OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

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

17149

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Provision of Consultancy Services on the Establishment and Operation of Metrological Laboratories for the National Metrology Centre in Ethiopia

Project No. DP/ETH/84/006
Contract No. 87/74

Vneshtechnika, Moscow
Gosstandard

Polytechna, Prague
Czechoslovak Institute
of Metrology

July 1988

RESTRICTED

April 1988
English

NATIONAL METROLOGY CENTRE

DP/ETH/84/006

ETHIOPIA

Final Report

Prepared for the Government of Ethiopia by the United Nations Industrial Development Organization, acting as executing agency for the United Nations Development Programme.

Based on the work of the contractor's Team for provision of consultancy services on the establishment and operation of Metrological Laboratories for the National Metrology Centre.

During the period of six months from 15th October 1988 up to 14th April 1988.

United Nations Industrial Development Organization
Vienna

CONTENTS

1. INTRODUCTION

The National Metrology Centre /NMC/ is being now created with help of UNIDO in premises of Ethiopian Standards Authority under project DP/ETH/84/006. NMC in Addis Ababa and its branches located in Asmara, Dire Dawa, Jimma, Awassa, Dessie, Debre Marcos, Assab, Nazareth , Debre Berhan and Massawa will be responsible for verification, calibration and inspection of measuring instruments of the whole country.

In accordance with the first step of creation of the state metrological service, the primary standards will be developed in some measuring fields such as mass, length and angle, temperature, time and frequency, electrical units, pressure and force. The measuring instruments used in industry, trade, transport, health services and other areas of Ethiopian economy can be verified and controlled by means of reference devices using hierarchy schemes. Without solution of this problem, the technical progress of these areas, quality ensurance of production, equipment, machines, development of the national resources, export and import production are impossible.

According to UNDP/UNIDO project DP/ETH/84/006, the establishment of NMC oversees the following activities:

- the installation, operation and testing of equipment of metrological laboratories: length and angle, mass, density and viscosity, temperature and volume, electrical units, time and frequency, pressure and force;
- the preparation of normative-technical documents: national standards, regulations, prescription, guidelines and other legal documents for the national system of ensuring uniformity of measurement;
- the development of procedures for verification and certification of measuring instruments with the aim to ensure accurate measurements with traceability to national and international standards;
- the training of local staff on the verification and cetification of measuring instruments;

- the establishment of necessary linkage between domestic industry and cooperation of standardization and metrology.

For the realization of the mentioned activities, the team of seven highly qualified metrology specialists came to Addis Ababa on October 1987.

In accordance with contract No 87/74 /between UNIDO and VNESHTECHNIKA/POLYTECHNA /, the contractor personnel was as follows:

- Mr. Yulij Boukharov /team leader/	Metrology of pressure and force
- Mr. Jurij Domnin	Metrology of time and frequency
- Mr. Pavel Klenovsky	Metrology of temperature and volume
- Mr. Jurij Kozhemyakin	Metrology of electric quantities
- Mr. Vasilij Mardin	Establishment and furnituring of metrology laboratories
- Mr. Robert Spurny	Metrology of mass, density and viscosity
- Mr. Vladimir Stezka	Metrology of length and angle

This team worked at Addis Ababa from October 1987 to April 1988 - together six months. From the beginning, the team worked under the general supervision of Chief Technical Advisor /CTA/ Mr. A.Kuruc, who left Ethiopia at the end of November 1987. The new CTA Mr. A.Vellingri arrived to Ethiopia on March 4-th 1988.

The general and special duties which were performed by the consultants at the project area are described in chapter 2 - Job Description and in chapter 3 - Working Plan.

The realization of this duties is described in chapter 4 - Executed Activities, and in chapter 5 - Other Activities /beside working plan/.

Chapter 6 - Recommendations -contains the findings of the mission and the recommendations to the Government of Ethiopia on the further action, which might be taken. The recommendations concerns the next instruments equipment of the laboratories, educational programme abroad for Ethiopian specialists and necessary activities of UNIDO consultants /for the case of next mission with the aim of introduction of new instruments into the metrology service/.

2. JOB DESCRIPTION

Every consultant received the "Job Description" containing his general and particular duties. The job descriptions are included to Annex E to contract No 87/74 / UNIDO terms of reference dated 1-st July 1986/.

General duties resulting from the job description for all consultants were as follows:

- To prepare a comprehensive plan and programme for the verification, calibration and certification of the metrological equipment being delivered in the centre.
- To advise on and participate in the installation of equipment in the laboratories.
- To develop a unified methodology and train local staff in performing calibration, verification and certification of instrument mentioned above.
- To advise on and participate in providing technical consultancy services to industry particularly in the areas including respective measurements, selection and installation of equipment.
- To participate in the elaboration of national standards, regulations, prescriptions, guidelines and other documents.
- To prepare a final report, setting out the findings of their mission and their recommendations.

3. WORKING PLAN

For realization of the duties demanded by UNIDO /described in the job descriptions /, the "Working Plan", containing all consultants activities was elaborated. The working plan, agreed with CTA and EAS management, served as a time shedule for coordination of particular activities.

The working plan was carried out on base of present and expected measuring instruments and working conditions. The working plan covers the following items:

- To study the received equipment for the project from the point of view of creating of hierarchy schemes for respective measuring fields to elaborate the draft Ethiopian Standard "state system for ensuring the uniformity of measurements. General provision".
- Cooperation with respective consultants, elaboration of state standards and hierarchy schemes for various units of measurements.
- Installation of measuring instruments and their testing.
- Development of unified methodology and theoretical and practical on the job training of the local staff in verification and calibration of measuring instruments.
- At specific request of ESA to participate on elaboration of national standards, regulations and guidelines.
- Work out the final report.

4. EXECUTED ACTIVITIES ACCORDING TO WORKINC PLAN

4.1. Consultant on Establishing and Furnishing of Laboratories

Consultant on establishment and furnishing of metrological laboratories carried out following:

- analysis of state legal documents related to metrology in Ethiopia and equipment received on the project.

There are following legal documents valid at present in Ethiopia:

Weights and Measures Proclamation,1963

Ethiopian Standards Institution order 1970
Ethiopian Standards Institution proclamation, 1972
Ethiopian Standards Institution Regulations 1973

Weights and Measures Regulations 1973.

As can be seen from date of publication all documents were issued by the former government, and at present they do not fulfil the needs of metrology, nor the needs of the country.

In accordance with the first step of creation of the state system for ensuring the uniformity of measurements in Ethiopia the normative-technical bases are elaborated in the form of following national standards:

- "State system for ensuring the uniformity of measurements /SSU/, Basic regulation". This standard establishes organizational, technical and normative basis of the state system for ensuring the uniformity of measurements, activity and tasks of bodies of state and departmental metrological services, mechanical metrological means and objects of normative-technical documents of SSU.

  This standard establishes basic regulation of state supervision for the elaboration, utilization and repairing of measuring instruments, for application and observance of metrological rules in all branches of national economy
- "Verification of measuring instruments , organizations and procedure". This standard establishes the general requirements

for organization and procedure of state tests of measuring instruments intended for serial manufacture or imported.

- "Metrological certification of measuring instruments". This standard establishes the basic regulation of metrological certification for measuring instruments of single production or imported single pattern, of serial production used in the conditions different from conditions for which their metrological characteristics are standardized.
- "Normative-Technical documents for verification the methods of measuring instruments". This standard establishes requirements for lay-out scope and wording.
- "Reference materials, Basic statements". This standard establishes general statements for system references materials, their classification and general requirements to reference materials , register's procedure.
- "Metrological ensuring for preparation of production. General statements". This standard establishes common statements and general requirements concerning the organization and conducting of works related with metrological ensuring for preparation of industrial products.

