout the laboratory and/or its sections,
- responsibilities, qualifications, and experience of staff,
- plans of the laboratory and its facilities,
- "housekeeping" procedures,
- the humidity and temperature control essential for the satisfactory operation of the laboratory,
- the equipment which is available,
- procedures for care and maintenance of the equipment,
- the calibration history of the equipment and the recalibration timetable,

- procedures for checking, recording and reporting of measuremen results,
- procedures for maintaining confidentiality of work done for clients,

as well as the detailed procedures for performing the measurements an working out the results. Examples of some of the measurement procedur used in my laboratory will also be passed to the director of CEMCI.

Traceable Measurements Throughout INMETRO

In order for a traceable measurement system to be completely effectiv the organisations which promote the system must themselves adhere to it. In other words, it is important that they be seen to lead by example. Hence, CEMCI has recognised the need for a quality manual covering the services it performs for customers from INMETRO, other government departments, and industry.

The other elements of INMETRO, namely the directorates for legal metrology (DIMEL), standardization (DINOR). and industrial quality control (DQUAI), all make use of CEMCI's calibration and testing services - either directly, or by customer referral. Although, at present, there is no formal requirement that all measurements associated with the operations of DIMEL etc. be traceable to the national standards, the value of procedures advocated by Internationa Organisation of Legal Metrology (OIML) is generally recognised.

For example, DIMEL relies on CEMCI for type approval of many of the weighing and metering devices used in commerce. However, this excellent procedure will be largely negated unless there is some kind of follow-up activity to ensure the continuing accuracy of those devices. Naturally, such activity would need to be undertaken using measuring instruments which were themselves traceable to the national standards.

According to an IBQN report (1985), no office of the legal metrology network has ever sent its mass standards to CEMCI for calibration. Consequently there is no guarantee that the weights and measures used in one state conform with those used in another. A regular calibratio programme for the local standards of those weights and measures would overcome this problem.

It is recognised that a formal calibration programme for all the standards used in the legal metrology network would be beyond the present resources of CEMCI. Hence, to overcome this traceability problem for commercial weights and measures, some consideration might be given to the possibility of DIMEL staff undertaking some of the associated calibration work at CEMCI. I understand this is already done in some type approval testing. Alternatively, DIMEL might consider the establishment of its own reference laboratory under the guidance of CEMCI. In this case only DIMEL's reference weights and measures would need to be calibrated by CEMCI. DIMEL staff could then undertake the calibration of the various States' measurement standards against those reference standards.

With regard to the activities of DINOR, there appears to be some overlap between its responsibilities and that of the Brazilian Association for Technical Standards. At the time of writing, I am unable to appreciate the differences between these two organisations. However, it is self-evident that any tests performed to a written specification should be with equipment which is in calibration. If not then there is every possibility that the test, or the product being tested, will not conform to that specification.

Finally, one of DQUAI's prime responsibilities will be accreditation of laboratories and inspection agents in the area of industrial produc testing. If Brazil follows an accreditation programme which is simila to those operating overseas, then accreditation should not be granted unless the applicant laboratory has established traceability for its measuring equipment back to the national standards. Presumably this will be either by calibration at CEMCI directly or at one of the laboratories of the National Calibration Network (RNC).

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O SISTEMA DE CALIBRAÇÃO EM NOVA ZELÂNDIA

Dr. J. H. Buckingham
Perito da UNIDO, INMETRO/CEMCI

Eu gostaria de falar sobre o Sistema de Calibração da Nova Zelândia para garantia da qualidade de medições.

O Sistema da Nova Zelândia é paralelo ao Sistema Australiano. Espero poder comparar este Sistema com o do Brasil.

Na Nova Zelândia, o principal laboratório é o Laboratório de Física e Engenharia (PEL) do Departamento de Pesquisa Científica e Industrial (DSIR).

O PEL é responsável pelos padrões nacionais.

As rastreabilidades internacionais são feitas através do Bureau Internacional de Pesos e Medidas (BIPM) em Sèvres, próximo de Paris, França. O BIPM é o Laboratório dos padrões internacionais de grandezas físicas de:

1) Comprimento (metro)
2) Massa (protótipo do quilograma)
3) Tempo (segundo)
4) Corrente Elétrica (ampére)
5) Temperatura Termodinâmica (kelvin)
6) Quantidade da Substância (mol)
7) Intensidade da luz (candela)

Na Nova Zelândia, esta rastreabilidade é obtida através de materiais de referência e fenômenos de física fundamental. Por exemplo, o metro é obtido através da velocidade da luz (c) e uma freqüência óptica. Similarmente, o volt é obtido através do efeito de Josephson; o farad, através do Teorema de Thompson e Lampard; o kelvin através do ponto

tríplice da água; o segundo, através de três relógios de Cesio; e
candela, através da radiometria absoluta. Somente o quilograma dev
ser calibrado contra o protótipo internacional do BIPM.

Abaixo do PEL (conforme diagrama 1), temos os laboratórios credenc
ados do TELARC (Conselho para Registro de Laboratórios de Ensaios) o
quais deverão estabelecer rastreabilidade aos padrões nacionais.
TELARC é equivalente ao NATA (Associação Nacional das Autoridades e
Ensaios) na Austrália.

Esta rastreabilidade é uma garantia da qualidade dos instrumentos d
medições para ensaios industriais, ensaios em medicina, pesquisas c
entíficas, agricultura, horticultura, sistemas de transportes, prod
ção da energia, defesa militar, etc.

Uma outra parte do sistema de calibração na Nova Zelândia garante
qualidade da rede de metrologia legal. Todas as medições comerciai
deverão ter rastreabilidade aos padrões nacionais. Isto garante a qu
lidade dos pesos e medidas de lojas, bombas de gasolina, taxímetros
medidores de energia elétrica, etc.

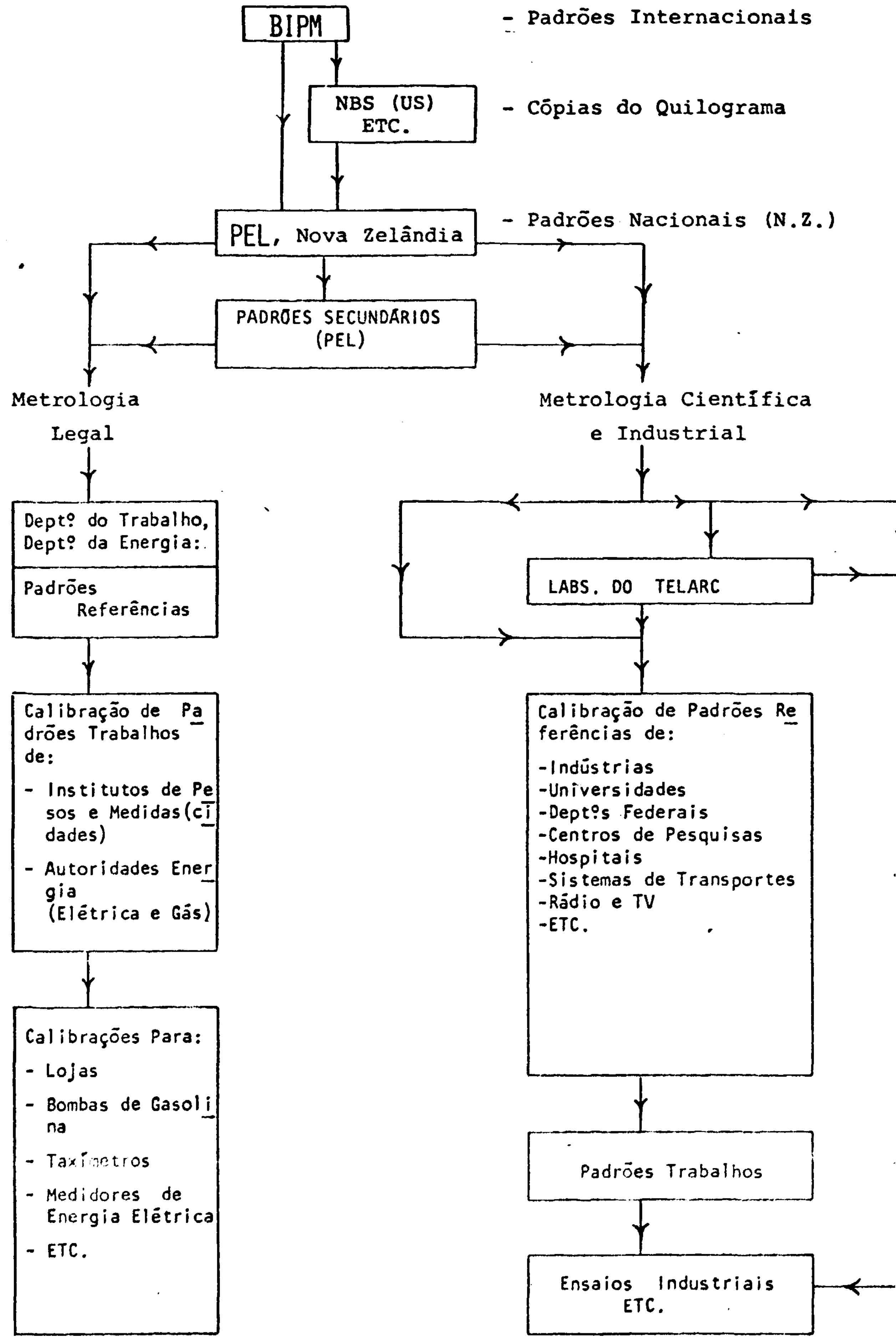
Na Nova Zelândia, os padrões nacionais são "absolutos", com exceçã
da massa. Mas não é importante estabelecer padrões absolutos.

No Brasil, a calibração internacional dos padrões nacionais é sufic
ente para uma garantia da rastreabilidade. Mas, é muito important
que as medições no Brasil sejam rastreadas aos padrões nacionais!

Hoje, no Brasil, pouquíssimos instrumentos de medidas da indústria
da rede de metrologia legal estão calibrados! Esta calibração dev
estar rastreada aos padrões do INMETRO/CEMCI.

Quando estas rastreabilidades para todas as medições forem realizada
no Brasil, a qualidade das medições será melhor. Isto é muito impo
tante para a economia; para a exportação; para a substituição de i
portações; e para o bem-estar das pessoas.

DIAGRAMA 1: O SISTEMA DE CALIBRAÇÃO EM NOVA ZELÂNDIA



COMMENTS ON PAPERS PREPARED BY DR. K.G.KESSLER, NBS (USA)

a) Metrology support in Brazil (january, 1984).
b) An evaluation of CEMCI (september, 1985)

By Dr. J.H. Buckingham,
UNIDO Consultant in National Calibration Services, 28 july 1986.

a) Metrology Support in Brazil

1. Kessler states that the Brazilian measurement system must have four goals:

1.1-Its calibration services must enable uniformity of manufactured products and assure their quality.
I agree. This is essential in any modern industrial operation.

1.2-It must ensure compatibility between Brazilian and overseas products.
I agree. This is obvious if Brazilian products are to compete successfully in international markets. Such compatibility is essential in cases where Brazilian firms undertake sub-contract work for overseas companies.

1.3-Brazil's central measurement laboratory needs to develop new measurement techniques by exploiting modern technology.
I partly agree. Brazil does not need to develop new measurement techniques *per se*. It is sufficient to adopt, or adapt, those techniques which are required to satisfy the needs of Brazil's industries.

1.4-The central measurement laboratory should undertake basic research in metrology.
I disagree. State-of-the-art research in measurement science is best left to overseas institutions like NBS (USA), NPL (UK), PTB (FRG), etc. Research on the so-called "absolute" standards of measurement and on fundamental physical constants is not required in Brazil at the present time, or is it likely to be in the foreseeable future.
Such research is very expensive and requires highly qualified

Personnel. From my experience of some countries in the Asia/ Pacific region, whose industrial development is similar to that of Brazil, such research is neither well done, nor does it contribute greatly to the measurement infrastructure required by their industries. In my own institute (PEL, New Zealand), it is debatable whether our research in measurement standards has had any effect on the quality of New Zealand products. Moreover, if proposals to commence such research were made now, they would be unlikely to obtain support from the New Zealand Government. This research was commenced when our economy was buoyant. At the present time, it is a luxury which New Zealand cannot really afford.

Consequently, I believe that Brazil cannot, and should not, attempt to encourage research aimed at giving the central laboratory an international reputation in measurement science. Any funding from the World Bank, or elsewhere, would be better spent on the provision of facilities, personnel, and equipment to support those calibration and testing services essential for continued industrial growth.

If any research is undertaken, it should be to improve those services, or to solve problems associated with industrial products or processes. Such research would contribute to the intellectual environment of the central measurement laboratory. This, in turn, would assist the recruitment and retention of good scientific staff.

2. Kessler states that the Brazilian infrastructure required to achieve the goals 1.1.-1.4 should include the following:

2.1-An effective tie to international measurement standards.
I agree. However, it is sufficient for Brazil to maintain this tie via overseas calibration of her primary measurement standards and by participation in "round-robin" intercomparison experiment The latter have the additional advantage that they

help to demonstrate any deficiencies in calibration and measurement procedures.

2.2-Brazil must have a single laboratory coordinating the country's calibration services.

I agree. Those services should be always "traceable" to the primary standards of measurement. This applies as much to the calibration service of the legal metrology network as it does to those of industry.

2.3-Measurements requiring the highest accuracy should be performed in the central measurement laboratory.

I agree. Problems of uniformity can arise where more than one institution attempts this task.

2.4-The central measurement laboratory must coordinate the calibration base of all secondary laboratories.

I agree. My comments in paras 2.2. and 2.3. apply.

2.5-The central laboratory must be familiar with new international developments in metrology.

I agree. However, the emphasis should be on an awareness of, rather than expertise in, such developments. In other words, the central laboratory should first rely on overseas expertise as much as possible.

2.6-Industry must have access to well equipped and competently operated secondary measurement laboratories.

I agree strongly. Without this infrastructure, Brazil's industries cannot hope to compete on equal terms with overseas companies. Also, reliable secondary laboratories are needed to take some of the calibration load from the central laboratory. Otherwise, the time will come when the central laboratory will be unable to keep pace with the demand for its services.

3. Kessler has discussed the present status of Brazil's measurement system. I cannot comment on all his findings since I have as yet no first hand experience of the measurement infrastructure existing in the country. From my limited experience I would have to agree that the central laboratory, CEMCI, is somewhat understaffed at the present time. However, I understand that attempts are being made to rectify this problem, together with those associated with facilities and equipment.

Kessler states that there is an urgent need for CEMCI to recruit staff at Ph.D. level. Unfortunately, he tends to equate the attainment of a Ph.D with technical competence and innovative ability. Certainly, this is true in some cases. However, from my experience, most Ph.D. holders take just as long to train in the art of accurate measurement as do staff at graduate level. Some of the most reliable and innovative staff in my own institution are those I have recruited at graduate level.

In addition, there is a problem of retaining overqualified staff in that the work environment may not necessarily provide sufficient stimulation - at least for a number of years. Again, Ph.D. level recruitment could lead to CEMCI becoming too academic and "remote" from its industrial customers. It is worth bearing mind that a number of the world's major standards laboratories have tended to become too "ivory towered". This has resulted in the trauma of cutbacks in their support by governments concerned at the lack of relevance of the work to the measurement problem facing commerce and industry. I cannot emphasize too strongly that a national measurement laboratory should exist to serve the needs of its customers, not vice versa!

I understand that a World Bank loan for upgrading the operations at CEMCI was negotiated some time ago, but that this loan is conditional on the recruitment of a number of Ph.D. qualified staff. I regard this condition as a little unfortunate. It shoul not be the intention to develop CEMCI in the image of an oversea national measurement laboratory. Rather, CEMCI must be what is needed by Brazil and her industries.

It is important to differentiate between what is essential for a country, and what may be considered "desirable" in overseas eyes. Unfortunately, the latter often look first to the situation in their own countries, and believe sincerely that what works well for them must work well everywhere. This is seldom the case in reality. Consequently, there have been some institutions established overseas which have been subsequently of little relevance to the problems facing the industries they were set up to serve. This has been accompanied by a stagnation of the academically overqualified staff of those institutions.

Therefore, I believe that the staffing condition of the loan should be relaxed to one which requires professional recruitment from candidates who, first and foremost, have a definite interest in, and a potential aptitude for, high quality measurement and calibration work. That some of these may be Ph.D. qualified should be incidental to, and not a prerequisite for, any consideration for appointment at CEMCI.

However, it might be worth examining the possibility of arranging Ph.D. students to undertake their practical work at CEMCI. This scheme works well overseas in that the student's experimental program is arranged to be of relevance to the host institution, rather than just of prime interest to the University Supervisor. In addition to their Ph.D. studies, such students could be encouraged to take an active part in the normal work at CEMCI. This would not only provide experience in measurement techniques but would also enable those students to decide whether they would be interested in employment at CEMCI at the conclusion of their studies. In addition, such a scheme could help foster an increased research "atmosphere" at CEMCI.

4. I am in broad agreement with Kessler's other comments regarding staff training, further academic study for existing staff, and attendance at overseas conferences and institutions. I also agree with his very constructive comments regarding equipment maintenance. In addition, I suggest some capacity for glassworking would be an advantage, and would complement the mechanical machine shop and the proposed electronics equipment repair facility.

My initial impression of CEMCI's existing equipment is that, with some exceptions, it is reasonably adequate. I too would question the proposed level of funding for new equipment. In my own institution, such funding would represent purchases extending over 20 years or more. Also, there is little point in purchasing large amounts of new equipment if there are no staff available to operate it. Staff recruitment and training must be the first consideration. At this stage in its operations, I do not believe CEMCI needs to have a capability for the design of prototype measuring equipment.

Granted that the Xerém site is rather remote from Rio de Janeiro (although no more so than, say, NPL is from central London) it does have the advantage that there are fewer problems in maintaining a clean environment. Once the move to the new accommodation is complete, CEMCI will have excellent metrological facilities.

b) An Evaluation of CEMCI

I have already commented that I doubt that CEMCI needs to establish absolute standards for the base units of the International System (S.I.). With regard to some of Kessler's specific points:

1. His statement that CEMCI possesses only two standard cells is incorrect. Brazil's volt is defined by two sets totalling 24 cells in all. These could be complemented with the purchase of a Guildline Transvolt and/or a Cropico electronic cell to facilitate overseas calibrations and intercomparisons. A voltage standard based on the a.c. Josephson Effect is not necessary, any more than is a calculable capacitor of the Thompson-Lampard type for defining impedance standards. With regard to the "Von Klitzing", or quantized Hall Effect, NPL (UK) has been working on the apparatus for a number of years and has yet to realize the ohm in this manner!

2. The recent re-definition of the metre in terms of the veloci[illegible] of light and an optical frequency has, to my knowledge, not negated the use of secondary standards such as [illegible]tain spectral

lines of Hg^{198} and Cd^{114}. The wavelenghts of these lines are known to parts in 10^8, which is more than adequate for interferometric calibration of gauge blocks. Line standards can be calibrated by laser interferometry to better than 1 part in 10^6. Only if higher accuracy is required should the laser interferometer be calibrated using an iodine - or methane-stabilized laser. A Moore table and photoelectric auto--collimators can define angle to better than 0,5 arc sec.

3. There is a need to establish certain IPTS fixed points at CEMCI to facilitate the calibration of resistance thermometers. Some capacity for spectrophotometry is also required to assure colorimetric standards required by industry. However, light intensity standards can be realized via overseas-calibrated lamps. There is no necessity to establish an absolute electrically calibrated radiometer at CEMCI.

LABORATORY ACCREDITATION IN BRAZIL

Dr. J.H. Buckingham
UNIDO Consultant in National Calibration Services
INMETRO/CEMCI, Xerém-RJ, Brasil

October 1986

SUMMARY

This report discusses the present situation pertaining to laboratory accreditation schemes in Brazil, and how these might develop in the future. It makes a number of recommendations which are intended to supplement those contained in a more detailed report by Mr. A.J. Russell, UNIDO consultant in laboratory accreditation systems.

LABORATORY ACCREDITATION IN BRAZIL

RECOMMENDATIONS

This discussion of laboratory accreditation in Brazil includes a number of recommendations. These are summarised below:

1. That RNC and RNLE activities be coordinated by a single authority, Rede Nacional de Laboratórios, RNL.

2. That RNL concentrate initially on 1 or 2 fields of testing vital to Brazil's economy.

3. That RNL concentrate on the quality, rather than quantity, of potentially accreditable laboratories.

4. That RNL recruit the services of advisers and laboratory assessors from institutions outside of INMETRO.

5. That these advisers develop detailed criteria for accreditation and procedures for laboratory assessment.

6. That RNL seek a significant increase in government funds to support an enlarged secretariat.

7. That RNL maintain close ties with CEMCI.

8. That INMETRO publicise CEMCI and encourage Brazilian industry to use CEMCI calibration services in preference to those of overseas institutions.

9. That INMETRO advertise the aims and activities of RNL.

10. That RNL fully investigate several overseas accreditation schemes before deciding on the system most suited to Brazil.

11. That RNC and RNLE staff visit NAMAS, NVLAP, NATA and TELARC to observe their operations.

LABORATORY ACCREDITATION IN BRAZIL

CONTENTS

INTRODUCTION

Brazil has established a national calibration network (Rede Nacional de Calibração-RNC), which is organised by INMETRO/CEMCI (Centro de Metrologia Científica e Industrial) at Xerém-RJ. Currently, INMETRO is in the process of setting up a corresponding system for industrial product testing. Plans for this system (Rede Nacional de Laboratórics Ensaios-RNLE) have been developed by INMETRO's Directorate for Industrial Quality Assurance (DQUAI) in close association with the RNC secretariat at CEMCI.

A recent proposal by INMETRO is that RNC and RNLE should come under a single accreditation authority (Rede Nacional de Laboratórios-RNL), whose function would be to coordinate calibration and testing activities throughout Brazil. RNL would be responsible for assuring the quality and reliability of all services provided by the member laboratories of RNC and RNLE.

Thus, RNL would be similar to the National Association of Testing Authorities (NATA) in Australia, and the Testing Laboratories Registration Council (TELARC) in New Zealand. A similar arrangement occurred recently in Britain(1) when NAMAS, the National Measurement Accreditation Service, was formed by merging the British Calibration Service (BCS) and the National Testing Laboratory Accreditation Scheme (NATLAS).

The detailed proposals for a Brazilian laboratory accreditation scheme are currently being prepared by Mr. A.J. Russell, a UNIDO consultant from the Australian NATA organisation(2). Therefore, the present document will not include a lengthy discussion of accreditation procedures. Suffice it to say that NATA was the first full laboratory accreditation system in the World, and that TELARC (New Zealand) was the second. The procedures of these organisations are very similar.

This report examines the present situation with regard to RNC and RNLE, together with the strengths and weaknesses of some the accredited and potentially accreditable laboratories of both systems. It discusses the implications of laboratory accreditation in general, the methods of operation of accreditation schemes, the resources that are required, and how existing schemes in Brazil might be combined and coordinated.

It makes a number of suggestions for the successful promotion and enhancement of laboratory accreditation in Brazil, and describes the potential advantages to the economy and to the general well-being of the people.

THE PRESENT SITUATION IN BRAZIL

INMETRO staff have worked very hard to establish the RNC and RNLE schemes, and have achieved a great deal in a relatively short time. Much of the documentation needed to operate these schemes has already been produced, as has that for the proposed RNL system. CEMCI and DQUAI are to be congratulated on introducing laboratory accreditation to Brazil rather more quickly than was possible in either Australia or New Zealand.

However, the secretariats of both RNC and RNLE would be the first to agree that their schemes are still in their infancy and that much work remains to be done. The production of documentation for an organisation is always easier than the implementation of its procedures. In other words, one always knows what to do. The hard part is to actually do it! For instance, the resources required are always greater than originally envisaged. Also, with laboratory accreditation a great deal of promotional activity is required to convince the calibration and testing community that it should invest in something which is going to cost it money! Then there are all the educational and training aspects to be considered - not only for the secretariat staff but also for the staff of potentially accreditable laboratories.

Consequently, although RNC and RNLE schemes are envisaged as embracing all aspects of calibration and testing, it is wise to stop short of the ideal and concentrate on what can be achieved in practice. It is better to have a scheme involving a small number of competent and reliable laboratories, rather than one which is less selective, less able to guarantee the quality of its services, and, hence, unlikely to gain recognition and respect. If a high quality operation is established at the outset, it will gain momentum and grow, provided its resources grow at the same rate. Conversely, an ill-conceived, low quality operation will be short lived. It will not attract the necessary resources, and all the excellent preparatory work will have been for nothing.

Currently, RNC consists of 7 laboratories, 2 of which are directly sub-contracted to CENCI to maintain the national standards of time and ionizing radiation. Of the other 5, 2 are accredited for length metrology, 2 for electrical, and 1 for aerophotogrammetry and camera calibrations. In addition, there are 11 potentially accreditable laboratories: 5 for length, 5 for pressure, and 1 for electrical. With its small full time staff (3 professional and 2 secretarial). RNC is already under a heavy work load, and, at present, would find the assessment(and reassessment) of some 18 laboratories a daunting task.

Apart from arranging laboratory assessments RNC staff organise measurement intercomparisons (proficiency testing) among the member laboratories. The work involved in this and in subsequent analyses of results is not inconsiderable. Remember, there are only 24 hours in a day!

As I understand it, the situation with RNLE staff is similar. Currently, it has 12 accredited laboratories spread among a number of fields of testing (chemical, health, food, etc). In addition, DQUAI staff conduct a product quality certification program and are called upon to "trouble shoot" when problems occur in production processes. For instance, one officer is currently involved in an investigation into the cause of contaminated blood intended for transfusion purposes.

Clearly, there is a danger that the resources of both RNC and RNLE will become too thinly spread to be effective if steps are not taken to limit activities or, alternatively, to increase staff numbers in the near future.

So far, I have visited very few calibration and testing laboratories(; and therefore am not in a position to gain an overall picture of the reliability or effectiveness of the services performed by the accredited laboratories of RNC and RNLE. It would be fair to say that some problems exist in all the installations I have visited, especially as far as measurement traceability and the determination of uncertainties are concerned. These are due partly to the inexperience of some laboratory staff, partly to a lack of appreciati of the services CEMCI can perform, and partly to an absence of certain facilities and experience within CEMCI itself. However, I should point out that similar problems existed in Australia and New Zealand for many years (and, in some cases, still exist!)

On the positive side, I have detected an attitude of enthusiasm and a willingness to learn wherever I have visited in Brazil. This applies equally to CEMCI, DQUAI, and the accredited (and potentially accreditable) laboratories. This suggests that most of the present "teething" problems with the RNC and RNLE schemes will be overcome in time.

THE IMPLICATIONS OF LABORATORY ACCREDITATION

In recent years, there has been a large number of publications about laboratory accreditation to support the establishment of programs in many countries. Much of this literature has been produced by the International Laboratory Accreditation Conference (ILAC). Like most "specialist" organisations, ILAC has developed its own peculiar terminology. So one frequently hears references to terms like "task forces", "peer group assessment", "proficiency testing" etc, instead of "committees", "examination by people of similar experience" "interlaboratory measurements", and so on. It is always a mystery to me why it is considered that a special language represents maturity in an organisation. I tend to the reverse opinion!

Unfortunately, throughout this mass of information, I have never been able to find a truly satisfactory definition of the most important term of all: "Laboratory Accreditation"! I believe this is the reason the words are often used glibly (especially by applicant laboratories) without realising their implication for laboratory practice. As a result there can exist the naive belief that an accreditation system is some kind of club, membership of which magically confers "respectability" on a laboratory's operations, thus leading to increased demand for its services and a consequent improvement in its income expectations!

This attitude still persists in some private sector laboratories in

Australia and New Zealand, even though those countries have had accreditation schemes operating successfully for many years.

In reality, laboratory accreditation is a quality assurance scheme for laboratories in both the public and private sectors. It is the means whereby the quality of performance of a laboratory is improved, with the result that the measurements and tests undertaken become more consistent and reliable. As I have stated elsewhere[4,5], a laboratory accreditation scheme is analogous to a specification standard (norm) which prescribes the quality of a product, except that the product "under test" in this case is the laboratory itself.

Like all good quality assurance schemes, laboratory accreditation should guarantee the integrity of:

a) The raw materials - that is, the competence and ethics of the staff, and the reliability of the equipment used;

b) The production process - in this case, the method of test, determination of measurement uncertainties, and the methods of recording and checking the results;

c) The end product - that is, the test certificate.

Thus, an effective laboratory accreditation program is one which will approve a laboratory's application for "membership" when, and only when, the various components conform to the required specification. In other words, a bland endorsement of a laboratory's operations is insufficient. The laboratory must comply with a number of quite stringent conditions of entry, not merely pay any membership fees which may be levied.

Recently, it has been suggested[6] that the existence of documentation such as organograms and quality manuals is a useful measure of the quality of performance of testing laboratories in Brazil. I do not agree. Some of the least competant laboratories in my own country have produced the most beautiful documentation in support of their applications for accreditation under the TELARC scheme. On the other hand, some of the best have no time (or inclination) to develop organograms and detailed quality manuals. This is because they are too busy catering for the needs of customers who are already aware of the reliability of the services provided by those laboratories!

Consequently, although many accreditation programs require applicant laboratories to produce written evidence of their procedures, this should never be the main criterion for acceptability.

In practice, the determination of acceptability under an accreditation scheme should involve an extremely thorough investigation of every aspect of an applicant laboratory's affairs. The organisers of the scheme should be just as ready to turn down an application from a well-documented, but incompetant, laboratory as to accept that from a poorly documented but obviously reliable one.

Again, the scheme should be completely "independent" of outside pressures to accept or not accept a particular laboratory. It should be just as ready to refuse admission of a government laboratory as to admit a private one (and vice-versa). The emphasis must always be on the quality of a laboratory's operations and never on the importance of that laboratory's contacts.