Beside this, the consultant elaborated methodological material, related with conducting of analyses of measurements in economic branch.

He has formed long-term national programme in field of legal metrology /1988-1991/ with relevant standards, regulations and other legal documents. It includes /besides above mentioned/ elaboration of 23 legal documents.

Together with the other project consultants he worked out draft national hierarchy schemes and corresponding standards:

- "National hierarchy scheme for measuring instruments of length / 0.5 - 1000/ mm."
- "National hierarchy scheme for measuring instruments of time and frequency."

- "National hierarchy scheme for means measuring voltage / 1-1000/ V in the range of frequencies of /50 + 5.10^3/Hz."
- "National hierarchy scheme for means measuring direct current."
- "National hierarchy scheme for means measuring of alternating current /1.10^{-5}+ 20 /A = /50 + 4.10^3/Hz."
- "National hierarchy scheme for means measuring electromotive force and electrical voltage."
- "National hierarchy scheme for means measuring electrical resistance."
- "National hierarchy scheme for pressure instruments in the range of / $0.7.10^5$ + 600.10^5/Pa."
- "National hierarchy scheme for means measuring temperature."

4.2. Consultant on Length and Angle Metrology

4.2.1. Present Measuring Instruments

- 2 pcs TESA UPC
- 1 pc Universal measuring centre SIP 1002 M
- 1 pc Dividing table OKT 500
- 1 pc Autocollimator D. A. 200 including auxiliary equipment
- 1 pc 12-sided polygon
- 2 sets Johanssons gauge blocks, class of accuracy 00, range 0.5 - 100 mm and 200 + 500 mm
- 2 sets Johanssons gauge blocks, class of accuracy 0, range 0.5 - 100 mm and 200 -500 mm

4.2.2. Installation of Present Measuring Instruments and Their Set Up and Testing

- Installation and checking of TESA instruments.

  Installation and set up of both instruments without any problems. Unfortunately one of the measuring instruments cannot work properly because of insufficient vacuum due to functional problem of vacuum pump.

Former CTA had informed TESA company about this problem and requested replacement of the device during guarantee time /see letter from November 16-th, 1987/.

Replacement of the device was requested once more on February 8-th, 1988. Pump will be replaced free of charge after receiving claimed one.

- Installation and checking on Dividing table OKT 500-Carl Zeiss, Jena.

  No problems.

- Installation and checking of Dual axis autocollimator D. A. 200 and its auxiliary equipment - Rank Taylor Hobson.

  No problems.

- Installation and checking of universal measuring centre, SIP 1002, SIP Geneve.

  Because of insufficient space in the laboratory of length and angle and due to utilization of the big hall was SIP 1002 M installed in the big hall.

  No problems.

- Checking the gauge blocks - class of accuracy 00, range 0.5 - 500 mm, 116 pcs, Johansson.

  From 112 pieces of essential set 10.5 - 100 mm six = pieces were certified only.

  Because of variation in length, 4 pieces of gauge blocks do not fulfil requirements given by IR No. 30 of OIML.

  This checking was executed after guarantee time and therefore no claims could be asserted.

  All long gauge blocks 200 - 500 mm are certified.

- Checking of gauge blocks - class of accuracy 0, range 0.5 - 500 mm,116 pcs, Johansson.

  From 112 pieces of essential set /0.5 - 100 mm/ six pieces were certified only.

  Gauge blocks, nominal size 22 is corroded on side faces and on one working face too.

  Because the checking was executed after guarantee time no claims could be asserted.

  All long gauge blocks /200 - 500/mm are certified.

4.2.3. Preparation of Methodologies for Calibration of Measuring Instruments

The methodologies for calibration of length and angle measuring instruments, elaborated by the consultant, were presented to the Ethiopian counterpart / and to the head of laboratories and to general manager of ESA/. These materials were worked out on the base of present measuring instruments and instruments which should be purchased in the future, except the device for verification and calibration of line measure blocks and measuring tapes. This device will be proposed by Mr. Bezabih Makonnen, who worked for several months in PTB / under this UNIDO project/ on the same equipment. Whole device will be made in the ESA workshop and estimated costs are below 1000 Birr. Also methodology will be worked out by Mr. Bezabih Makonnen according to his experience with mentioned device.

List of presented documents:

- Unified methodology in performing verification, calibration and certification of gauge blocks 0.5 + 100 mm on present measuring instrument TESA and 125 - 1000 mm on present universal measuring centre SIP 1002 M.

  This methodology contains proposal of hierarchy scheme for length measuring instruments. 18 pages

- Unified methodology in performing verification, calibration and certification of dividing heads and dividing tables with the help of present measuring instruments OKT 500. D. A. 200 and 12-sided polygon.

  Also this methodology contains proposal of hierarchy scheme for angle measuring instruments. 21 pages

- * Unified methodology in performing verification, calibration and certification of visual and photoelectric autocollimators.

- * Unified methodology in performing verification , calibration and certification of goniometers with the help

---

Methodologies and guidelines marked in this list by asterix * /for which are not present measuring instruments/ were discussed theoretically only.

of present measuring instruments
dual axis photoelectric autocollimater D. A. 200 and 12-sided polygon. 9 pages

- Guideline: Checking of micrometric measuring gauges. 4 pages
- Guideline: Checking of dial gauges. 3 pages
- Guideline: Checking of vernier callipers. 2 pages
- Guideline: Autocalibration of gauge blocks, including computer programme. 11 pages
- * Guideline: Calibration and certification of levels. 10 pages
- Guideline: Calibration and certification of angle gauges. 10 pages
- Proposal of Ethiopian Standard: Ethiopian Primary standard and national hierarchy scheme for length measuring instruments. 5 pages
- Proposal of periods of recalibrations of measuring instruments /length and angle/ . 4 pages
- List of recommended English written literature. 3 pages

All above mentioned methodologies, guidelines etc. are part of this final report - see enclosure.

4.2.4. On-the-job Training

After "unified methodologies" and "Guidelines" had been studied by counterpart, on-the-job training was performed and repeated.

4.3. Mass, Density and Viscosity Laboratory

4.3.1. List of Equipment of Mass, Density and Viscosity Laboratories

Mass Laboratory

Electronic comparator balances:

- Sartorius 1681 MP8 2 kg to 10kg ± 1mg
- Sartorius 1086 500g to 2kg ± 0.1mg
- Sartorius C500 100g to 500g ± 0.01mg
- Sartorius C50 10g to 50g ± 0.001mg

Weights:

- 1 pc 1mg to 10g E_2 Mettler
- 2 pcs 1mg to 50g E_2 Mettler
- 1 pc 100 g to 5kg/two sets/ E_2 Mettler
- 1 pc 10kg E_2 Mettler
- 1 pc 100 g to 5kg/one set/ E_2 Mettler
- 1 pc 10kg F_1 Mettler
- 1 pc 1mg to 1kg F_1 Mettler
- 1 pc 1kg to 10kg F_1 Mettler
- 1 pc 10kg F_1 Mettler
- 1 pc 1kg Primary Standard Troemner

Other instruments:

- 1 pc Barometer ± 0.1 hPa
- 1 pc Thermometer ± 0.1°C

Viscosity Laboratory

The viscosity laboratory has no viscometers. Two sets of capillary glass viscometers /Ubbelohde type, 90 mm length of capillary, nominal size 0, 0c, 1, 1c, 2, 2c, 3, 3c, 4, 4c/ were borrowed from laboratories of quality control.

The thermostat bath /with accessories/ was borrowed from temperature measurement laboratory.