OPERATION OF ACCREDITATION SCHEMES

The first step in any accreditation scheme is to decide what areas of testing and/or calibration should be covered. Although the organisers of the scheme may wish to cover all conceivable aspects of measurement, the available resources usually preclude this possibility. Consequently, some careful thought should be given as to where the scheme should begin.

In Brazil, there appear to be two options:

1. To concentrate initially on one or two fields of testing (for example, mechanical and electrical). The most important considerations here would seem to be:

   a) Which fields are most vital to the economy,

   b) Are there laboratories with established reputations for reliability already operating in these fields?

   Such laboratories could form the foundation on which to build the scheme. The Rede Nacional de Calibração (RNC) has already adopted this approach and, as a result seems likely to become a very valuable part of the national quality assurance system.

2. To concentrate on testing of specific products which have good export potential (for example, textiles or shoes). This approach can be more difficult since product testing can involve several fields of testing. Consequently, an interdisciplinary approach is required and assessment of laboratory competance can be a complex exercise.

On balance, accreditation by discipline rather than by product is simplest to arrange. This is the system adopted by the United Kingdom, Australia, and New Zealand. However, in the United States, a product oriented approach has been adopted. Both types of scheme have advantages and disadvantages. Brazil must decide what is best suited to the economy and available expertise.

Having established the scope of the accreditation scheme, the next step is to prepare the specifications[7] with which applicant laboratories must comply before accreditation can be granted. This is done in exactly the same way as the preparation of AENT norms for a product or method of test. Groups of experts decide, by concensus, the criteria for acceptability of laboratories operating in a specified field of testing. Clearly these "experts" must have wide knowledge and practical experience of the technologies involved. The aim is to develop specifications which will improve the performance and reliability of laboratories, not to make it impossible for them to operate. After all, many norms have been promulgated and subsequently found to be impossible in practice!

Once these specifications, or requirements for accreditation, have been developed, the scheme has reached the point where the examination, or "assessment" of applicant laboratories can be considered.

In any examination of a laboratory's operations, the most important aspect is the staff. Do they have the necessary knowledge and experience to perform the measurements to the stated level of accuracy? Are they "professional" in their activities - that is, are they reliable, honest, and un-biassed in their approach to their work. Also, are they complacent, or are they self-critical of their ability? This is important since the best staff are usually those who are never satisfied with their performance and who, therefore, try always to improve their knowledge and their techniques.

The next most important considerations are the laboratory's facilities and equipment. Are these adequate for the job in hand? Are the instruments in calibration and "traceable" to standards of measurement? Is the environmental control sufficient to guarantee the quality of the services performed? Are the working conditions suitable for the staff to perform their duties efficiently?

Thirdly, are the recording, checking and documentation procedures adequate? Is the identity of items submitted for test assured? Are the methods of recording the results likely to minimise errors? How long are records kept after a job is completed? Are the results checked by a third party? Is the test certificate complete in its information? Does it indicate the uncertainty in measurements, details of the environment, etc?

If the answers to all these questions are satisfactory, a final check is to select at random a member of staff and have him/her perform an actual measurement or test. This can often provide a better indication of performance than any amount of oral or written examination. It is a case of "a picture telling a thousand words".

Having assessed the level of competance and reliability of a laboratory, a decision can be made as to whether that laboratory should become accredited and, if so, for what tests. Since one of the main objectives of an accreditation scheme is to improve laboratory performance, the laboratory should be given a reasonable amount of time to rectify any problems which become apparent during the assessment. The emphasis here should be on constructive criticism, not on harsh negativity, so some degree of diplomacy is often required. Otherwise, applicant laboratories will lose interest in the scheme, and no useful purpose will have been served by the exercise.

Again, once laboratories have been assessed and accredited, an ongoing program of reassessment should be instituted. Otherwise there is no guarantee that a laboratory will continue to perform satisfactorily. Reassessments at regular (one or two year) intervals enable the accreditation authority to check whether any recommendations have been implemented. Also, it is often a failing of human nature that the best operations are only achieved when working to a deadline!

RESOURCE REQUIREMENTS OF ACCREDITATION SCHEME

An accreditation scheme such as outlined is dependent on a number of resources:

1. A full-time administration

This might consist of:

(i) senior management staff;

(ii) a number of technical staff, each of whom would be "responsible" for one or more fields of testing;

(iii) editorial and secretarial staff;

(iv) publicity staff;

(v) typists;

(vi) library and, possibly, data processing staff.

The functions of this administration are to:

(a) publish the aims and activities of the accrediting authority;

(b) recruit the resource pool of experts for the advisory groups and technical assessments;

(c) conduct pre-assessment visits of applicant laboratories in order to provide briefing notes for assessors;

(d) arrange assessments and reassessments and generally liaise with applicant or accredited laboratories;

(e) select and brief assessors;

(f) convene meetings of the advisory panels and other groups;

(g) advise applicant laboratories of the assessment result;

(h) collect assessment and annual membership fees;

(i) encourage accredited laboratories to issue reports endorsed in the name of the authority;

(j) encourage and sponsor inter-laboratory tests to improve the consistency of test methods and results;

(k) arrange technical workshops and training courses for staff of applicant and accredited laboratories;

(l) generally promote the advancement of laboratory practice;

(m) keep records and publish details of accredited laboratories and the tests for which they have been granted accreditation;

(n) maintain a library of material pertaining to laboratory accreditation schemes operating at home and overseas;

(o) correspond with similar organisations in other countries in an effort to promote the international acceptability of tests performed by the accredited laboratories;

(p) participate in the activities of the International Laboratory Accreditation Conference (ILAC).

2. Financial Resources

It can be seen from the extensive list itemised above that the organisation of an accreditation scheme is not something which should be done in a "piecemeal" fashion by people already busy with other responsibilities. It must be their full time occupation if it is to provide a real service to the testing and measurement community in Brazil.

Consequently, considerable financial resources are required to support the organisation during its formative stages. Central government is the logical source of such finance. Funds are required for staff salaries, administration and operating expenses, printing and publicity, assessment (and reassessment) costs, preparation of documentation etc. In addition, it may be necessary to pay fees, as well as travelling expenses, to people involved in an advisory or assessment capacity.

None of the existing schemes anywhere in the world could survive without government funding, and there is no reason to believe Brazil's will be any different. After a while, it may be possible to reduce the level of that funding when a significant income is derived from assessment and accreditation fees. But it is unwise to assume that complete dependence on such fees is possible. Any attempt at this would require fees far in excess of those which would be acceptable to applicant and member laboratories.

For example, in Australia, over 50% of NATA's funds come from central government, in New Zealand the figure is even higher (70%). And that is with a voluntary workforce of advisers and assessors. NATA estimates that without such voluntary assistance, an additional A$ 500,000 per year would be required to pay the fees of assessors etc. This would require a doubling of the pr[illegible] fees levied on member laboratories. Without government support, therefore, this fee structure could increase four-fold.

Brazil should address this problem very carefully when considering the coordination of, and extensions to, its existing accreditation schemes.

3. Advisers and Assessors

The most important human resource is the reservo[illegible] scientists, engineers, and technologists which is required fo[illegible] practical implementation of the scheme. These people are the guarantors of the quality of the service provided by the member laboratories. Not only are they important to the development of technical suppo[illegible] documentation (requirements for regist[illegible] details of test [illegible]egories and associated measurement proce[illegible], technical notes [illegible] metrology [illegible], [illegible]y are essential in a[illegible] laboratory assessme[illegible]

Consequ[illegible], their selection should be made very carefully.

Ideally, they should be people of wide knowledge and experience of the relevant technology. They should be capable of "conceptual" thought, and they should be critical of their own performance.

At present, RNC relies heavily on technical advice provided by metrology staff at CEMCI. However, there is always the danger that such staff will be used too often to the detriment of their own work. Also, if only CEMCI personnel are used, this could result in an in-bred, inward-looking organisation which was not amenable to outside influences and, therefore, is resistant to change. Both RNC and RNLE need to be more outward looking if they are to be of real value to Brazil's dynamic industrial economy.

Therefore, both schemes should attempt to obtain technical advisers from the universities, research institutions, hospitals, state-owned industries, and the private sector (although the latter are likely to require fees in payment for their services). Another likely source of expertise lies within the accredited laboratories themselves. The technological personnel of such institutions are obviously sympathetic to the aims of the scheme. Otherwise they would have not sought accreditation in the first instance. Also, since nobody is perfect, such personnel can benefit from their experience of other laboratories, and, as a result, improve their own procedures.

Urgent consideration should be given to the development of this resource pool of knowledge if the RNC and RNLE schemes are to grow at the rate required. It is suggested that, in the first instance, an attempt be made to recruit the support of suitably qualified personnel from the following institutions:

- IPT and IE-USP (São Paulo)
- CEPEL (Rio de Janeiro)
- CETEC (Belo Horizonte)

These institutions are already conversant with the activities of RNC and RNLE. Thus, they are more likely to support any request for expert advice and assistance than would other organisations at the present time.

4. Reliable Measurement Base

Since membership of an accreditation scheme implies quality assurance in measurement, such assurance can only be guaranteed if a system of national measurement standards already exists. Fortunately CEMCI, Serviço da Hora (SDH), and Instituto Radiometria e Dosimetria (IRD) have ensured the reliability of Brazil's national standards through their regular overseas calibration or intercomparison.

At present, the only area where problems could arise is that of colour and photometric testing. Otherwise, I have no criticism of the methods used in B for arranging international traceability. The problem of colour and photometric measurement is addressed in another report in this series[8].

However, I am concerned at the apparent lack of awareness in Brazil of the services which CEMCI, SDH, and IRD can perform. At present, only a few institutions throughout the country submit instruments for calibration against the national standards. Therefore, some effort should be made to promote the activities of CEMCI etc. Perhaps INMETRO could consider the possibility of television and newspaper advertising to overcome this problem.

In this connection, it is interesting that some Brazilian companies go to considerable expense to arrange overseas calibration of their equipment. In most cases, CEMCI can offer an equivalent (or better) calibration at less cost and with a shorter turn-round time. The other obvious advantage of local calibration would be that payment would be made in cruzados and not international currency!

COORDINATION OF EXISTING SCHEMES

I am in favour of the present proposal to bring RNC and RNLE under a single coordinating authority (RNL). However, care should be taken to ensure that two possible problems do not arise.

The first is that RNL might be considered more remote from the technological arm of INMETRO than is the present situation with RNC.

The "symbiotic" relationship between RNC and CEMCI works very well because RNC operates from within CEMCI itself. Consequently, RNC is able to draw on the resources of CEMCI whenever required. CEMCI staff provide RNC with advice and calibration services, and act as assessors of applicant laboratories. It would be most unfortunate if RNL was established in such a way as to make it less easy for RNC (and RNLE) to enlist this essential support.

However, I wish to emphasize that this is only a potential problem which, with care, can be easily avoided. For instance, it did not arise in Australia or New Zealand because the national laboratories of those countries (NML and PEL) were instrumental in establishing the NATA and TELARC schemes. These schemes have retained the full support of NML and PEL because the staffs of those institutions appreciate the amount of calibration and test work done on their behalf by the accredited laboratories. Without such delegation of responsibility, NML and PEL would be unable to cope with the present demand for measurement services in Australasia. Similarly, they would have less time to concentrate on their primary responsibility of maintaining the national standards.

In the United Kingdom and the United States, the ties are even closer. The accreditation schemes of those countries (NAMAS and NVLAP) are operated by NPL and NBS respectively. Therefore, it is recommended that, if established, RNL maintain the closest possible links with CEMCI.

The other problem which could arise from amalgamation of RNC and RNLE is an unintentional weakening of both resulting from the temptation to rely too much on each other's experience and expertise. Although "cross-fertilization" of ideas can enhance the operation of a joint accreditation service, care should be taken to avoid an <u>excess</u> reliance on each other's resources. Otherwise, those resources will become insufficient for the job in hand. This is a particular problem where the technological strengths of two organisations are different. The strong organisation will be called upon to help the weak one until the former is unable to cope with its own work load.

Therefore, I believe that the role of RNL should be restricted to a coordinating one. Clearly, some coordination of RNC and RNLE activities is essential. Otherwise, it is always possible that there could be overlapping responsibilities. This, in turn, could result in unnecessary duplication of resources, inefficient utilisation of existing resources, and a situation of conflict, rather than harmony, between the two. Sensible (and sensitive!) coordination should result in optimum performances by both RNC and RNLE.

Associated with any proposal to amalgamate RNC and RNLE, there is the question of whether other accreditation schemes should be brought under the umbrella of RNL. For example, I understand that separate schemes operate for medical testing and foods.

Although, in principle, the incorporation of such schemes may be desirable in the long term, and would undoubtedly lead to an improvement in their operation, any attempt to achieve this would require a significant increase in resources. Consequently, I doubt that RNL would be able to cope with a sudden increase in work load at the present time.

Therefore, I recommend that RNLE determine the number of laboratories which could be involved, and apply for additional resources before finalising any negotiations with these other schemes. Since the acquisition of additional staff is particularly difficult at the present time, I suggest that any moves towards incorporation of schemes other than RNC and RNLE be deferred for at least 2 or 3 years.

PROMOTION OF LABORATORY ACCREDITATION

It is very important to widely advertise the aims and activities of a laboratory accreditation scheme if it is to have a real chance of success.

When NATA was first established, the organisers made a fundamental error by not publicising their activities. Consequently, for the first 4 or 5 years of its operation, NATA attracted little support and a great deal of suspicion. Potentially accreditable laboratories, particularly those in the private sector, mistakenly believed that NATA was an unofficial arm of the Australian Government, and that it had been established for the prime purpose of enabling increased governmental control of industry's affairs[9]. Consequently, it was only after NATA had undertaken a vigorous publicity exercise in 1952 that the scheme began to receive the support it deserved.

Therefore, a clear statement of the aims of any national scheme for Brazil should be made at its outset. Although secrecy is often required for strategic reasons in the public service, it would spell disaster for an accreditation scheme. New Zealand learnt from Australia's mistakes and the publicity associated with the launching of TELARC ensured its immediate popularity.

Unfortunately, TELARC had a different kind of teething problem. I mentioned earlier the need to establish a reputation for quality, rather than quantity of accredited laboratories. Although organisers of accreditation schemes may wish to establish early credibility (particularly with sceptical government funding agencies!), the temptation to achieve this by accrediting large numbers of laboratories should be resisted. When TELARC commenced in New Zealand, the problems detected during certain laboratory assessments were understated in order to register those laboratories. As a result, 13 years later, TELARC still experiences difficulty in convincing certain of its member laboratories that their operations are not good enough.

Another problem with inadequate laboratories is that their customers will associate poor performance with the accreditation scheme itself. This will generate adverse publicity for the scheme and, in the user's mind,.will negate all the good points about laboratory accreditation.

On the other hand, a properly organised and managed scheme will:

(a) Improve the competence and professionalism of laboratory staff;

(b) Improve the reliability of test equipment through an insistence on regular calibration against recognised measurement standards;

(c) Ensure that the tests, for which accreditation has been granted, are condicted properly;

(d) Generally improve laboratory performance;

(e) Confer status on accredited laboratories;

(f) Guarantee the reliability of, and increase public confidence in, the reports produced by accredited laboratories;

(g) Generally improve the quality of products tested by accredited laboratories;

(h) Increase import substitution;

(i) Increase exports.

These points should be emphasized during any promotional campaign since they are of considerable importance to the national economy and to the well-being of all people in Brazil.

"TRY BEFORE YOU BUY"

As I have said, all existing schemes have advantages and disadvantages. Similarly, they have all made errors of judgement at one time or another. Therefore, I urge Brazil to carefully appraise all schemes before deciding on a particular course of action. At this stage, I am not prepared to recommended any one scheme to Brazil since it may not be entirely appropriate to local conditions.

Brazil has a golden opportunity to develop a scheme which will rank with the best anywhere in the world. By drawing together all the positive and relevant aspects of existing schemes, and ignoring the bad, Brazil will be able to develop a laboratory accreditation service suited to its own needs; not those of Australia, New Zealand, or elsewhere.

In this connection, I believe funds should be allocated to enable RNC and RNLE to observe at first hand the operations of NATA, TELARC, NAMAS and NVLAP. Arrangements are already in hand to visit NATA and I do not envisage any obstacle to a visit to TELARC. In addition, I will be happy to discuss with NAMAS officers the possibility of INMETRO staff observing their operations. I propose to do this on 14 November 1986 during a brief visit to the United Kingdom.

RNC and RNLE staff already have details of, and contacts in, NATA following the visit to Brazil of Mr. A.J. Russell. Should they require full details of the other accreditation schemes to which I refer in this report, these can be obtained from:

1. NAMAS: Mr. John D. Summerfield
Head of NAMAS
National Physical Laboratory
Teddington, Middlesex TW 11 OLW
England.

2. NVLAP: Mr. John W. Locke
Coordinator of NVLAP
United States Department of Commerce
National Bureau of Standards
Washington DC 20234
USA

3. TELARC: Dr. Jack Garside
Director of TELARC
P.o.Box 37042, Parnell,
Auckland
New Zealand

From personal experience of these people, I am sure they will be pleased to assist Brazil with its accreditation scheme.

ACKNOWLEDGEMENTS

My grateful thanks go to the staff of RNC for their advice and assistance, to Graça my secretary for her patience and excellent typing, and to Natalina Martins, dental surgeon, for her love and understanding.

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REPORT ON VISITS TO ADRIANÓPOLIS, PETRÓPOLIS, BELO HORIZONTE, MONTES CLAROS, AND FLORIANÓPOLIS

8-29 OCTOBER 1986

Dr. J.H. Buckingham
UNIDO Consultant in National Calibration Services
INMETRO/CEMCI, Xerém-RJ, Brasil.

November 1986

SUMMARY

The purpose of these visits was to increase my knowledge of Brazil's present and potential measurement services. Visits to several industrial laboratories were included at my request in order to assess the level of quality assurance operations in the private sector. In addition, on 23 October, I presented a paper in Montes Claros on the basic concepts of scientific and industrial metrology. This presentation was part of a UNIDO Seminar on standardisation, metrology and quality assurance. The original oral presentation was in Portuguese. I have included an English language version as an appendix to this report.

The institutions and industrial companies visited were:

1. Centro de Pesquisas de Energia Elétrica-CEPEL (Grupo Eletrobrás), Electrical Equipment Laboratories, Adrianópolis. 08 October.

2. Companhia Eletromecânica-CELMA, Petrópolis. 16 October.

3. Instituto de Pesos e Medidas de Minas Gerais-IPEM-MG, Belo Horizonte. 20 October and p.m. 24 October.

4. Centro Tecnológico de Minas Gerais-CETEC, Belo Horizonte. 21 October.

5. Magnesita S.A. Minas Gerais, Belo Horizonte. 22 October.

6. Fiat S.A. Minas Gerais, Belo Horizonte. 24 October.

7. Centro Regional de Tecnologia em Informática de Santa Catarina,

Florianópolis. 28 and 29 October.

Air travel for the visits to Belo Horizonte, Montes Claros and Florianópolis was arranged by INMETRO.

This report details my impressions of the various organisations and makes a number of suggestions on how these might be of use to Rede Nacional de Calibração (RNC), Rede Nacional de Laboratórios Ensaios (RNLE), and INMETRO's directorate for Legal Metrology (DIMEL).

1. Centro de Pesquisas de Energia Elétrica, Adrianópolis

Principal Contacts

- Marcelo Appel da Silva, Chefe da Divisão de Medição.
- Agenor O.F. Mundim, Chefe do Departamento de Alta Tensão e Potência.

Sections Visited

High voltage, high power, metrology, pollution testing, explosion testing.

Impressions

The staff of CEPEL total approximately 500, of which about 240 are employed at the Adrianópolis site. The scale of operations at CEPEL's electrical equipment laboratories is impressive by world standards. For example, tests up to 800 kV are undertaken in a 27 metre high laboratory, and up to 1500 kV outside. The high power laboratory uses a high current circuit of up to 144 MVA, 5s, with a maximum of 300 kA, and a medium power circuit of up to 1300 MVA, 5s with a maximum of 100 kV. The constructed area comprises 12,000 square metres of laboratory and testing facilities. The electrical equipment laboratories perform studies, research and development projects, and tests in the areas of:

- Lines and Substations
- Electrical Equipment

The facilities are available to manufacturers as well as government and, currently, are fully committed for the next 12 months.

CEPEL is a member laboratory of RNC and maintains traceability to CEMCI via a Fluke Electronic Voltage reference. The metrology laboratory is well equipped and competently staffed.

Test work includes short circuit testing of breakers, transformers, and switch gear, dielectric and insulator tests, and pollution tests (insulation breakdown in a salt laden atmosphere). Tests are performed primarily on locally manufactured equipment for use both within Brazil and for export.

New laboratories for explosion proof testing are nearing completion. Partly financed by Petrobrás, these laboratories should be in operation early 1987. Much of the equipment for explosion proof testing, gas mixing, and gas analysis has been designed and manufactured by CEPEL.

I have no criticism whatever regarding the operation of the electrical equipment laboratories. Brazil is indeed fortunate to have such magnificent support for its electricity supply industry.

2. Companhia Eletromecânica, Petrópolis

Principal Contacts

- A.S. Ecimar, Engº, Test Cells
- G.D.P.S. José, Engº, Helicopters
- Eduard G. Stumpf, Engº, Metrology
- Renato M. Soares, Engº, Metrology
- Ricardo Gentil, Engº, Non destructive testing.

Sections Visited

Engine inspection and repair, engine testing, non-destructive testing, heat treatment, plasma metalisation, electric arc erosion, and metrology.

Impressions

CELMA employs a staff of 1600, of which over 300 are qualified engineers. The company services and tests aircraft engines to CTA and FAA specifications for Brazil:

- Força Aérea Brasileira, VARIG, VASP, Cruzeiro do Sul, Transbrasil, Rio Sul, Toba, Votec, Nordeste, Orgãos Governamentais, Empresas Privadas.

- Other Countries:

  Uruguai, Peru, Argentina, Chile, Equador, Colômbia, Panamá, Venezuela, Costa Rica, and France.

In addition, in 1987, CELMA will commence manufacture of 26% of the components of the Rolls Royce SPEY-.. 807 jet engine for the AMX aircraft project.

All but the very large power plants h as the General Electric CF6-80 (for Boing 767 aircraft) can be tested at CELMA. During my visit a J85 motor from a military rcraft was under test.

This company has over 20 years experience of aircraft engine servicing and has acquired an enviable reputation for quality assurance. Nothing is left to chance, and its highly skilled staff undergo frequent training in the latest techniques of maintenance and inspection. Much of this training is undertaken at the engine manufacturing companies in the USA, UK, France etc.

All instruments are in calibration and traceable either to CEMCI or to overseas measurement standards. It is recommended that staff of RNLE visit CELMA to gain experience of the quality of mechanical testing which can be obtained in Brazil.

3. Instituto de Pesos e Medidas, Belo Horizonte

Principal Contacts

- Engº Hélio Oliveira de Souza, Diretor Geral

- Dr. Roberto Guimarães, Diretor

Sections Visited

Mass and balances, length, volume, electrical, densitometry, large volume (petrol tankers), testing of petrol and alcohol fuel dispensers, taximeters, data processing and storage.

Impressions

IPEM-MG is a well organised and efficient component of Brazil's legal metrology network. Its 180 staff, are innovative and hard working, and perform an excellent service. Currently over 97,000 tests of all kinds are performed each year. Income from this work is in excess of US$ 1.5 million per year.

However, with increasing numbers of consumer complaints regarding the sale of underweight items in shops etc, much time now has to be given to investigative work instead of merely assuring the accuracy of trade weights and measures. Consumer complaints have increased by 80% since February 1986 and IPEM staff estimate that these now produce an extra 16 hours of work per person each week.

Consequently, IPEM staff are concerned that possible new legal metrology requirements will increase this load further. INMETRO staff at Xerém have initiated proposals for additional temperature measurements for certain trade purposes, such as the sale of fuel alcohol and gasolene. Although I can appreciate the logic behind these proposals, I doubt whether their practical implementation is possible because of the extra work which will be involved. If IPEM staff do have to measure temperature as well as other parameters, this will further dilute their already their weakened resources.

Therefore, INMETRO should look very carefully at the wisdom of measuring temperature if the tolerances are already sufficient to ensure the sale of temperature-dependent quantities within legal limits.

At the present time, the lack of traceability of trade weights and measures is of far greater importance. Although INMETRO organises intercomparisons between some IPEMs, the experiments do not cover all states. Again, these experiments do not involve test pieces which are themselves traceable to the national standards maintained by CEMCI. Consequently, there is no guarantee at the present time that the weights and measures used in one state are equivalent to those used in all others. Or indeed, that any are correct!

I believe that institutes such as IPEM-MG have an important role to play in this area. If, for example, IPEM-MG could be allocated extra staff, then it could serve as a secondary calibration authority for INMETRO/DIMEL. Certainly, the competence and experience exists within IPEM-MG. In this case, it would be sufficient for the latter to have its reference standards calibrated by CEMCI once every two years. Traceability of the reference standards used in other states then could be assured by their calibration against those of IPEM-MG.

4. CENTRO TECNOLÓGICO DE MINAS GERAIS

Principal Contacts

- Dr. João Lopes Faria Neto, Presidente do CETEC
- Engº José Eustaquio da Silva, Setor de Tecnologia Metalúrgica
- Prof. Harry Gomes, Deptº de Química Orgânica
- Dra. Sonya Calil, Matemática, Deptº de Medições de Água.

Sections Visited

Chemistry, atmospheric pollution, water quality, engine testing, metallurgy, force measurement.

Before visiting these sections, I delived a seminar on Brazil's national calibration service and watched an audiovisual presentation about the work undertaken by CETEC.

Impressions

CETEC is a fine institute with excellent staff and equipment.

Currently the space allocated to certain activities, particularly chemistry, is rather cramped. However, this situation should improve early 1987. The quality of the work that I saw was excellent, and I have no criticism of the technical procedures used at CETEC.

I understand that CETEC has been negotiating with RNC to obtain accredited laboratory status. However, until recently, the philosophy of traceability in measurement was not appreciated by the administration at CETEC. Fortunately, this problem has now desappeared, and funds have been made available to allow a vigorous program of calibration of CETEC reference equipment by CEMCI. For example, all the load cells used by the force measurement section at CETEC are now in calibration. It is interesting that the new calibrations are significantly different from those of the manufacturer from which the equipment was purchased several years ago. This is an excellent illustration of the importance of regular calibration. Elastic proving devices are notorious for the rapidity with which their properties will change.

At the present time, staff in the metallurgy section are concerned at the lack of traceability in temperature measurement, and are proposing to purchase a number of fixed point cells. However, I have suggested that such purchases should be made only after consultation with staff in CEMCI's temperature measurement section. In this connection, I believe such consultation would be a valuable exercise for CEMCI since CETEC staff appear to have more experience of high temperature measurements than do their CEMCI counterparts.

I believe CETEC has an important role to play in both RNC and RNLE. For example, its testing machine calibration service is growing rapidly. Currently, staff verify more than 150 machines in Minas Gerais each year. Two years ago, the number was about 75. Again, CETEC is very active in all forms of pollution testing: airborne contaminents such as smoke particles and oxides of nitrogen, sulphur, and carbon; noise pollution; water COD and BOD tests, levels of fluoride, cyanide, and heavy metals etc in industrial effluents. CETEC was one of the pioneers in the use of alternative fuels, and is now testing the effects on automobile engines of the alkaline additives in fuel alcohol. It is also looking at the possible use of vegetable oils as alternatives to diesel for heavy trucks.

I recommend that the secretariats of RNC and RNLE negotiate with CETEC regarding the latter's early accreditation in these important areas.

5. MAGNESITA S.A. MINAS GERAIS

Principal Contacts

- Engº Arnaldo Lucas Machado, Chefe da Divisão de Normas e Padrões
- Dr. Carlos Alfonso, Chefe da Divisão de Pesquisas

Sections Visited

Metrology and quality assurance laboratories, manufacturing plant, research laboratories.

Impressions

Magnesita S.A. is the 5th largest producer of refractory materials in the world. Its 7000 employees (4000 in the Belo Horizonte factory) produce 600,000 tonnes of refractory elements each year. Exports to 47 countries in Europe, America, Africa, Asia, and Australasia now exceed US$ 33 million annually. The company also exports raw materials to the USA, Chile and Poland.

The quality control procedures at Magnesita are excellent. Testing is carried out at every stage in the manufacturing process, from the raw materials to the finished products. All equipment is in calibration, either to INMETRO/CEMCI direct, or via laboratories of RNC such as IPT, São Paulo.

Some idea of the extent of Magnesita's QA procedures can be obtained from the range of tests I saw being performed. These include:

- Compression testing up to 100 TF

- Chemical analyses,

- Porosity and density measurements,

- Sieve analyses, determination of dry weight and moisture content of raw materials,

- Permeability tests with on-line computer analysis of results,

- Non-destructive testing (ultrasonics) to determine internal defects in products,

- Viscosity of resins,

- High temperature testing under load, creep tests, slag tests etc,

- Compaction of raw materials.

Magnesita designs and builds its own presses for the manufacture of refractory elements of various "standard" shapes and sizes. For non-standard shapes and complex geometrical form, molds are constructed on site, hand filled, and then heat and pressure treated in the normal way.

The research laboratories are some of the most impressive that I have seen anywhere in the world. Clearly, Magnesita understands the value to its operations of considerable investment in equipment and research at the state-of-the-art level.

Magnesita's instrumentation includes computer-controlled pilot plants for prototype material fabrication: X-ray diffraction; X-ray, infra red and atomic absorption spectroscopy; optical microscopes with magnifications up to 2000 X; scanning electron microscopy with X-ray dispersion and EDAX facilities.