Density Laboratory

The density laboratory has following hydrometers /all delivered without lettre of certificate/:

- Hydrometers for mineral oils; range: From /0.6 gcm^{-3} to 0.65 gcm^{-3} / to /1.0 $g.cm^{-3}$ to 1.05 $g.cm^{-3}$/; /together 2 x 9 pieces scale division d = 0.0005 $g.cm^{-3}$/

- Hydrometers for acids; range: From /1.05g.cm^{-3}to 1.10g.cm^{-3}/ to /1.95 g.cm^{-3} to 2.00g.cm^{-3}/; together / 20 x 2 pieces/; d = 0.0005g.cm^{-3}
- Alcoholometers; range from /0 to 10% vol/ to /90 to 100% vol/; together 2 x 11 pieces; d = 0.1% vol
- Sacharimeters; range from / 0 to 10% mass / to / 40 to 50% mass/; together 2 x 5 pieces; d = 0.01% mass
- Picnometers: 100ml /2pcs/; 50ml /2pcs/; 25ml /2pcs/; 10ml /2 pcs/; 5ml /2 pcs/

4.3.2. Installations of Measuring Instruments

Mass Laboratory

All the comparator balances were installed at the mass laboratory, put into operation and their metrological parameters were tested. It was found, that all the comparator balances are in good state, their parameters are suitable for usage in primary mass standardization for calibration of mass scale by national mass standard in the range 1mg to 10kg and for calibration of secondary standards of 1st order.

Viscosity Laboratory

The Lauda thermostatic bath /originally sugested for temperature laboratory/ was modified for viscosity measurement. It was found that temperature stability and adjusting is $\pm$ 0.01°C which is sufficient for calibration of working standard and ordinary instruments.

Density Laboratory

EAS has no instruments for calibration of working standard hydrometers.

4.3.3. Preparation of Methodology for Calibration of Instruments

Mass Metrology

For the calibration of mass measuring instruments and for the purpose of the most accurate mass measurement, the "Methodology of mass measuring instruments calibration" consisting of three parts, was elaborated.

Part one: "general theory and methods of measurement" contains following chapters: Definitions; Measurement of mass; Theory of balances; El. mag. force compensation; Methods of weighing; Mass determinations of standards; Equation for the air density; The least squares calibration /50 pages/

Part two: "methods of calibration of balances" contains: Calibration of two-pan balances; Calibration of single-pan balances; Calibration of El. mag. force compensation balances; Least-square calibration of built-in weights /32 pages/

Part three: "methods of calibration of weights and mass standards" contains: Calibration of weights and mass standards; Ethiopian scheme of hierarchy; Examples of calibration schemes; Programme for computer; Examples - numerical /85 pages/.

This methodology was presented to general manager, to the head of metrology centre and to two counterparts. /Mr. Bazabeh, Mr. Challa/.

For the purpose of the next study, the supplementary literature /containing 10 articles of the most important scientific works: comparison of PtIr standard to stainless steel, description of the most accurate balances, optimal calibrating schemes/ was presented to the counterparts. /Mr. Challa/

Viscosity Metrology

For the calibration of viscosity measuring instruments and for the most accurate viscosity measurements, the "Methodology of viscosity measuring instruments calibration" /containing 73 pages/ was elaborated. Methodology contains following chapters: Definitions; Theory of capillary viscometers, rotational viscometers; Falling sphere method; Measurement of viscosity;

Methods of calibrations /stepping up, direct comparison/; Scheme of hierarchy.

This methodology was presented to general manager, to the head of metrology laboratories, and to two counterparts /Mr. Challa, Mr. Lulu/.

For the purpose of the next study, the supplementary literature /containing 11 articles of the most relevant scientific works: absolute viscosity of water, theory of laminary flow, calibration methods/ was presented to the counterpart /Mr. Lulu/.

Density Metrology

For the calibration of hydrometers and the most accurate liquid density and solid density measurements the "Methodology of density measuring instruments calibration" containing 65 pages was elaborated. Methodology is subdivided to following chapters: Definitions and weighing; Hydrostatic weighing /Determination of solids volume, determination of liquid density, calibration of hydrometers by hydrostatic weighing/, direct comparison method of hydrometer calibrations.

This "Methodology" was presented to general manager, to the head of metrology laboratories, and to two counterparts /Mr. Challa, Mr. Lulu/.

For the possibilities of deep study of density metrology, the supplementary literature /containing 8 articles of the most important scientific works: hydrostatic weighing , calibration of aerometers, density scale based on solid objects/ was presented to the counterpart /Mr. Challa/.

4.3.4. Practical on a Job Training

Mass Metrology

Getting out of elaborated "methodology" concerning theory and guidelines, the counterpart /Mr. Challa/ was trained and

..

now is prepared for executing the following metrological works:

- to calibrate and to measure with three-knife-edge balance /analytical, technical/
- to make the calibration and to measure with two-knife /single-pan/ balance
- to make the calibration and to measure with el. mag. force compensating balance
- to calibrate the set of weights /mass standards or ordinary weights/ by calibrating method
- to calibrate the weights by direct comparison method
- to use the computer programme for determination of calibration results; to operate the personal computer commodore 128 D.

Viscosity Metrology

Getting out of elaborated "Methodology", the counterpart /Mr. Lulu/ was trained and is prepared for:

- calibration of viscometer /working standards/ by stepping up methods
- calibration of viscometers /secondary standards, ordinary instruments - glass capillary viscometer/ by direct comparison method
- measurement of viscosity of liquid by Glass capillary viscometers.

Density Metrology

Getting out of elaborated "Methodology" the counterpart /Mr. Challa/ was trained and is prepared for:

- determination of volume of solid bodies /mass standard, density standards/
- determination of liquid density by hydrostatic weighing /density of calibrating liquids.

The calibration of hydrometers secondary standards by hydrostatic method was explained and discussed but as the ESA has no suitable measuring device for this purposes, next training is necessary. The calibration of hydrometers /ordinary instruments/ by direct comparison method was explained, but this method cannot be used, as the hydrometers in ESA are not calibrated /delivered without letter of certificate/.

After the calibration of hydrometers by hydrostatic weighing in ESA /or abroad/ the direct comparison method of ordinary instruments can be introduced.

4.4. Consultant on Time and Frequency Metrology

4.4.1. Present Measuring Instruments and Units

- Power supply XSRM - Z
- Rubidium frequency standard XSRM
- Frequency convertor XSRM - Z
- Phase comparator
- Digital clock CADM
- VLF receiver XKE - 2
- Ferrite Antenna XKE 2 - Z1
- Universal counter /timer 7261A Fluke - 2pcs/.

From the list above some very important and some auxiliary parts were not presented at the beginning of consultant work. Electronic counter-timer have not had any power supply cords or any signal cables. The VLF receiver has not any filter plate board and this made significant difficulty in proper operation of checking this instrument.

After revising presented instruments it was cleare that time measurement and time service cannot start in right mood unless necessary equipment will be added. These neccesary equipment may be as follows:

- Crystal oscillator XSDZ 283.6010.02
- Power supply XSRM - Z 237.8013.02

- YT - Recorder ZSG2 110.2007.92
- 19"Cabinet XSRM 237.7317.02
- Filter plate board 299.3238 Var 05 12.3 KHZ.

All these equipments are manufactured by Rohde and Schwarz, West Germany.

4.4.2. Installation of Present Equipment

There were no problems with the installation of Rubidium Frequency Standard, Power Supply for standard and other related equipment, Frequency convertor and phase comparator. After careful checking all these were put into operation.

Above mentioned equipment refers to frequency measurement. In order to ensure necessary time measurement one must have reserve AC or DC power supply because of frequent AC power interruption in Addis Ababa.

It was supposed to equip the laboratory with twc car batteries to ensure rubidium clock continuous operation. The local authorities managed to find money to arrange all necessary equipment and to perform the work.

Now the laboratory is equipped with two 70 AHZ batteries to feed rubidium clock and other equipment and one 70 AHZ 6V battery is used for experimental part of laboratory activity. In addition, AC/DC generator with possibility of getting automatic start was ordered in Hong-Kong by CTA after consultation with time and frequency expert and from the point of view of the other laboratories needs.

Two Fluke 7261 A universal counter timer were also put into operation after borrowing necessary AC and RF cords.

Concerning "Omega" signal reception in Addis Ababa there are two suitably placed transmitting stations - La Reunion and Monzwia. They are placed at nearly equal distance from Addis Ababa. It is preferable to receive signals which propagate in meridional direction. Thus La Reunion "Omega" station with unique frequency 12.3kHz was chosen for permanent frequency comparisons.

The place of installation of the Ferrite antenna to receive "Omega" station time and frequency signals was chosen. The necessary workshop's job and preparations were made and Ferrite antenna was installed by NMC workers in accordance with consultant's recommendation.

To check Ferrite antenna the plate was manufactured and it was insured that antenna and its built-in amplifier are in normal condition.

XKE - 2 receiver was delivered without filter plate board. This filter plate board is usually chosen by consumer minding possible station signal reception in the most suitable way. If there was no demand of which filter plate would be supplied, the standard filter plate board would be inserted into receiver. But in our case there was no filter plate board at all, so the receiver could not be checked.

The scheme of simplified model filter plate board has been developed having in mind poor market possibility to supply necessary radiocomponents. This scheme was assembled and after inserting this hand-made filter plate into receiver we were able to check some parts of receiver in working conditions. We managed to receive pure enough "Omega" navigation system signals and these were recognized as La Reunion station signals. After some adjustment we even could not only receive but also to use these signals to control the frequency of local oscillator. Thus the operation of XKE - Z receiver was checked in full scale.

4.4.3. Worked out Projects of Documents

The following projects of documents were worked out:

- Unified methodology of performing verification of actual low precision frequency measures. This document evolves the shedule of performing verification, necessary equipment means, order of performing verification and issuing of final verification document.
- Verification methodology in performing verification, calibration and certification of actual limited accuracy frequency measures.

These measures cover frequency range 0.1 + 125 MHz and accuracy 10^{-6}+ 5.10^{-3}.

- Unified methodology in performing verification, calibration and certification of high accuracy frequency and time measures. This covers frequency range 0.1 + 10 MHz, time range 0.1 m S + 10^{8}S and accuracy 5.10^{-9}+ 2.10^{-11} or higher.
- The hierarchy scheme of time and frequency was developed.

All these documents were discussed and studied carefully with counterpart and terminate project versions were prepared for considerations.

4.4.4. On a Job Training

Three times a week lectures on time and frequency measurement were delivered including lectures on the following subjects: Astronomical conception of time and astronomic time definition, atomic definition of time unit, quantum time and frequency devices, crystal oscillators, time and frequency stability - - definitions and characterizations, measurement technique for frequency stability, time and frequency dessiminations via radio and other communication means, VLF receivers, phase and frequency comparators, electronic counters etc., methods of time and frequency measurements and errors evaluation.

According to the prepared guidelines some staff's training on verification performing was carried out. Using rubidium frequency standard the counter crystal oscillator performances were measured by different methods including phase-temporary method and phase comparisons method. The processing of data and evaluation of frequency stability, random error and others were carried out.

Exercises on transferring measurement results from frequency domain to time domain and vice versa were carried out.

4.5. Consultant on Electrical Units Metrology

4.5.1. Present Measuring Instruments:

- 1 pc direct current comparator potentiometer Guideline model 9930
- 1 pc DC Reference standard Fluke Model 732 A
- 1 pc Calibrator Fluke model 5101B
- 1 pc Precision power amplifier Fluke model 5205A
- 1 pc Transconductance amplifier Fluke model 5220A
- 1 pc Portable calibrator Fluke model 515 A
- 1 pc Digital multimeter Fluke model 8502 A
- 2 pcs Digital multimeter Fluke Model 8840A
- 1 pc Constant temperature oilbath guideline model 9732VT
- 1 pc powermeter siemens model B4301
- 1 pc portable meter test equipment LANDIS & GYR model TVH4322
- 1 pc DC power supply HEWLETT PACKARD Model 6260 B
- 10 pcs Standard resistors TINSLEY & COLTD types 5686,5615, 5685A, 5685B
- 1 pc Transvolt standard cell enclosure guideline model 9140D
- 2 pcs Current shunt Fluke model A90
- 3 pcs Line conditions PHILIPS model PE1414/10

4.5.2. Installation of Present Measuring Instruments and Their Set Up and Testing

There were no problems with the installation of the present instruments. All the instruments were installed at laboratory of electrical quantities, put into operation and functionally checked; only one instrument: powermeter - siemens model B4301 was not functional, but it was repaired.

All instruments of laboratory of electrical quantities were calibrated in accordance with the procedures for calibration. These procedures were elaborated for each instrument of laboratory of electrical quantities.

For each instrument reports of calibration with application results of measurement were done.

In accordance with the working plan the consultant visited 11 factories in Addis Ababa where he advised and participated in providing technical consultancy on electrical measurements. After the visits had finished, the analyses for development of electrical measurements in Ethiopia had been elaborated.

4.5.3. Preparation of Documents for the Counterpart

The following documents /worked out on the basis of present measuring instruments/ were presented to the Ethiopian counterpart /and to the head of laboratories and to general manager of ESA/:

Unified methodology in performing calibration, verification and certification of following instruments:

- Procedure for calibration of the direct current comparator potentiometer guideline model 9930 - 2 pages
- Procedure for calibration of the DC Reference standard Fluke model 732A - 4 pages
- Procedure for calibration of the calibrator Fluke model 5101 - - 14 pages
- Procedure for calibration of the precision power amplifier Fluke model 5205A - 4 pages
- Procedure for calibration of the transconductance amplifier Fluke model 5220A - 5 pages
- Procedure for calibration of the portable calibrator Fluke model 515A - 8 pages
- Procedure for calibration of the digital multimeter Fluke model 8502A - 8pages
- Procedure for calibration of the digital multimeter Fluke model 8840A - 13 pages
- Procedure for calibration of the constant temperature oilbath guideline model 9732 VT - 4 pages
- Procedure for calibration of the powermeter siemens model B4301 - 5 pages
- Procedure for calibration of the portable meter test equipment LANDIS & GYR model TVH4.322 - 9 pages
- Procedure for calibration of the DC power supply HEWLETT PACKARD model 6260B - 7 pages
- Procedure for calibration of the standard resistors TINSLEY & COLTD types 5686, 5615, 5685A, 5685B - 5 pages

- Procedure for calibration of the transvolt standard cell enclosure guideline model 9154D - 6 pages
- Procedure for calibration of the volt ratio box G20YDON model VRSZ - 4 pages
- Procedure for calibration of the current shunt model A90 - 4pages

Beside this, the following materials were worked out:

- National verification chart for measuring electrical resistance
- National verification chart for measuring electromotive force and DC voltage
- National verification chart for measuring DC current
- National verification chart for measuring AC voltage /1.10^{-3} to 1000/ V in the frequency range of /50 to 50.10^{3}/Hz
- National verification chart for measuring AC current / 1.10^{-3} to 20/ A, f= /50 to 5.10^{3}/Hz
- National primary standard and verification schedule for means measuring electromotive force and electrical voltage - 4 pages
- National primary standard and verification schedule for means measuring electrical resistance - 4 pages
- Standard for verification schedule of measuring direct current - - 3 pages
- Standard for verification schedule of measuring alternating current - 3 pages
- Standard for verification schedule for the measuring means of AC voltage - 3 pages

Reports of calibration of the following instruments were elaborated:
direct current comparator potentiometer guideline model 9930, N54212, DC reference standard Fluke model 732A, N 3935013, Calibrator Fluke model 5101B N 4050000, Precision power amplifier Fluke model 5205A N 4020009, Transconductance amplifier Fluke model 5220A N 3985013, portable calibrator Fluke model 515A, N 3970012 digital multimeter Fluke model 8502A N 4075003, digital multimeter Fluke model 8840A N3997134, N 4002056, constant temperature oilbath guideline model 9732VT N 54338, powermeter siemens model B4301, N 05025630, portable meter test equipment LANDIS & GYR model TVH4.322 N 57011450, 246276, 246790, 248811, 249425, 246814, 246267, 244672, 246629, 246564,247287

Standard resistors TINSLEY & CO LTD types 5686,5615, 5685A,5685B, current shunt Fluke model A90 N 3675024, N 3675023 transvolt standard cell enclosure guideline model 9154D N 54454, volt ratio box GOYDON N model VRSZN N43222
All these documents were discussed and studied with the counterpart

4.5.4. On the Job Training

After the metrology documents had been prepared, they were studied by the counterpart. In accordance with these procedures for calibration of the present measuring instruments on the job training and calibration was performed.