Magnesita's Belo Horizonte factory and laboratories constitute an fine example of the interface between technology and industry. I recommend that the staff of RNLE visit Magnesita to obtain experience of the excellent level of quality assurance in measurement and testing which is attainable in Brazilian industries at the present time. The extremely high standards set by this company demonstrate the kind of operation which the accredited laboratories of RNLE should attempt to achieve.

6. FIAT AUTOMÓVEIS S.A.

Contact Person

- Engº Gilvan Ferreira, Chefe do Serviço de Qualidade Fornecedores Mecânicos.

Section Visited

- Dimensional engineering metrology

Impressions

The FIAT plant at Rodovia Fernão Dias, Belo Horizonte, manufactures engines, both for local use and for export to Italy. Consequently, there is a heavy reliance on high accuracy metrology during all stages of manufacture.

The metrology laboratory is well equipped and much of the instrumentation is under semi automatic control with on-line data processing. All aspects of length, angle, and form measurement are undertaken in the laboratory, with heavy emphasis on gears, splines, threads etc, profiles and surface finish of pistons and cam shafts, and complete engine assemblies. Much of the work concerns the checking of go and no-go gauges, gear cutters, etc, used for on-line testing and manufacture.

However, this laboratory is deficient in one very important area at the present time. Although the laboratory staff go to considerable lengths to ensure all in-house measurements are traceable to the company's reference standards (set of "00" grade gauge blocks), the latter are not in calibration! The reference blocks were purchased from Mitutoyo, Japan, 5 years ago and Fiat uses the manufacturer's original calibration.

I urged the metrology staff to obtain an interferometric calibration against CEMCI's wavelength standards as soon as possible. In addition, Fiat would like 4 or 5 of its metrology staff to visit CEMCI to look at the dimensional metrology facilities at Xerém. I undertook to discuss this possibility with CEMCI's acting director.

7. CENTRO REGIONAL DE TECNOLOGIA EM INFORMÁTICA DE SANTA CATARINA

Main Contacts

- Engº Nelson Schoeler, Responsável pelo Setor de Qualificação de Instrumentos
- Engº Armando Albertazzi Gonçalves, Superintendente de Ciência e Tecnologia.

Section Visited

- Laboratório de Metrologia e Automatização (LABMETRO).

Impressions

Unfortunately, this institute had not prepared for my visit and my reception was noticably cool. Although the laboratory had received advance notice (3 weeks) of my visit, the coordinator of LABMETRO, Prof. Carlos Schneider had another meeting in Brasilia on the same day. Consequently, it was not possible to discuss future activities of LABMETRO in any detail. For some reason, the laboratory staff were anticipating a confirmatory letter in addition to CEMCI's telephone calls about my visit.

However, I was able to discuss with Mr Schoeler LABMETRO's application for RNC accreditation. This application has been pending for about 3 years and, while not wishing to lay the blame in any particular quarter, I suggest that RNC personnel should treat this application with some degree of urgency. LABMETRO has already taken part in interlaboratory tests organised by RNC. In the area of length measurement, the results achieved by LABMETRO agree very well with those of IPT, São Paulo (already an accredited laboratory).

Again, I detected some acrimony over the fact that (apparently!) LABMETRO had been waiting for 4 years to obtain a CEMCI calibratio for its 50 T elastic proving divice. However, I believe the problem is partly due to internal difficulties at CERTI, together with some clash of personalities and consequent inadequate communications between LABMETRO staff and those at CEMCI. Nevertheless, it might be diplomatic of CEMCI/RNC staff to liaise with LABMETRO to discuss these problems.

The dimensional laboratory at LABMETRO is small and, in some areas, inadequately equipped. However, it is providing a service to organisations in several states, including Rio de Janeiro. Consequently, its calibrations and tests need to be placed on a more official footing than at present.

LABMETRO requires new equipment in several areas before it can operate satisfactorily. The main items being a 3-dimensional measuring machine and a laser interferometer for length measurement; platinum resistance thermometers and a triple point of water cell for temperature measurement; force transducers (load cells) over the range 2 kN - 5 MN; dead weight testers for pressures up to 1500 bar; and associated electronic measuring equipment (bridges, recorders, temperature controlled enclosures etc).

I believe that a portion of the World Bank loan for upgrading Brazil's metrology facilities should be made available to regional organisations such as LABMETRO, IPT, CETEC etc for equipment purchases. These laboratories will have an important role to play in RNC in the years to come. If they are to fully support CEMCI and accept some of the increased load of calibration work (which otherwise will fall on CEMCI), they must be satisfactorily equipped. However, I suggest that World Bank funds should be used ONLY where no other sources exist. So some degree of caution needs to be exercised in the allocation of these funds.

CONCLUSIONS

1. Existing laboratories of RNC are competantly staffed and, for the most part, well-equipped. They are making a valuable contribution to the national metrology system.

2. Industrial organisations with proven reputations for quality, such as CELMA, Magnesita, and Fiat, are obvious candidates for accreditation under RNLE.

3. CETEC and LABMETRO should be accredited by RNC as soon as possible

4. IPEM-MG should be given additional staff to enable it to provide a calibration service for other weights and measures institutes.

5. Some de-centralisation of World Bank funds may be necessary to enable present and potential laboratories of RNC to operate satisfactorily.

BASIC CONCEPTS OF SCIENTIFIC AND INDUSTRIAL METROLOGY

Dr. J.H. Buckingham
UNIDO Consultant in National Calibration Services
INMETRO/CEMCI, Xerém-RJ, Brazil

November 1986

SUMMARY

This paper was presented at the UNIDO seminar on Standardisation, Metrology, and Quality Assurance, Montes Claros, 23 October 1986. It describes the need for accurate standards of measurement, the importance of consistent measurements in modern industry, and the system by which the quality of manufactured items can be assured throughout Brazil.

The original (oral) presentation was in Portuguese. This translation is included as an appendix to my report on visits to Brazilian industries and scientific institutions, 8-29 October 1986.

INTRODUCTION

Why are measurement standards necessary?

The search for suitable standards of measurement has gone on for many thousands of years. Originally, these standards were only for trade purposes - to overcome the traditional conflict between the buyer who wants to obtain more and the seller who wants to give less.

In 1791, Tallyrand suggested to the Franch National Assembly that a new system of weights and measures was required. The French Academy of Sciences responded by establishing an expert committee chaired by mathematician Jean Charles Borda. Associated with that committee were such eminent names as Lagrange, Laplace, and Lavoisier.

The committee decided on a decimel system of weights and measures based on the kilogram (mass), the metre (length), and the second (time). This marked the begining of the International System of Units (SI) used throughout the World today. Responsibility for maintaining the "prototype" standards of SI is vested in the International Bureau of Weights and Measures (BIPM) at Sevres, near Paris, France. All countries which have adopted SI have measurement standards which are traceable to the international prototypes.

IMPORTANCE OF MEASUREMENT STANDARDS TO INDUSTRY

Before the industrial revolution of the 18th and 19th centuries, craftsmen hand-made one-off items. Components were individually worked to fit, so there was little need for more precise measurements than could be obtained from the use of various linear scales. However, modern methods of mass production, considered to have started with the manufacture of the colt revolver in 1850, changed all that. Present-day industry relies on the interchangeability of components made to the same specification in different factories, often in different countries.

This kind of endeavour requires the use of a bewildering variety of gauges and instruments for rapid production line testing. Each instrument has its own particular use, but must comply with two very important criteria. It must be easy to use, and it must give reproducible answers within certain limits of accuracy.

Sensible design takes care of the first requirement, but the second can be achieved only through a hierarchy of calibrations traceable to national and international measurement standards. The best industrial companies in Brazil recognise the need for such calibrations. Consequently, their operations, and the quality of their products are equal to the best anywhere in the world. The problem in Brazil at the present time is that these enlightened companies are relatively few in number. Many others are capable of the same level of performance, but do not appreciate the need for good quality assurance procedures. Consequently, there is considerable waste of raw materials and finished products, and export rejection is a common experience at the present time.

BRAZIL's MEASUREMENT SYSTEM

Brazil's primary standards of measurement are maintained by INMETRO/ CEMCI: Centro de Metrologia Científica e Industrial, at Xerém, 40 km from Rio de Janeiro. These standards are traceable to their international counterparts through regular calibration and intercomparison. Below CEMCI, accredited laboratories of the National Calibration and National Testing Laboratory Networks (RNC and RNLE) perform calibrations and tests for other organisations in Brazil. Laboratories of RNC and RNLE have their instruments and equipment calibrated against the national standards at regular intervals.

However, few industries in Brazil make use of these calibration services. In addition, some of the best industries prefer to use the services of calibration laboratories in other countries. This involves considerable time when important instruments are unavailable plus unnecessary expenditure of international funds. In most cases, CEMCI and the accredited laboratories of RNL and RNLE can offer a more efficient service, at cheaper cost, and no wastage of overseas funds.

EXTENSION OF MEASUREMENT SERVICES IN BRAZIL

If Brazil's industries are to overcome their current teething problems there must be a greater reliance on quality assurance procedures. These procedures are impossible to implement without reliable measurements. And measurements are only reliable if they are performed with instruments which are in calibration.

Consequently, a vigorous promotional campaign is required to advertise the services which CEMCI, RNC, and RNLE can perform. Only by informing Brazilian industries of the importance and availability of these services will those industries commence to appreciate the desirability of improving their own performance.

However, promotion by itself is insufficient. When more of Brazil's industries begin to use the national measurement services, it will be necessary to increase staff levels in CEMCI etc to cope with the demand. Otherwise, there will be delays which are unacceptable to clients.

Staff recruitment in the public sector is extremely difficult at the present time because the Brazilian Government is (quite rightly) committed to reducing expenditure. However, with careful planning and natural attrition in areas other than science and technology, the problem is not insurmountable. I recommend some thought be given to the possibility of increasing staff levels at CEMCI at the expense of a corresponding reduction in staff levels in some other area of the public service.

CONCLUSIONS

Brazil's existing measurement system is extremely good and is of great potential benefit to the country. The staff of CEMCI, and the laboratories of RNC and RNLE, are competant and reliable, and the facilities at their disposal frequently rank with the best to be found anywhere in the world. I urge Brazilian industries to make use of them

Finally, I have detected a mistaken sense of inferiority in some Brazilian organisations. A similar feeling existed in New Zealand for many years and encouraged an unhealthy dependence on the supposedly more "developed" countries of Europe and America. We suffered from the "buy British - It's Best" syndrome!

Today, New Zealand is proud of its ability to produce goods and services of high quality. But they are no better than those of Brazil! You have a wonderful country with a great future, and it has been a privilege to be of service to you. I will follow your progress with great interest.

EXTENSIONS TO CEMCI FACILITIES:

PROPOSALS FOR EQUIPMENT PURCHASES DURING 1987

Dr J.H. Buckingham
UNIDO Consultant in National Calibration Services
INMETRO/CEMCI, Xerém-RJ, Brasil

November 1986

SUMMARY

This document contains lists of equipment considered important for CEMCI's continued development. It is hoped that the major items will be purchased by means of a World Bank loan originally allocated for the 1986 financial year. To date, this has not been drawn upon, and is unlikely to be before 31 December 1986.

Also included are my comments about areas of work currently outside CEMCI's field of experience and which, I believe, should be left to other organisations.

INTRODUCTION

CEMCI (Centro de Metrologia Científica e Industrial) has experience in the following areas of measurement:

1. Mechanical

- Mass and volume
- Force and pressure
- Length, angle and form

2. Electrical

- DC Voltage and current
- LF Voltage and current
- Resistance
- Capacitance and inductance
- DC and LF power and energy
- Transformers

3. Heat

- Temperature
- Surface tension, viscosity, density, etc.

4. Acoustics and Vibration

All areas are somewhat understaffed. Consequently, there are delays in the services which CEMCI can perform for its customers in RNC and RNLE laboratories, industry, etc. It is anticipated that this problem will worsen unless steps are taken to increase staff numbers and/or provide more efficient methods of measurement.

Present fiscal policies make staff recruitment very difficult. The problem is exacerbated through low rates of pay and a lack of promotion prospects within the public service. As with many countries at the present time, the employment opportunities which exist within industry in Brazil tend to attract skilled personnel from the public service. Consequently, CEMCI's staffing problems are not easy to solve.

Because of this, I believe it would be unwise for CEMCI to attempt to commence work in areas currently outside of its experience. For instance, it has been suggested that a group be established to fabricate standard reference materials. I do not agree. There already exists such a group at IPT (Instituto de Pesquisas Tecnológicas), São Paulo. This group has acquired an international reputation for the excellence of its work, and its materials are sold throughout the world. It would be extremely naive for INMETRO/CEMCI to attempt to establish an alternative group at Xerém.

Again, in the area of optical measurements (colour and photometry), CEMCI has established the position of a coordinator. However, at the present time, this officer has no practical experience, staff, or facilities. Until this officer has completed his training, and has experience of optical measurements, I believe CEMCI should not attempt to establish a colour and photometric measurement service at Xerém. Currently, IE-USP (Instituto de Eletrotécnica-Universidade de São Paulo) provides a very good service in optical measurements of the type envisaged by CEMCI. Therefore, I recommend CEMCI delegates this work to IE-USP, or some other institution, for a minimum of 3 years. Precedence for such delegation has already been established. For instance, the maintenance of the unit of time interval (second) is the responsibility of the National Observatory, and not CEMCI.

At the present time, it is for more important for CEMCI to consolidate its position, improve the efficiency of its existing services, and to attract the recognition and support from Brazilian industries which it deserves. To achieve this, CEMCI should attempt to automate certain of its operations by the use of modern equipment and data handling techniques. The following lists of proposed equipment purchases are intended to promote this aim. I urge the appropriate World Bank authorities to assist with these purchases.