All instruments of electrical quantities laboratory were calibrated, verified and certified in accordance with these calibration procedures.

All reports on calibration instruments are part of the elaborated unified methodologies.

Knowledge and practical skill of counterpart in performing the above mentioned calibration of the electrical instruments is very good.

4.6. Consultant on Temperature and Volume Laboratory

4.6.1. Present Measuring Instruments:

Temperature:

- FB-08 HT calibration Fluidized Bath + F 1200 air compressor
- Solartron 7061½ - digit High Speed Systems Voltmeter
- 2 Special Baths Lauda CD 30 for Calibration of Liquid-in-glass Thermometers
- Through-flow Cooler DLK 15
- 8 Thermocouple Switches Tettex
- 2 sets of Thermoschneider precision Type Laboratory Mercury-in-glass Thermometers /scale division 0.02°C/
- 2 sets of Thermoschneider Precision Type Laboratory Thermometers /scale division 0.1°C/

- Tinsley 5840 D "Senator" Automatic Resistance Bridge
  + Type 5840 C56 Selector Switch
- Tinsley 5685 Standard Resistor 25 ohms
- 2 Secondary S-type Thermocouples
- 3 Secondary B-type Thermocouples
- 3 S-type primary Thermocouple assemblies
- Test Fufnace Equipment Hereaus TPKE
- 3 Triple-Point-of-Water Cells M1501
- 3 Primary Platinum Resistance Thermometer Tinsley 5187SA
- Ice Bath KB-03
- 6 Plastic Dewar Flasks Nalgene

Volume:

- 8 sets of Volumetric Flasks
- 4 sets of Volumetric Pipettes
- 4 sets of Measuring Cylinders
- Standard Capacity Tanks 100l and 1000l
- Glass Cylinders, Glass Bottles

4.6.2. Installation and Checking of the Instruments

The present equipment of NMC was thoroughly inspected, its completeness checked and additional recommended items essential for further progress were specified:

- items to purchase at local shops - minor tools, electrical heaters for liquid baths, a small Dewar vessel for thermocouple reference junctions, a refrigerator with a freezer /to maintain triple-point-of-water cells and for ice making/, rubber hoses, fluorescent lamps, on electrical pan, electrical wiring items and needed chemicals:
  for temperature - ethanols, pure petrol, HF acid, dry ice, CO_2 ,
  for volume- sulphuric acid, potassium dichromate, acethone.
- items to be manufactured or to be adapted at the local workshop specification of details of the Techne air compressor location outside the building /due to excessive noise/, an adaptation of the measuring wells for the techne bath, an adaptation of the liquid baths for fixing up external heaters and fluorescent lamps.

A number of minor but substantial items had been brought from Czechoslovakia by the consultant for temperature /based on before-hand estimated lacks/ and have been donated to ESA. Among them an accessory apparatus for the thermocouple welding and items for the thermocouple calibration set-up /electrical wiring items, protecting sleeves, ceramic protective tubes and rods/ are to be mentioned. Without the latter, the set-up could not be put into operation.

Major adaptation was necessary on the liquid baths - they exhibit insufficient vertical working space and, as such, do not enable to create the steady small temperature rise during calibration, required by the methodology . The latter problem has been overcome by means of an external heater and an autotransformer. As all the available Dewar flasks are of insufficient depth, a deep Dewar vessel will be devoted to the ESA by the Czechslovak Metrological Institute at the consultant's request. The vessel will be used for these purposes:

- the long-term maintaining of triple-point-of water cells
- the calibration of liquid-in-glass thermometers in the range $-60^{\circ}C$ to $0^{\circ}C$ according to the procedure described in the corresponding methodology
- a makeshift solution for the liquid-in-glass thermometers calibration above $0^{\circ}C$.

As the accuracy requirements for liquid-in-glass thermometers calibration in the range $0^{\circ}C$ to $100^{\circ}C$ are extremely high, it is highly recommendable to purchase one sufficiently deep liquid bath /e.g. Tamson/, enabling the steady temperature rise, too.

All the equipment specified in part 1, with the exception of the 10001 capacity tank, has been put into operation or has been adapted to the requirements of the relevant calibration methods. Up to now it has been operating smoothly and it is fully prepared for starting verifications and calibrations /with the indicated exception/.

The measurement results up to now are in an excellent agreement with the delivered calibration certificates from the manufacturers.

4.6.3. Preparation of Unified Methodologies

Temperature:

According to the schedule, on-the-job training in temperature metrology was started with the assigned Ethiopian counterparts Lulu Mebrahtu /full-time/ and Alem Seged /part-time/. The jobs accomplished are summarized and presented to the ESA management by inner-office memos.

The following guidelines and methodologies have been presented to the counterparts in temperature metrology:

- a translation of the instruction manual for the cooler DLK 15 /originally in German/;
- a copy of ASTM Standard: Standard definitions of terms related to temperature measurement;
- a copy of International Practical Temperature Scale 1968 /amended edition of 1975/;
- an explanatory note on control systems in temperature equipments /3pages/;
- a theoretical guideline "The Thermodynamic Temperature Scale" /20 pages/;
- a guideline "Liquid-in-glass Thermometers" /15 pages/;
- a unified methodology for verification of liquid-in-glass thermometers /30 pages/;
- a guideline for users "Liquid-in-glass Thermometers" /3 pages/;
- a guideline "Thermocouples" /21 pages/;
- a unified methodology for calibration of thermocouples /17 pages/
- a theoretical guideline, "Resistance Thermometers" /11 pages/;
- a unified methodology for calibration of resistance thermometers /15 pages/;
- a methodology for operations with triple-point cell of water /5 pages/;
- provisional hierarchy schemes for temperature ;
- a theoretical guideline "Evaluation of errors in temperature measurement" /17 pages/;
- a theoretical guideline "Numerical Methods in temperature measurement" /11 pages/.

Volume:

In volume metrology, on-the-job training has been carried out with assigned counterparts Challa Bekele and Tafesse Muluneh /flow measurement problems only/.

The following papers have been presented to them:

- a methodology for calibration and verification of standard glass flasks /covers also ordinary laboratory flasks, metal test provers and tanks and capacity serving measures/;
- a methodology for verification of pipettes and burettes;
- a methodology for verification of fuel delivery pumps;
- a methodology for calibration of fuel tanks trucks;
- a provisional hierarchy scheme for volume.

After having inspected flow meter facilities in the field /fuel, cold water/, master flowmeters for these purposes have been specified, including the whole calibration set-up. As to tank trucks, it is recommendable to replace the current method based on metal tanks and water by the flow meter method using the corresponding technical liquid.