1. MECHANICAL

Priority	CEMCI Code	Description	Manufacturer	Price US$
1.	LAMIT	Laser measurement system 5518A, and accessories	Hewlett Packard	40,000
2.	LAREA	Photoelectric autocollimator TA81, and accessories	Hilger Watts	16,000
3.	LAMAS	Electronic balances 5787, 5404 MP8, BFE 630Y, PFJ-761-E and accessories	Satorius, Mettler	25,000
4.	LAFOR	Load cells, U1, C3H2, C3 etc, up to 5 MN	HBM	41,000
5.	LACOM	Electro mechanical gauge block comparator, 16.10401 and accessories	Tesa	63,000
6.	LAMIT	Dial gauge comparator, 865SE, and accessories	Mahr	18,000
7.	LACOM	Quartz thermometer, 2804A, and accessories	Hewlett Packard	16,000
8.	LAPRE	Pressure multiplier, 200-800 bar No 1300	Desgranges	18,000
9.	LACOM	Gauge blocks, grade '00', 112 blocks, 516.937	Mitutoyo	8.500
10.	LAFRU	Personal computer, 85B	Hewlett Packard	10,000
11.	LACOM	Gauge blocks, grade '1', 82 blocks, 516.905	Mitutoyo	5,500
12.	LAPRE	Reference transducers for high pressures, 6903/6905	Kistler	10,000
13.	LACOM	Length bars, grade '00', 12 bars 125-1000 mm	Johansson	62,100
			Total Mechanical	333,100

Priority	CEMCI Code	Description	Manufacturer	Price US$
1.	LATED	Portable DC Voltage standard (transvolt) 9154D/120/A	Guildline	16,000
2.	LAENE	Test system for electrical energy meters, etalogyr 4001	Landys & Gyr	74,000
3.	LACAP	Standard capacitors 10 pF, 100 pF, 1000pF models 1404 : B/C/9701	General Radio	15,000
4.	LARES	Standard resistors 1Ω, 100Ω, 10kΩ Models 4210B, 4321B, 4323B	Leeds & Northrup	29,000
5.	LACAP	Standard inductors 100μH, 1mH, 10mH 100mH, 1H, 10H, Models 1432B,F, H, L, P. T	General Radio	23,000
6.	LARES	Decade resistance standard, RS5925D	ESI	9,200
7.	LARES	10KΩ transfer standard, SR1010	ESI	1,500
8.	LATEA	High frequency thermal convertor, A55	Fluke	10,000
9.	LTRON	Semi conductor parameter analyser, 4145A	Hewlett Packard	25,000
10.	LATED	Electronic voltage reference DC, 732A	Fluke	4,500
11.	LATED	Reference divider, 752A	Fluke	5,500
12.	LTRON	Synthesiser 6071A	Fluke	22,500
13.	LTRON	Calibrator 5101B	Fluke	14,000
14.	LATEA	AC/DC transfer standard, 7100.A	Guildline	8,000
15.	LATEA	AC voltage standard, 2703	Valhalla	6,100
16.	LTRON	Universal counter (time) 7261/A/331/529 and accessories	Fluke	4,000
17.	LTRON	Digital voltmeter, 7½ digits, 8650A	Fluke	6,200
18.	LTRON	Universal counter, 5335A	Hewlett Packard	4,200
19.	LATED	Programable voltage source, 3330B	Fluke	10,000
20.	LATED	Digital nanovoltmeter, 148	Keithley	8,000
21.	LATED	Current source, 0-12A, DCS105	Julie	10,000
22.	LTRON	AM/FM signal generator, 20/9A	Marconi	7,700

2. ELECTRICAL (Cont'd

Priority	CEMCI Code	Description	Manufacturer	Price US$
23.	LATEA	Active current shunt, AC/DC, 2575-A	Valhalla	2,000
24.	LATEA	Voltage calibrator DC/null detector 335-A	Fluke	8,900
25.	LATED	Multiple standard resistor, 9200	Guildline	4,400
26.	LATED	Calibrated current and voltage sources 6011A, 6115A, 6186C	Hewlett Packard	13,000
27.	LTRON	Modulation meter, 2305 and accessories	Marconi	17,000
28.	LATED	Voltage source DC, 10000 V, 410B	Fluke	5,000
29.	LAENE	High accuracy current transformer, TAM	Landys & Gyr	3,000
30.	LTRON	Logic analyser 1631/D	Hewlett Packard	13,000
			Total electrical	379,700

3. HEAT AND TEMPERATURE

Priority	CEMCI Code	Description	Manufacturer	Price US$
1.	LATEM	Test furnaces (3), type SE5020A	Chino Works	26,000
2.	LATEM	Temperature controllers for test furnaces (3), type SE 291	Chino Works	36,000
3.	LATEM	Accessories for tin, zinc and gold points	Chino Works	28,000
4.	LATEM	DCC Temperature and Resistance Bridge, 99751201	Guildline	24,000
5.	LATEM	Constant temperature oil bath, 9932 VT/120/AO	Guildline	8,500
6.	LAVOC	Analytical balance, 160g, H54AR+GD	Mettler	7,500
7.	LAVOC	Analytical balance, 3kg, 1264MP	Sartorius	3,600
8.	LAVOC	Sets of precision masses, 1mg-2kg	Kern	6,000
9.	LAVOC LATEM	Constant temperature baths (2) with refrigeration, TXVMB70	Tamson	12,000
10.	LATEM	Platinum resistance thermometers (2). 162 CE	Rosemount	4,000
11.	LATEM	Electronic voltage reference, 731B	Fluke	2,000
			Total heat and temperature	157,600

4. ACOUSTICS AND VIBRATION

Priority	CEMCI Code	Description	Manufacturer	Price US$
1.	LACUS	Computer, 9836S, and accessories	Hewlett Packard	27,000
2.	LARDO	Measurement amplifier, 2610	Brüel & Kjar	3,500
3.	LARDO	Measurement amplifier, 2636A	Brüel & Kjar	6,500
4.	LAVIB	Heterodyne amplifier, 2010A	Brüel & Kjar	15,000
5.	LAMBI	Sound level analyser, 4427, and accessories	Brüel & Kjar	12,000
6.	LAMBI	Signal generator, 4224	Brüel & Kjar	10,000
7.	LAVIB	Storage oscilloscope, 1741A	Hewlett Packard	8,500
8.	LACUS	Control unit for distortion measurements, 1902A	Brüel & Kjar	5,200
9.	LACUS	Sound level calibrators, 1562A and 1986	General Radio	2,000
10.	LACUS	Measurement amplifier, 2610A	Brüel & Kjar	3,500
11.	LACUS	Microphones (2), 4160	Brüel & Kjar	3,200
12.	LARDO	Microphone for external use (2) 4921, and accessories	Brüel & Kjar	10,000
13.	LAMBI	1" capacitative microphone (2), 4179	Brüel & Kjar	7,500
14.	LACUS	Frequency meter 5316 opt 001 and accessories	Hewlett Packard	3,000
15.	LAMBI	Audio analyser, 8903B	Hewlett Packard	9,500
16.	LAVIB	Accelerometer calibrator, 4294	Brüel & Kjar	1,500
17.	LAMBI	Measurement amplifier,2610A	Brüel & Kjar	3,500
			Total acoustics and vibration	131,400

Add :	1. Mechanical	333,100
	2. Electrical	379,700
	3. Heat and temperature	157,600
		US$1,001.800
Add:	20% for inflation since 1985	200,360
		Grand total US$1,202,160

RECOMMENDATIONS

The lists (1-4) of equipment are considered to be the minimum necessary to enable CEMCI to provide effective calibration and testing services for laboratories of RNC and RNLE and for industry. I understand that the original World Bank loan offer was US$2 million. Therefore, I recommend that up to US$1.2 million be spent as outlined.

The remaining US$800,000 should be apportioned among certain regional institutions as follows:

- Instituto de Pesquisas Tecnológicas (IPT) São Paulo: US$400,000 for force measuring equipment;

- Centro Tecnológico de Minas Gerais (CETEC), Belo Horizonte: US$250,000 for temperature standards and dimensional metrology;

- Laboratório de Metrologia and Automatização (LABMETRO), Florianópolis: US$100,000 for a three dimensional measuring machine;

- Instituto de Eletrotécnica, Universidade de São Paulo (IE-USP), São Paulo: US$50,000 for colour and photometric standards and measuring equipment.

These institutions should be invited to submit detailed proposals to CEMCI and the World Bank as soon as possible.

J.H. Buckingham

J.H. BUCKINGHAM

Wellington, New Zealand

25 November 1986

VISIT TO SÃO PAULO, 15-19 SEPTEMBER 1986

Dr. J.H.Buckingham
UNIDO Consultant in National Calibration Services

September 1986

SUMMARY

The purpose of the visit to São Paulo was to experience the operations of 4 selected institutions concerned with various aspects of industrial research, calibration, and testing. These institutions were selected by INMETRO/DQUAI staff as representative of accredited, or potentially accreditable, laboratories under the RNC and RNLE schemes. I was accompanied on the visits by Mr. A.J.Russell, UNIDO Consultant in Laboratory Accreditation Systems, and Mr. Luis Fernandes, INMETRO/DQUAI staff officer. During the visits, I presented 3 seminars on the calibration system in New Zealand and assisted Mr. Russell during his presentations on the Australian laboratory accreditation system, NATA. The institutions we visited were:

1) Instituto de Pesquisas Tecnológicas do Estado de São Paulo (IPT), 15/16 September.

2) Instituto de Eletrotécnica, Universidade de São Paulo (IE-USP), 17 September.

3) Instituto de Tecnologia de Alimentos, Campinas (ITAL), 18 September.

4) Instituto Mauá de Tecnologia, São Caetano do Sul (IMT), 19 September.

Air travel was arranged by INMETRO. The outward flight, VARIG 612, departed Rio at 10.10 hrs on Monday 15 September. We returned by flight 665, arriving Rio at 23.50 hrs on Friday 19 September.

This report details my impressions of the various institutions.

INSTITUTO DE PESQUISAS TECNOLÓGICAS (IPT)

1) Principal Contacts

- José Carlos de Castro Waeny, Assessor para Confiabilidade Metrológica.
- Sylvia L. Moro, Chefe de Agrupamento de Materiais de Referência.
- Peter J. Barry, Físico, Núcleo de Estudos de Acústica.
- Lúcia Angela de Genaro, Relações Públicas.
- Anna Ramalho, Relações Internacionais.

2) Sections Visited

Packaging research and testing; safety helmet testing; mechanical testing; railway and transport engineering; standard reference materials; mass, force and pressure measurement; acoustics and vibration measurement.

3) Impressions

Some of IPT's operations would rank with the best anywhere in the world. For instance, the care taken in the preparation of standard reference materials is excellent. The quality of these materials is recognised internationally and samples are sent to many overseas customers. The work of Miss Sylvia Moro and her group is a fine example of what can be achieved when overseas experience is combined with meticulous attention to detail. IPT's procedures in the area of standard reference materials serve as an excellent example of how to achieve a high quality operation. I congratulate them.

In the metrology laboratories, most of the equipment was in ibration and traceable to the national standard of length maintained by CEMCI. Environmental control of these laboratories was good and the laboratory space was accessed via air locks. I was pleased to see a policy of no smoking was strictly observed and access limited to authorised personnel. Measurement procedures conformed with international practice and I have confidence in the metrological services performed. However, an apparent shortage of staff may preclude a rapid turn-round of items submitted for test. In the metrology operations and the production of reference materials it was pleasing to see the emphasis on interlaboratory "round-robin" testing and proper statistical analyses of measurement results.

In the area of mass measurement, IPT possesses a BIPM-calibrated gold plated kilogram, but unfortunately this is not used. However, IPT maintains traceability via CEMCI-calibrated stainless-steel masses.

The acoustics work covered a wide range of applications and represented the great drive and energy of Peter Barry, Physicist in charge. His innovative ability has resulted in novel solutions to many problems and shows what can be done to overcome problems with equipment and facilities. It is unfortunate that he was not consulted by CEMCI during the design phase for its new acoustics facility at Xerém. I recommend he be invited to CEMCI to pass on his knowledge and experience.

IPT's suite of reverberation rooms are housed in a converted warehouse and, when complete, should provide one of the most extensive facilities of its type that I have seen anywhere. I was particularly impressed by the arrangement for test wall insertion in 2-room testing. Some of the electrical equipment had traceable calibration to CEMCI, but it is recommended that IPT endeavours to participate in the current international round-robin of microphones and accelerometers organised by NBS (USA). IPT should attempt to provide the resources necessary for early completion of its main anechoic chamber. This will enable the full range of acoustic testing to be undertaken.

The laboratories responsible for mechanical testing, packaging, etc had some shortcomings. For instance, the air conditioning system in those areas was not capable of providing environmental control to the required tolerances ($\pm$ 1°C and $\pm$ 5% RH). If such tight control is critical to tests on paper board, it is recommended this situation be rectified by installing a number of free standing air conditioning units of the large Hitachi type. Similarly, the main environmental test chamber was old, badly corroded, and poorly maintained. The door does not fit properly and it is debatable whether the chamber serves any useful purpose. In addition, I detected a certain naivity with regard to the need for traceable measurements. Consequently, a number of instruments were either out of calibration or had never been calibrated.

However, the staff in these areas demonstrated the same innovative ability which I noticed in other IPT sections. For instance, a home-made apparatus for penetration tests on paper board was very effective. A disused lift shaft had been converted for drop tests on containers. I was particularly impressed with the way a small calculator with paper print-out had been incorporated into a portable force measuring equipment.

In general, I was pleased to see the enthusiasm of staff throughout IPT. Their desire to extend and upgrade their operations is obvious. Dr. Waeny is a great asset in this respect. He is highly self-motivated and, with his experience and guidance, I am sure IPT will make a valuable contribution to RNC and RNLE activities.

INSTITUTO DE ELETROTÉCNICA (IE-USP)

1) Principal Contact

- Dr. Ernesto João Robba, Diretor

2) Sections Visited

Electrical Metrology, Electrical Instrument Checking, Optics and Photometry, Electrical Machine Testing, Explosion Proof Testing.

3) Impressions

Although the facilities at IE-USP are old (part of the original university buildings), the staff are highly professional and, for the most part, supported by good instruments and equipment. All staff recognised the need for traceable calibration, and the electrical metrology laboratory was a model of what can be achieved in this respect. Most of the reference instruments had current calibrations from CEMCI, although that for the Guildline DC voltage standard will need renewing in December 1986.

IE-USP has gone to considerable trouble to ensure proper environmental control for its electrical standards.

I must admit to a certain confusion over the terms "aferição" and "calibração". As I understand it, the former means a check without instrument adjustment while the latter involves a check, adjustment, subsequent check, readjustment, etc until the instrument under examination reads correctly. In international terms, both these operations are covered by the single word "Calibration" since this implies a statement as to the reading of an instrument when measuring a physical quantity of "known" magnitude ("known" in the sense that the magnitude is guaranteed to be within certain prescribed limits of accuracy). However, given that the words "aferição" and "calibração" do have quite distinct meanings in Brasil, the "aferição" laboratory is well run and competently staffed and, I believe, should be upgraded to a calibration laboratory under the RNC system.

Similar competence is demonstrated by staff in the optics and photometry laboratory. However, that laboratory is in need of traceable spectroradiometric measurements. I believe IE-USP should purchase 2 spectroradiometric standard lamps with full NBS calibration to overcome this problem. Although the initial cost would be in the region of US$ 3000 per lamp, this would improve the reliability of colour measurements for many years and would supplement the photometric standards currently held by the laboratory.

Unfortunately, CEMCI has no photometric or colorimetric facilities or experience at the present time, so IE-USP and other light and colour measuring laboratories will need to rely on overseas calibration of their standards for some time to come. I have suggested that IE-USP seek advice from NRC Canada and NML Australia when considering extensions to its existing colour and photometric operations.

IE-USP has difficulty in maintaining the integrity of the barium oxide coating on integrating spheres, and I have suggested the staff experiment with "halon" powder instead. Halon powder is a finely divided fluorohalocarbon resin similar to PTFE and can be pressed into place unlike barium oxide. The latter has to be applied as a wet emulsion and tends to flake off when drying. Halon powder is now accepted internationally as providing the same spectral homogeneity and reflectivity as barium oxide.