4.6.4. On a Job Training

After these materials have been properly studied by the counterparts, the subject on hand is thoroughly explained and relevant questions answered.

On-the-job training both in temperature and in volume metrology has been succesfully completed. No special national standards in these fields, other than those of OIML and ISO, are urgently needed, because the assigned fields are well covered by the international standards.

4.7. Consultant on Pressure and Force Metrology

4.7.1. Present Measuring Instruments

Pressure:

- Bundenberg dead-weight pressure testor with the range of 1.10^5Pa + 600.10^5Pa and additional equipment;
- bench mounting oil seal;
- power rotation unit;
- mercury control barometer 20k with the range of 700.10^2Pa + 1100.10^2Pa including accessories;
- mercury station barometer 1169 with the range of 700.10^2 Pa + 1100.10^2Pa including accessories;
- Test gauge with the range of 0 + 10MPa - 2 pieces;
- Test gauge with the range of 0 + 60MPa - 2 pieces;
- Manometer with the range of 0 + 400kPa - 2 pieces;
- Manometer with the range of 0 + 10MPa - 2 pieces;
- Manometer with the range of 0 + 2.5MPa - 2 pieces;
- Manometer with the range of 0 + 6.0MPa - 2 pieces;

Force:

Dynamometric Bridles /Elastic providing devices/ type KB 00.03.02, with mechanic measuring instrument /Dial gauge for tension and compression force/ and optical microscope for compression force;

Range of Dynamometric Bridles:

- 1kN - tension and compression force - 2 pieces
- 5kN - tension and compression force - 2 pieces
- 20kN - tension and compression force - 2 pieces
- 50kN - tension and compression force - 2 pieces
- 100kN - tension and compression force - 2 pieces
- 200kN - tension and compression force - 2 pieces
- 500kN - tension and compression force - 2 pieces

4.7.2. Installation and Checking of the Instruments

The present equipment of NMC was thoroughly inspected and checked. Bundenberg dead-weight tester, control barometer 20K

and station barometer 1169 were installed at the pressure laboratory, put into operation and their metrological parameters were tested. It was found that dead-weight pressure tester, control barometer 20K and station barometer 1169 are in a good state, their metrological parameters are suitable for using these equipments as primary standard of Ethiopia in the range of $0,7.10^5 + 600.10^5$ Pa. The completeness of pressure and force equipment was checked.

Because some parts of force and pressure equipment are absent, the consultant gave some recommendation for purchase or making them in the local workshop. Some of these items are as follows:

- connectors for comparison between control barometer 20K and station barometer 1169;
- high pressure connector for dead-weight pressure tester and oil seal for using some kind liquids;
- stand for compression dynamometric bridle 200kN;
- extension parts for tension dynamometric bridles - 200kN and 500kN;
- rubber hoses;
- stop watch;
- stand for dial gauge.

All force equipment was thoroughly inspected and checked by means of the testing machine installed at the Quality Control Centre /mechanical and building material testing laboratory/.

4.7.3. Preparation of Unified Methodology

According to the working plan the training course on pressure and force metrology was stated with the assigned Ethiopian counterparts. The counterparts were educated for the following questions, both practical and theoretical:

- principles and basic theory of the pressure balance;
- intrinsic correction terms /corrections to the effective area, the load force, acceleration of gravity, air buoyancy, ambient pressure/;
- determination of effective area;

- aspects of practical application of pressure instruments;
- effect of departures from axial symmetry of a piston-cylinder assembly;

The job accomplished are summarized and presented to the ESA management by inter-office memos.

The following guidelines and methodologies have been presented to the counterparts of pressure and force metrology:

- Unified methodology for verification, calibration of pressure instruments - 57 pages. The methodology contains the basic determination of pressure measurement, state hierarchic schemes for pressure measuring devices, difference types pressure instrument using in practical, procedure of verification and calibration of pressure instruments etc.
- The draft of the Ethiopian state standard and the hierarchy scheme for measuring devices of pressure measurement within the range of $0,7.10^5 + 600.10^5$Pa - 4 pages. The draft of standard contains hierarchy scheme for pressure measuring devices in the range of $0,7.10^5 + 600.10^5$Pa, establishes the purpose for the National primary standard, basic measuring devices including into this standard, common metrological characteristics and the order of the transference of the pressure unit from the primary standard to the working instruments with the errors and the methods of verification.
- The draft of the Ethiopian state standard of dead- weight manometer, methods of verification - 13 pages. The draft of the standard is spreaded on the dead-weight manometers up to maximum pressure limit 600.10^5Pa and class accuracy 0.03 + 0.3. The standard establishes the methods and means of the first and periodic verifications.
- The instruction on manufacture, graduation, measurement and verification of mercury barometer and manometer - 14 pages. The instruction contains the basic principle of action of mercury barometer, installation and filling of mercury barometer, graduation, verification and execution of measurement of mercury barometer and determination of basic metrological parameters.

- The instruction of the washing of glass manometer and barometer tubes and rubber hoses - 2 pages. The instruction for washing of glass manometer and barometer tubes and rubber hoses intends to prepare the tubes and hoses before filling them in by some liquid /mercury, water, alcohol/.
- The instruction on graduation, measurement and verification of dynamometric bridles /Elastic providing devices/ with mechanic measuring instrument and optical microscope - 14 pages. The instruction is intended for graduation measurement and the methods of verification of dynamometric bridle with mechanic measuring instrument and optical microscope. The instruction contains the design of dynamometric bridles for compression and tension force, direction for using the dynamometric bridles, determination of metrological parameters. There is basic information about distribution of random quantities, normal law of errors distribution and procedure of verification in the metrology section.

4.7.4. On a Job Training

The drafts of state standards unified methodology guidelines and instructions cover practically all basic aspects of pressure and force measurement.

All these metrological documents were explained to the counterpart theoretically and demonstrated practically.

The practical knowledge and experience of counterpart Tamrat Endale is sufficient enough for making verification and calibration of pressure and force instruments without any assistance. The metrological documents can be used for calibration industrial instruments and devices in the field pressure and force measurement.

5. OTHER ACTIVITIES

5.1. Consultant on Establishment and Furnishing Metrological Laboratories

Consultant on establishment and furnishing metrological laboratories carried out the following:

- programme of studying course "Basic of metrology and measurement assurance" ;
- teaching and elaboration of the methodological material /100 pages/ in following areas of metrological activities: meaning metrology and measurement assurance, units, realization of unit and dissemination of accurate measurements, verification of measuring instruments, methods of verification, measuring instruments, their errors, estimate of errors, measurements, their errors, methods of exception of systematic errors, random errors, methods of processing the results of observations, normative technical documents related to measurements procedures, state and departmental supervision of measuring instruments, calculation of accuracy of measuring instruments etc.

5.2. Consultant on Length and Angle Metrology

According to the working plan approved by management of ESA, all tasks were fulfilled. But because of presence of measuring instruments and needs of Ethiopian national ecenomy, some not planned methodologies and guidelines were worked out, some of them were prectically demonstrated and taught. Among them are:

- measuring of straightness and flatness
- measuring of inside and outside diameters
- autocalibration of gauge blocks

Because some measuring instruments are not present, but their purchase is recommended, methodologies or guidelines for their utilization were worked out. To them belong:

- verification and certification of goniometers

- verification and certification of autocollimators
- calibration and certification of levels.

At special request of ESA the following proposals were prepared:
- for utilization of big hall of NMC, especially in field of length and angle
- of recalibration periods of measuring instruments.

From Czechoslovak Metrological Institute the Czechoslovak standard of first order was brought and with its help the Ethiopian primary standard of length was verified.

This important step enabled ESA to start immediately any length measurements and verifications of gauge blocks.

Transportation of Czechoslovak standard from Czechoslovakia to Ethiopia and back was provided by Czechoslovakia, free of charge.