The testing of electrical machines and explosion proof housings for electrical equipment represents a large part of IE-USP operations. Both aspects are supported by good staff and equipment (most of which is in calibration). For instance, in explosion testing, the constitution of various air/gas mixtures is checked by gas chromatography, and flame propogation by high speed electronics. IE-USP's explosion testing operations have been approved by the Underwriters' Authority of Canada.

Tests on electrical machines, equipment, and conductors up to 10 kV (and up to 300 kVA) include brake tests, insulation tests, weld tests, and dynamic balancing. All are competently performed and are frequently used to support exports of electrical equipment.

Dr. Robba and his enthusiastic staff are to be congratulated on a very professional operation. As with IPT, IE-USP should become a valuable member of both RNC and RNLE.

INSTITUTO DE TECNOLOGIA DE ALIMENTOS (ITAL)

1) Principal Contact

- Iacy dos Santos Draetta, Diretor-Divisão de Pesquisa.

2) Sections Visited

Food biochemistry, organoleptic testing, general analytical chemistry, meat processing pilot plant.

3) Impressions

ITAL is a research and development organisation which does some product testing for the food industry. It publishes its own house journal on its research activities. ITAL also coordinates a quasi test-house scheme for checking the quality of food used in educational institutions throughout Brasil.

I understand that ITAL research activities are recognised internationally and that many of the staff have been trained overseas. However, it was disturbing to note some ignorance of the need to make traceable measurements in both research and testing of foods. Although most of the sections visited maintained fairly extensive manuals of analytical procedures, I did not see any instruments which had been calibrated by CEMCI. Consequently, although it could be argued that any testing is better than no testing at all, the validity of some of the tests performed by ITAL and its "accredited" laboratories must be open to doubt.

At this stage, it is doubtful whether ITAL would be acceptable as an accredited laboratory under the RNLE scheme. The first step will be to educate the staff on the importance of having their equipment calibrated at regular intervals - especially the sets of reference masses which form the basis of all chemical measurements. In-house equipment checks should always be done using instruments that are in calibration. Also, a better understanding of measurement uncertainties appears to be required by many of the staff. Even if it is not possible to obtain equipment calibrations immediately, a calibration schedule should be established prior to any RNLE assessment visit to ITAL.

ITAL has the potential to become a reliable test-house under the RNLE scheme. Its facilities are good, most of the equipment is serviceable, and its staff are undoubtedly competent researchers. However, as with many research workers throughout the world, those at ITAL tend to the belief that their instrument readings are correct and exact. Hence the need for an educational program.

INSTITUTO MAUÁ DE TECNOLOGIA

1) Principal Contacts

- Hélio Nanni, Vice-Diretor Adjunto
- A. Octavio M. Andrade, Professor, Deptº de Engenharia Elétrica.
- Edson S. Iwamoto, Engenheiro, Deptº de Engenharia Mecânica.

2) Sections Visited

Dimensional engineering metrology, mechanical testing, metallography, paint testing, fermentation chemistry, food technology (pilot plants), microwave engineering and research.

3) Impressions

IMT is primarily an educational institution. Privately funded, it provides technology courses for some 2500 students. It undertakes research and some testing for industry. As with ITAL, there are problems of traceability in its measurement operations.

For instance, the temperature sensors in the dimensional metrology laboratory had never been calibrated and were placed on the walls remote from the measurement site. This laboratory also has windows down one side which could give rise to unwanted heat loading during sunny conditions. There was a general lack of appreciation of the need to quote uncertainties in measurement results or to record the temperature. The reference sets of gauge blocks and end bars did have calibration certificates (supplied by the manufacturer) and these instruments are used to check the accuracy of a small coordinate measuring machine and other equipment. However, as it was pointed out, the laboratory is primarily a teaching facility, and so the emphasis is on training in the use of measuring equipment rather than in its calibration. The metrology laboratory is experiencing problems with shrinkage in zinc moulds used for profiling manufactured components. This problem appears to be associated with the high temperatures which occur during the moulding process. I suggested experiments with fibre-glass moulds may overcome this problem. Most of the equipment was fairly new and in good condition. I do not believe it would be difficult to arrange an acceptable calibration schedule in this laboratory.

Similar non-traceability was associated with the proving rings used for calibrating tensile and compression testing machines, and with the sets of masses in the chemical laboratories. A certain amount of equipment was unserviceable and some laboratories appeared to be short of staff.

In the area of microwave engineering, there was some attempt to get over the measurement traceability problem. However, with microwave power measurements, traceability is notoriously difficult to arrange and is proving to be the limiting factor in the testing of microwave ovens intended for commercial use in Brasil.

There is evidence of some very innovative research at IMT. For example, attempts are being made to measure the dielectric constant of oil shale at 600°C. This is to determine whether microwave heating could be used to extract the oil from the material. Unfortunately, at 600°C, corrosive by-products from the oil shale seem likely to damage the S-band waveguide used for the experiment. I have suggested that attempts be made to gold plate the cavity to alleviate this problem. In another interesting experiment, attempts are being made to detect metallic particles in absorbent pads by means of 10 GHz microwaves. This is to solve the quality control problem a manufacturer is experiencing in the production of baby napkins. One of the most elegant demonstrations of waveguide modes that I have ever seen has been developed by Dr. Andrade. Using a slotted line and a microwave detector, the student "draws" the modes on graph paper by a pantograph pen attachment while keeping the amplitude of the oscilloscope trace constant. A beautifully simple apparatus which would be of great value in any teaching institution.

In general, although IMT operations are not traceable to CEMCI's standards at the present time, it could become a very valuable member of RNLE once its equipment is in calibration. IMT produces a brochure of its testing capability. Although, at first sight, the number of tests which IMT claims it can perform appears rather large, I have no doubt the facilities exist to do the work. The lack of suitably trained staff may be the limiting factor.

CONCLUSIONS

All laboratories visited have problems with traceability in measurement. Two of them (IPT and IE-USP) are obvious candidates for

RNC and RNLE operations. The other institutions (ITAL and IMT) are potentially accreditable, although it may take some time to arrange the necessary calibration of their reference instruments. However, it should be noted that all 4 institutions are considerably more competent than many laboratories in my own country. This competence coupled with an obvious enthusiasm to improve performance is very encouraging and augers well for the future of testing in Brasil.

J.H. Buckingham

23 September 1986

ASSIGNMENT WITH INMETRO/CEMCI, XERÉM-RJ-BRAZIL :

FINAL REPORT TO UNIDO

Dr J.H. Buckingham
UNIDO Consultant in National Calibration Services

December 1986

Summary

This report summarises the current situation with regard to Brazil's national standards of measurement and how these and associated calibration services might be improved. It outlines my work with INMETRO/CEMCI (Centro de Metrologia Científica e Industrial), together with associated activities since leaving Brazil. It should be read in conjunction with my detailed reports on the assignment, copies of which are attached.

ASSIGNMENT WITH INMETRO/CEMCI : FINAL REPORT

Contents	Page

Introduction

There is a growing awareness in Brazil of the importance of traceable measurements to industrial quality control. Brazil's most advanced industries (aerospace, electronics, steel, etc) have established excellent quality assurance procedures and, consequently, are acquiring international reputations for reliability. Their products compete well with those of other countries and are having a significant effect on the Brazilian economy.

However, INMETRO (the National Institute for Metrology, Standardization, and Industrial Quality) is conscious that this reputation for quality and reliability does not extend to many industries in Brazil at the present time. INMETRO has embarked on a vigorous campaign to improve the situation. It is hoped that this campaign will ultimately reduce the number of sub-standard products and increase both exports and import substitution.

My assignment with INMETRO was originally to improve the quality and efficiency of the services performed by its centre for scientific and industrial metrology (CEMCI). The demand for these services is growing as industries become aware that effective quality control depends on the use of measuring instruments whose calibrations are traceable to the national standards of measurement. Latterly, my work extended into the areas of laboratory accreditation, legal metrology, and industrial quality assurance.

The initial phases of my assignment were difficult for two reasons:

1. The briefing papers supplied before I left New Zealand were inadequate. Consequently, my background knowledge of Brazil's measurement problems was insufficient for me to develop any tentative work plan prior to commencing the assignment. Fortunately, on my arrival at INMETRO/CEMCI, I was immediately asked to comment on some recommendations concerning CEMCI's future activities which had been prepared by an officer of the US National Bureau of Standards. From then on, the problems requiring my attention tended to present themselves. However, I do urge UNIDO to address the question of supplying <u>complete</u> background details of projects to its future consultants and experts. Without such documentation, there will always be the possibility of an expert prejudging a situation, or of 're-inventing the wheel' by embarking on work previously covered by others. Again, given the limited duration of an assignment, background research should be done before the event rather than during it if UNIDO and the recipient nation are to obtain the full benefit of a consultant's services.

2. The level of English spoken and understood by the staff in CEMCI is not high. This language problem was not made clear to me prior to the assignment. Had it been, I would have endeavoured to acquire some knowledge of Portuguese before leaving New Zealand. Consequently, for the first two months of my assignment, communication with my local

counterparts was difficult to say the least. Fortunately, by virtue of considerable patience on the part of my CEMCI colleagues and some very good friends, I was able to gain a useful working knowledge of Portuguese in the last two months. Communications were improved to the point where it was possible for me to present a one hour seminar in Portuguese without notes. However, the fact that I can now speak, write and understand Portuguese should not be construed as negating the underlying problem. I am fortunate to possess a certain linguistic ability and a desire to communicate in the language of the country to which I have been invited. Other experts may not have the same incentives or opportunities. Therefore, I believe UNIDO should place more importance on language qualifications than is apparently the case at present.

The various phases of my assignment have already been documented in a series of reports which I have passed to UNIDO's chief technical adviser in Rio de Janeiro, Dr B.S. Krishnamachar. I understand he has sent, or is in the process of sending, copies of these documents to UNIDO headquarters in Vienna. However, I enclose further copies with this report in order to provide a complete record of my Brazilian activities. The documents are as follows (in order of preparation):

1. Comments on papers prepared by Dr K.G. Kestler NBS (USA) July 1986.

2. Measurement traceability in Brazil: first impressions. August 1986.

3. Dissemination of time and standard frequencies in Brazil. August 1986.

4. A quality manual for the Centre for Scientific and Industrial Metrology. August 1986.

5. O Sistema de Calibração em Nova Zelândia (in Portuguese). September 1986.

6. Report on visits to São Paulo, 15-19 September. September 1986.*

7. Laboratory accreditation in Brazil. October 1986.

8. Report on visits to Adrianópolis, Petrópolis, Belo Horizonte, Montes Claros, and Florianópolis, 8-29 October. November 1986.

9. Basic concepts of scientific and industrial metrology. November 1986.

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*Missing from present set. I have telexed INMETRO/CEMCI for another copy. This will be sent to UNIDO Vienna as soon as possible.

Also enclosed are copies of covering memoranda to Dr Krishnamachar and the report "Extensions to CEMCI facilities: proposals for equipment purchases during 1987". This report was completed following my return to New Zealand.

ITINERARY

19 Jul 86:	1900.	Dep Lower Hutt (New Zealand) by car
	1945.	Arr Wellington Airport.
	2030.	Dep Wellington, NZ486.
	2130.	Arr Auckland, flight time 1 hour.
	2359.	Dep Auckland, TE002 (cross Date Line gain 24 hours).
	1655.	Arr Los Angeles, flight time 11 hours 56.
	1730.	Arr hotel (Sheraton Plaza La Reina) (overnight stay in Los Angeles).
20 Jul 86:	1200.	Dep hotel.
	1600.	Dep Los Angeles, PA441 (delayed 2 hours)
	2330.	Arr Miami, flight time 4 hours 30.
21 Jul 86:	0130.	Dep Miami, PA441 (continued).
	1045.	Arr Rio de Janerio, flight time 8 hours 15.
	1155.	Arr hotel (Riviera, Copacabana).
22 Jul 86:	0900.	Reported for duty at INMETRO/CEMCI, Xerém. At the end of my first week with CEMCI, I moved to the Casablanca Hotel, Petropolis since this was more convenient to Xerem.
		Detailed summaries of my meetings and contacts at INMETRO and other Brazilian institutions have been lodged with Dr Krishnamachar.
10 Nov 86:	Last day of duty at INMETRO/CEMCI.	
11 Nov 86:	2350.	Dep Rio de Janeiro, RG742.
12 Nov 86:	1330.	Arr Frankfurt, flight time 10 hours 40.
	1630.	Dep Frankfurt, LH254.
	1800.	Arr Vienna, flight time 1 hour 30.
	1930.	Arr hotel (Parkhotel Schönbrunn) (overnight stay in Vienna).
13 Nov 86:	0900.	Debriefing, UNIDO headquarters.
	1850.	Dep Vienna, BA605.
	1950.	Arr London, flight time 2 hours.
	2130.	Arr hotel (Coburg Hotel, Bayswater)
14 Nov 86:	1030.	Conference at UK National Physical Laboratory re - Brazil's laboratory accreditation requirements.
15 Nov 86:	Saturday. Day off in lieu of authorised rest day between Rio de Janeiro and Vienna.	
16 Nov 86:	1430.	Dep London, JL422.

16 Nov 86:	1420.	Arr Anchorage, Alaska, flight time 8 hours 50.
	1600.	Dep Anchorage, JL422 (continued) (cross Date Line, lose 24 hours).
17 Nov 86:	1830.	Arr Tokyo, flight time 7 hours 30.
	2130.	Dep Tokyo, JL775.
18 Nov 86:	1000.	Arr Nadi (Fiji), flight time 8 hours 30.
	1100.	Dep Nadi, JL775 (continued)
	1350.	Arr Auckland, flight time 2 hours 50.
	1550.	Dep Auckland, NZ455.
	1650.	Arr Wellington, flight time 1 hour.
	1800.	Arr Lower Hutt.

ACTIVITIES SINCE LEAVING BRAZIL

1. Debriefing at UNIDO, Vienna (13 November)

My debriefing officer was Mr Martial Comble, Assistant Industrial Development Officer. I was surprised to learn that he had not seen any of the documentation I had produced in Brazil. Mr Comble made enquiries with other staff at UNIDO headquarters, but nobody with whom he spoke had any knowledge of my reports. I can only assume that these have been delayed in transit from Rio de Janeiro to Vienna.

This is rather unfortunate since the documentation was produced at intervals to make it less cumbersome, more easy to read, and to keep UNIDO up to date with my activities. Also, I hoped that, by producing a series of reports, this would enable UNIDO to provide me with feedback regarding the progress and most appropriate future directions for the project.

Fortunately, I had brought copies of most of the documentation to Vienna and was able to go over this with Mr Comble. In this connection, I am pleased to report that Dr Woodward Eicke, UNIDO consultant, who is currently working at INMETRO/CEMCI supports my comments with regard to CEMCI's future development. Formerly with the US National Bureau of Standards, Dr Eicke considers that NBS's proposals for fundamental research at CEMCI are somewhat inappropriate and that a more practical approach is called for if CEMCI is to be of real use to Brazilian industries.

As far as CEMCI's current operations are concerned, it is important that the staff commence to document the procedures used in the laboratory. The large turnover of staff within CEMCI means that relatively inexperienced people are often required to perform complex measurement operations. Therefore, without written instructions, there is a very real possibility of error at the present time.