Lecture - short lecture about length and angle including slides was presented to the counterpart
- video film about metrology in Czechoslovakia was presented to all counterparts.

To provide certain measurements, cooperation with workshop personnel was necessary and some auxiliary equipment had to be made. To liable workers of ESA were submitted sketches of:
- Wooden casette /necessary for manipulation with gauge blocks during their verification/
- Cylinder /for fixation of polygon/
- Checking and measuring mandrels /for measuring radial and axial run out of dividing tables and heads/
- Special support /for verification of long gauges with help of only one measuring table of universal measuring centre SIP 1002.

Unfortunately, production of very simple needed parts was slow and only one cylinder for fixing the polygon was made. Due to this problems many measurements described in methodologies were not practically exercised.

5.3. Consultant on Mass, Density and Viscosity Metrology

- The introduction to computer operating and programming technique of three members of Ethiopian National Metrology Centre. /Basic-programming language/.
- The preparation /elaboration/ and explanation of the most common programmes for personal computer Commodore 128D /arithmetic mean, standard deviation of measurement, linear regresion, correlation coefficient, system of linear equation solution by Gaus-Jordan elimination, determinants and inversion matrix calculation, the universal programme for least-square method applicated to sclution of indirectly measured quantities/.
- The determination of metrological parameters and adjustments of two analytical + two technical balances of ESA.
- The reperation of one damaged analytical three-knife-edge balance which was used for training purposes.
- The participation in new subdivision for optimal utilization of the big hall of NMC.
- The calibration of working mass standards of ESA by Czechoslovak working mass 1kg standard, brought for this purpose from Czechoslovakia. This enabled to recalibrate the mass scale /at the level of working standard/ of ESA in the range 1mg to 10kg.
- The preparation of proposals for recalibration periods of mass, density and viscosity measuring instruments /ordinary instruments/.
- The presentation of 5 video films on metrology in Czechoslovakia. Titles of the films: Metrology in the Service of the Nation, Length Metrology, Mass Metrology, Time and Frequency Metrology, PH Metrology. These films were coppied for ESA purposes.

5.4. Consultant on Time and Frequency Metrology

- On specific request of ESA the matter of organization of time and frequency signals transmission was considered. At first it was proposed that ESA could buy moderate power transmitter to transmit time and frequency signals from ESA Time and

Frequency Laboratory. To ensure more wi application, these time signals could be received and retransmitted by TV and radio broadcast through the whole area of Ethiopia.

But because of very high cost of that equipment in Ethiopia, the less expensive way of signals transmission was found. We agreed that lease telephone cables for time signals transmission to TV and Radio may give us an opportunity to transmit these time signals by the most cheapest way. In order to realise this in practice special clock and time coder would have been manufactured.

- The scheme of hand-made clock was designed to produce different types of time signals and frequency signals which are to be controlled and manipulated by time coder. As a reference or master oscillator the rubidium standard frequency 1 MHz was chosen to drive our hand-made clock. In the future it gives us an opportunity to use crystal oscillator controlled by VLF receiver as a master oscillator.

The designed scheme was assembled and put into operation by the counterpart. Different questions of setting and manual control of the clock were settled having in mind complete absence of such things as LED-indicators, push.buttons, switches, transistors, integrated circuits etc. on the local market.

After assembling the clock adjustment was finished so that the clock,practically in any time, could be synchronized with master digital clock with an error not more than a few ten's nanoseconds.

- To produce necessary format of time signals in propper time coder was designed after agreement about time signal format. Time coder has to produce 1kHz frequency signal at 58 minutes and at 59 minutes. Duration of this signal in both cases is 10 seconds. This signal is destinated to call attention for TV and Radio broadcast personnel and actually this is auxiliary signal. Six audio tips at 1kHz frequency have to be transmitted so that the beginning of the last six's tip will be in coincidence with N hours 00 minutes and 00 seconds.

. Actually designed and assembled time coder produces all necessary signals and main six signals are 1 second pulses with 1kHz padding frequency and 0.1 second duration each.

- All these additional equipment were assembled, adjusted, checked, put into operation and provided with spare battery supply to ensure permanent operation in the case of AC interruption. After a few weeks of operation we cannot see any interference from other electronic or electric units that could bring into time divergency or something like that.

All equipment was ready to start experimental time signals transmission through telephone line to transmitting stations and this could really supply public with Ethiopian Time.

- Time and Frequency Service cooperation agreement of COMECON countries to create and to develop unified Time of COMECON countries was translated and presented to ESA as well as some auxiliary verification guidances.

5.5. Consultant on Electrical Units Metrology

According to working plan /which was approved by management of ESA/ all tasks were fulfilled. Besides, the following materials were prepared:

- elaboration of the national verification chart for measuring 5 electrical units
- calibration instruments of electrical measurement for factories in Addis Ababa and in other laboratories of ESA
- recommendations to establish national primary standards of electromotive force and electrical resistance
- recommendations to elaborate national standards for calibration of instruments of electrical quantities
- recommendations for the placement of equipment in the laboratory
- installation and calibration of instruments which are not mentioned in the job description: Constant temperature oil bath
- Guideline model 9732 VT. Volt ratio box G20YDON model VR52, Line conditioners Philips model PE1414/10 - 3pcs.

5.6. Consultant on Temperature and Volume Metrology

To set up the temperature laboratory would be inherent impossible without computer processing of measured data.

Together with Mr. Spurny we have set up and installed a personal computer Commodore 128D with a printer Seikosha and colour monitor Taxan. By the end of November 1987, due to missing cables to the monitor, we were forced to operate the computer with a TV set at the hotel /largely beyond working hours/. The following Programmes have been written and debugged /on the disk T1/:

- STANDARD PRT - evaluation of measurements with standard platinum resistance thermometers;
- LIG CERT - assembling and printing the certificate for liquid-in-glass thermometers;
- THERMOCOUPLE - a comprehensive programme for calibration of all the types of thermocouples by the least square polynomial regression, together with assembling and printing of certificates /550 instructions/;
- RESTHERM - a comprehensive programme for calibration of all the resistance thermometer types including printing of certificates /540 instructions/;
- VOLUME - calculation of nominal capacities at 20°C for glass flasks, pipettes and burettes /with Mr. Challa/.

Presenting proposals to the ESA management as to the temperature and volume equipment to be located in the big hall on NMC premises.

A basic training course in BASIC programming has been staged for some of the counterparts as a part of the metrology training /responsing to a great interest on their parts/.

On the 14th January 1988, a cooperation with the Ethioplastics factory was established and is being under development /technical assistance to the quality control lab, calibration of spare thermocouples, adjustment of panel temperature meters in the technology/.

A series of letters to leading manufacturers of metrological equipment have been sent to gather background

information on additional instruments to be recommended /temperature - Hereaus, Degussa, Thermoschneider, Techme; volume and flow - Flow Technology, Bopp-Reuther; the computer - Commodore /.

When required, basic maintenence and cleaning of the copying machine Nashua was performed.

The translation of assigned parts of the Czechoslovak Metrological Law into English to be used in a draft of the corresponding Ethiopian National Law.

About 10 factories in the Addis Ababa region were visited ith the aim of initiating metrological cooperation with the NMC.

A draft fellowship programme for the counterpart Lulu Mebrahtu in Czechoslovakia was prepared for the CTA.

5.7. Consultant on Pressure and Force Metrology

At special request of ESA the following items were prepared:

- translation of test certificate from German into English /6 pages/;
- translation of manual of dynamometric bridle from German into English /37 pages/;
- the list of metrology equipment including the equipment that was not yet received and additional instruments ordered on October - November last year;
- physical inventory check of all property purchased from UNDP/UNIDO/UN funds;
- the sketch of reconstruction of the big hall of the metrology centre.