Consequently, I spent some time developing proposals for quality assurance procedures within CEMCI, and advising and training staff in their use. In preparing these proposals, I deliberately chose as my "guinea pigs" those members of staff considered by CEMCI director Dr Alexandre Sette Camara to be most opposed to formal

Q.A. procedures. I reasoned that, if I could convince them, there would be no problem convincing other staff. I am pleased to report that my assumption was correct, that the proposals have been well received, and that they are now being implemented.

I should mention that while preparing these proposals, I was mindful of the danger of attempting to reproduce any system which might work in my own institution. I believe I avoided this temptation. Great care needs to be taken to ensure that advice is always appropriate to the local situation, and not that of an expert's home environment. Again, gentle persuasion is invariably more successful than a dogmatic approach - and, of course, the latter is impertinent! Therefore, I endeavoured to write the proposals in a form which was not only "acceptable" to CEMCI staff, but also could be adapted easily to suit local conditions. By illustrating the text with examples of where my own institution had made mistakes by departing from procedures, I was able to sustain the interest of CEMCI staff and enlist their support for the implementation phase of the project.

The other major aspect of my work at CEMCI was in the area of laboratory accreditation. Consequently, there was some overlap between my responsibilities and those of Mr A.J. Russell of Australia's National Association of Testing Authorities (NATA). Mr Russell acted as a UNIDO consultant to Rede Nacional de Laboratorios Ensaios (RNLE), Brazil's accreditation scheme for testing laboratories, while I advised the staff of Rede Nacional de Calibração (RNC), the national calibration network. The main thrust of my work was a discussion of the full implications of laboratory accreditation and the resources necessary to operate an extensive program.

At this stage, I am not convinced that Brazil should model its proposed joint (RNC and RNLE) accreditation program on only one of the systems operating overseas. Therefore, I advised Mr Comble of my intention to discuss Brazil's requirements with staff of the UK National Measurement Accreditation Service (NAMAS) before returning to New Zealand. NAMAS operates from the UK National Physical Laboratory at Teddington, near London. It was therefore a relatively simple matter to organise my homeward itinerary to include a London stopover for this purpose.

At the present time, Brazil has only received advice about the Australian (NATA) and New Zealand (Testing Laboratories Registration Council, TELARC) schemes. Successful though these schemes undoubtedly are, I consider that knowledge of other systems, particularly those of the United Kingdom, and the United States is desirable before Brazil becomes committed to a particular course of action.

2. Meeting at NPL Teddington (14 November)

I had a most useful meeting with Mr J.D. Summerfield, executive director of NAMAS.

The NAMAS organisation is interesting since it resulted from the 1985 amalgamation of the British Calibration Service (BCS) and the National Testing Laboratory Accreditation Scheme (NATLAS). A parallel situation is envisaged in Brazil now that INMETRO has proposed the amalgamation of RNC and RNLE into a single authority, Rede Nacional de Laboratorios (RNL).

Mr Summerfield supports my contention that, with such an amalgamation, care needs to be exercised to ensure that both components receive appropriate support. Also, that one does not sap the resources of the other. Such problems existed between BCS and NATLAS during the formative stages of NAMAS.

At the time of our meeting, Mr Summerfield had recently returned from the 1986 International Laboratory Accreditation Conference (ILAC), held in Tel Aviv. Unfortunately, Brazil was not represented at ILAC 86, although laboratory accreditation in that country was discussed by the Australian delegation.

I discussed the content of my report on Brazil's requirements with Mr Summerfield, and he is in broad agreement with my recommendations. He has undertaken to supply Mr Eduardo Luiz da Silva, co-ordinator of RNC and acting director of CEMCI, with full details of, and documentation pertaining to, the NAMAS system and to help Brazil in any other way possible. I was heartened by his insistance that this documentation would be supplied free of charge - a refreshing change from the attitude of many organisations whose major preoccupation at the present time seems to be one of making financial recoveries!

It is interesting to record that NAMAS has recently advised Thailand on the implementation of a laboratory accreditation scheme. Mr Summerfield told me that the Thai Ministry of Science, Technology and Energy had adopted virtually all the recommendations pertaining to laboratory accreditation which I had made during the course of a UNESCO assignment with that organisation in 1983.

I hope the comments made during the present assignment are of similar value to Brazil.

3. CEMCI Equipment Purchases during 1987

Since returning to New Zealand, I have prepared a series of proposals for new equipment which I hope CEMCI will be able to acquire by means of a US$2 million World Bank loan. I consider that this equipment is the bare minimum which is required in order for CEMCI to provide an efficient calibration service to the laboratories of RNC, RNLE, industry, and other Brazilian organisations.

In that report, I emphasize the need for CEMCI to consolidate its present position and not to embark on areas of measurement currently outside its experience. It is important for CEMCI to delegate such activities and not to attempt to reproduce resources and facilities already well established elsewhere in Brazil. Otherwise, CEMCI's staffing problems will only become more severe, and lead to an undesirable reduction in existing services.

I understand that under the terms of the World Bank loan, the equipment should have been purchased before the end of the current financial year (31 December 1986). However, since other loan conditions were not feasible (particularly those relating to CEMCI staff and research programs), these have had to be renegotiated. Therefore, I am hopeful that the time limit can be extended for a further 12 months. Should the World Bank require further comments from me about this matter, I will be happy to supply them.

CONCLUDING REMARKS

From comments made to me by UNIDO staff in Rio de Janeiro and Vienna, I understand that, at present, there is some discussion regarding the continuing availability of UNIDO funds for the project BRA/82/020. Since this project is only now beginning to realise its full potential, I believe it would be extremely unfortunate if the funding was not continued for at least another two years.

Although Brazil can be considered an industrialized nation, much work remains to be done to improve the measurement infrastructure between CEMCI and the industrial workface. More effort is needed in the areas of education, training, planning and resource management to ensure the ultimate success of the project.

For instance, the whole concept of laboratory accreditation in Brazil needs to be reconsidered. The problem of building up a resource pool of advisors and laboratory assessors for the accreditation programs has yet to be addressed. Detailed accreditation procedures and criteria for registration of accreditable laboratories have to be developed. These activities take considerable time.

Again, CEMCI has severe staff retention problems. These need to be overcome, and additional staff recruited to enable CEMCI to extend its services. Other areas of INMETRO, particularly the legal metrology network (state weights and measures institutes), RNC and RNLE, are similarly understaffed. Given the Brazilian Government's aim to reduce expenditure in the public service, recruitment of additional technical staff is extremely difficult at the present time.

Therefore, it is suggested that INMETRO investigate the possibility of reducing staff ceilings in other areas to compensate for the extra staff required by CEMCI etc. Given the already high staff turnover rate in INMETRO, and normal attrition through retirement, I believe such 'redeployment' could be achieved relatively easily and without enforced redundancies. The problem of staff retention within CEMCI should be addressed at the same time. Currently, conditions of service, salaries, promotion prospects etc, do not compare favourably with those existing in the private sector. Consequently many technical staff are attracted to other institutions after spending less than a year at CEMCI.

One other major problem should be mentioned. Currently, a number of appointments within INMETRO are political in nature. Therefore, a change of government (or minister), or a disagreement over policy, can result in a change of certain very senior staff in INMETRO. For instance, INMETRO has had five different presidents during the last four years. The last to resign (Juarez) did so in October 1986. As a consequence, CEMCI director, Dr Alexandre Sette Camara, had to resign as well. Alexandre was appointed by Juarez only in October 1985. A materials scientist by training, Alexandre had been director of a nuclear materials research laboratory prior to his CEMCI appointment. He was not experienced in metrology and, consequently, was only beginning to appreciate the problems associated with measurement standards and calibration services when he was forced to resign.

Not surprisingly, the morale of the staff at CEMCI is rather low at the present time. Such a rapid turnover in senior management makes it quite impossible to plan the future of an institution like CEMCI, or to organise the activities of its staff in an effective manner. It is usually considered detrimental to an institution if its director does not remain in place for at least five years. It is to be hoped that a lasting solution to this type of problem can be found, and that the staff at CEMCI can experience a more stable management structure. I urge the Brazilian Government to give some thought to this matter.

In conclusion, I must say that I found my assignment in Brazil most challenging and the staff at CEMCI and elsewhere very receptive to my proposals. Consequently, it was unfortunate that certain pressures from within New Zealand necessitated shortening my time with CEMCI by approximately one month. However, I hope that the work I have been able to complete since leaving Xerẽm compensates in some way for my early departure, and that, overall, my proposals prove to be of long term benefit to Brazil's national calibration services and measurement infrastructure.

I thank UNIDO and the Government of Brazil for the opportunity to be of service to INMETRO/CEMCI. For me, it has been a great privilege and a real pleasure.

ACKNOWLEDGEMENTS

UNIDO, Vienna - for funding the assignment, arranging my international travel, and meeting the cost of my accommodation and living expenses;

DSIR, New Zealand - for allowing me to undertake the assignment;

B.S. Krishnamachar and his staff, UNIDO, Rio de Janeiro - for local arrangements;

Alexandre Sette Camara, director of CEMCI until 17 October 1986 - for his enthusiasm and support for my suggestions;

José Joaquim Vinge and other CEMCI staff - for their willing assistance and constructive comments;

Eduardo Luiz da Silva and his RNC staff - for arranging my visits to other institutions;

INMETRO Administration - for providing excellent support services and for funding my travel within Brazil;

Raymundo A Razende, engineer - for his companionship when it was most needed;

Maria Natalina Martins, dental surgeon - for her patience and tranquility while teaching me Portuguese;

Maria das Graças Cardoza (Graça), my secretary at CEMCI - for her excellent typing and preparation of manuscripts;

My wife, Rosalind, and my three sons, who had to remain in New Zealand - for their encouragement and support during a difficult period for them.

I am indebted to these people and organisations, and to many other Brazilian colleagues and friends. I hope the results of my labours justify the trust you have all placed in me.

J.H. Buckingham

J.H. BUCKINGHAM
Wellington, New Zealand

3 December 1986

APPENDIX TO FINAL REPORT

MAJOR CONTACTS:

1 UNIDO:

Dr B.S. Krishnamachar, Chief Technical Advisor, Rio de Janeiro
Mr Martial Comble, Assistant Industrial Development Officer, Vienna
Mr C.H. Winkelmann, Project Personnel Recruitment Officer, Vienna

2 INMETRO:

Dr Alexandre Sette Camara, Director of CEMCI
Sr José Joaquim Vinge, Chief of Electrical Group, CEMCI
Sr Mauro Corrêa Fagundes, Physicist, Electrical Group, CEMCI
Sra Dulce Aparecida Liechoski, Physicist, Electrical Group, CEMCI
Sr Luiz Macoto Ogino, Physicist, Electrical Group, CEMCI
Sr Ivan Marreiros de Costa, Technical Officer, Electrical Group, CEMCI
Sr Walmir Pinheiro de Aranjo, Physicist, Electrical Group, CEMCI
Sr Marcos Aurélio Maciel, Technical Officer, Temperature Group, CEMCI
Sra Joana D'Arc de Brito, Electronics Engineer, Electrical Group, CEMCI
Sr Florisvaldo Sampaio, Physicist, Optics Co-ordinator, CEMCI
Sra Lélia Rita Monteiro, Physicist, New Buildings Co-ordinator, CEMCI
Dr Joern Zinkernagel PTB, Adviser on Electrical Instruments, CEMCI
Dr Woodward Eicke, UNIDO Consultant in Electrical Metrology, CEMCI
Sra Maria das Graças Cardoza, Secretary, CEMCI
Sra Iris Andrade de Carvalho, Secretarial Assistant, CEMCI
Sr Eduardo Luiz da Silva, Physicist, Co-ordinator of RNC
Sra Regina Coeli Mendes, Physicist, RNC
Sra Maria Teresa Rozeira, Physicist, RNC
Sra Isabel Laurenço Japor, Physicist, RNC
Dr Armenio Lobo da Cunha Filho, Director of DIMEL
Sra Silvia Helena Moto Rabelo, Physicist, DIMEL
Sr Lino Oliveira Marujo, Engineer, DIMEL
Sr José Eduardo Alves da Costa, Co-ordinator for International Affairs
Dr Joseph Brais, Director of DINOR
Dr Nilo Antonio Severino, Director of DQUAI
Dr Humberto Beltramini, Executive Director, General Administration
Dr Júlio Villas Lopes, Director of Finance, General Administration
Sr Ramundo A. Razende, Engineer, General Administration
Mr A.J. Russell, UNIDO Consultant in Laboratory Accreditation
Mr D.W. Parry, Director, Philip Harris Holdings UK, World Bank Consultant

3 IPT Sao Paulo

Dr José Carlos de Castro Waeny, Metrology Quality Assurance Assessor
Mr Peter J. Barry, Physicist, Acoustic Studies
Dra Sylvia L. Moro, Chief, Reference Materials Group
Sra Anna Ramalha Co-ordinator for International Relations
Sra Lucia Angela de Genaro, Public Relations Officer

4 IE-USP, Sao Paulo

Dr Ernesto João Robba, Director

5 Instituto de Tecnologia de Alimentos, Campinas

Dr Iacy dos Santos Draetta, Director of Research

6 Instituto Maua de Tecnologia, S Caetano do Sul

Dr Hélio Nanni, Vice-Director
Dr Octavio M. Andrade, Professor, Microwave Engineering
Sr Edson S. Iwamoto, Engineer, Mechanical Testing

7 CEPEL Adrianópolis

Sr Marcelo Appel da Silva, Chief, Measurement Division
Sr Agenor O.F. Mundim, Chief, High Voltage and Power Division

8 CELMA, Petrópolis

Sr A.S. Ecimar, Engineer, Test Cells
Sr G.D.P.S. Jose, Engineer, Helicopters Section
Sr Eduard G. Stumpf, Engineer, Metrology Section
Sr Renato M. Soares, Engineer, Metrology Section
Sr Ricardo Gentil, Physicist, Non-destructive testing

9 Equipamentos Villares, Sao Paulo

Sr Ruy Cortez de Oliveira, Supervisor, Technical Standards

10 IPEM - Minas Gerais

Dr Helio Oliveira de Souza, Director General
Dr Roberto Guimaraes, Technical Director

11 CETEC - Minas Gerais

Dr João Lopes Faria Neto, President
Dr Harry Gomes, Professor, Organic Chemistry
Dra Sonya Calil, Mathematician, Water Laboratory
Sr José Eustáquio da Silva, Engineer, Metallurgy Department

12 Magnesita, Belo Horizonte

Dr Carlos Alfonso, Head of Research Division
Sr Arnaldo Lucas Machado, Head of Standards Division

13 Fiat Automoveis, Belo Horizonte

Sr Gilvan Ferreira, Engineer, Head of Metrology

14 Labmetro, CERTI, Florianópolis

Sr Nelson Schoeler, Engineer, Metrology Section
Sr Armando Goncalves, Superintendent of Technological Research

15 NAMAS, Teddington, UK

Mr J.D. Summerfield, Executive Director