6. RECOMMENDATIONS

6.1. General Recommendations

6.1.1. Measuring Instruments

The following recommendations are based on information and experience drawn out of the activities in NMC laboratories and inspections in industries, although rather limited.

The ESA management should consistently pursue the task of establishing proper links with local industries to achieve full utilization of the current NMC equipment to the benefits of national economy. It may be accomplished proceeding along two lines:

- on the legitimate basis, to be put fully into practice; Provisions of the national metrological law, now under preparation, applying restrictive measures whenever necessary;
- on the technical basis, to start metrological cooperations with industrial plants and to offer the NMC services nationwide and, if possible, to neighbouring countries as well.

6.1.2. To create in NMC the Division "Legal Metrology" for realization of long-term national programme of develpoment of basis standards and normative-technical documents of state system for ensuring the uniformity of measurements /1988-1991/.

6.1.3. To conduct the analysis of measurements in industry with the purpose of realization units of physical "SI" determination of state of measurement equipment and on this basis to elaborate the programme of further equipment state metrological service by primary and secondary standards.

6.1.4. To accomplish international cooperation in the field of ensuring the uniformity of measurements /participation in the international organization BIPM, OIML, IEC, and of bilateral and multilateral cooperation/.

6.1.5. For conducting the state tests and certification of measuring instruments to supply NMC with test equipment /for mechanical, electrical and climatic influences/ and corresponding rooms.

6.1.6. Within now available instruments at NMC there is a number of electronic devices /e.g. digital voltmeters/ that can be remotely controlled by an external computer ,thus enabling to automate measurements and to set up various automatic calibration and data acquisition systems. In this way, the productivity and effectiveness of metrological work at NMC could be considerably enhanced at low cost. Furthermore, modern electronic instruments are specially designed for system operation, several functions being not accesible through manual operation /e.g. the Solartron 7061 digital voltmeter in the temperature lab cannot be recalibrated manually/. The following instruments, after having been equipped with interfaces specified below, can be used in system applications:

- multicalibrator Fluke 5100B
- digital multimeter Fluke 8840 A /2 units/
- digital multimeter Fluke 8502
- digital multimeter Solartron 7061
- resistance bridge Tinsley 5840D
  + Selector switch 5840 CS/6T
- universal measuring centre SIP 1002 M.

Examples of systems:

- automatic verification /and calibration in certain cases/ of digital multimeters by means of the calibrator Fluke
- data acquisition and processing in temperature metrology
- data acquisition and processing in length measurement made on the SIP machine.

Specification of needed items /the 2nd order priority/:

- for calibrator Fluke 5101B: Option 05 IEEE-488 Interface
  Y 8002 IEEE cable /2 pieces/
- for DMM Fluke 8502 : Option 05 IEEE-488 Interface
  Y 8002 Cable

Price: See the pro-forma invoice sent by Fluke upon request /the letter has been sent/

Manufacturer /supplier/: Fluke /Holland B. V./;
Post. Petersstraat 16 ; 5612 LR Eindhoven;
The NETHERLANDS

- for SIP machine: Outlet for peripheral No. 561.889 according to IEEE-488 /see the attached copy of the letter/

Price: 2,000 US$

Manufacturer: SIP ; P.O. Box 441; CH - 1211 Geneve 11;
Switzerland

As to computers, the now available Commodore 128D is not designed for system application and is not fitted with an IEEE-488 interface. Two options are now open:

1. to source this interface up on market in the manufacturer's country /England/ by the consultant /it is not commercially available/ or to design and build it up by the consultant.

   In both cases, however, the software has to be written in the machine code, which is a tiresome and in-effective procedure.

2. It is utmost reasonable to cover all the computerized activities at NMC by two computers because, even now, a number of measurement data evaluations are computerized /temperature, mass, volume, pressure/, the number of application supposed to keep increasing in the future.

   The other one should be an IBM XT worldwide accepted standard /with a Winchester disk, a colour monitor and a printer/ fitted with an IEEE-488 interface.

   A letter has been sent to Datron, UK, a company adapting these computers specifically for system applications with digital multimeters and calibrators, asking for an offer /see attached copy/.

The latter option should be preferred. In both cases, the set-up of these systems and preparation of basic software should be incorporated in the second phase of the project /including on-the-job training and preparation of corresponding guidelines/.

For regular maintenance and on-spot repairs /fault-findings/ of Fluke instrumentation in the electrical lab the following minor items are recommended to purchase:

- Extender kit 5100 A - 7005 K
- Troubleshooting kit 8840A - 9000
- Extender Assembly MIS - 7011K
- Static controller MIS - 7190
- Test Module MIS - 7191K
- Bus Intervonnect and Monitor MIS - 7013K

Price/ See the pro-forma invoice sent by Fluke.

Generally, it is highly advisable to build up at NMC a maintenance set-up comprising of power sources, generators, osciloscopes, multimeters etc. and of basic components to faciliate on-spot repairs to keep the equipment properly operating /basic training of local staff in this respect is advisable/.

6.2. Recommendations for Length and Angle Metrology

6.2.1. Furnishing of Laboratories of Length and Angle

Recommendations in this point of view can be devided to two groups·

a/ Absolutely necessary measuring instruments, which have to be present in ESA

b/ Additional reccommended measuring instruments and auxiliary devices and equipment, which could be useful for more precise, more comfortable and faster measurements in ESA.

a/ ABSOLUTELY NECESSARY MEASURING INSTRUMENTS which have to be present in ESA for securing of present needs of Ethiopian national economy:

- Line gauge block 1m, block, 1st class of accuracy;
  This line measure will serve as primary standard of line measures.
  Producer: Th. Schweitzer; 7131 Sternenfelds; FRG
- 2 Line gauge blocks, 1m, block, 2nd class of accuracy;
  One of them will serve as reference standard of ESA,

the second one will serve as working standard of ESA for verification of all line measures of lower order.
Recommended type: TH. Schweitzer
Producer: TH. Schweitzer; 7131 Sternenfelds; FRG

- Device for verifying the line gauge blocks to 1m, including microscope;
  This device can be made in ESA workshop according to the proposal and sketch of CTA or purchased.

For the time being it can be done with the help of SIP 1002 according consultants proposals.

- Steel Measuring Tape, 1st class of accuracy, length 20m of CTA 10m, 5, including certificates;
  These measuring tapes can serve as primary standards of ESA and will serve for verification of reference standards of ESA.

Producer: BMI; Arno Keller GmbH; 8562 Hersbruck; FRG

- Steel Measuring Tape, 2nd class of accuracy, length 20m, 10m, 5m, including certificates;
  These measuring tapes can serve as reference standards of ESA and will serve for verification of working standards of ESA and the most precise ordinary measuring tapes.
  Recommended type: BMI
  Producer: BMI; Arno Keller GmbH; 8562 Hersbruck; FRG
- 2 Invar Steel Measuring Tapes No 3081/10m including certificate
- 2 Invar Steel Measuring Tapes No 3081/20m including certificate
- 2 Invar Steel Measuring Tapes No 3081/30m including certificate
- Device for verification of measuring tapes;
  Device for verification of measuring tapes should be made in ESA according to CTA proposal, or it can be purchased, but exactly specified. In this case is measuring device equipped with test precision tape.
  Recommended producer: Friedrich Richter; P.O. Box 63;
  8585 Spechersdorf; FRG

- Small angle generator;
  This is a measuring instrument absolutely necessary for ESA angle laboratory. It will serve as a part of primary standard of ESA and also as a measuring instrument for verification, calibration and checking of common levels, coincidence levels, electronical levels, visual autocollimators, photoelectric autocollimators.
  Recommended type: TA 48 0 + 200'
  Recommended producer: RANK TAYLOR HOBSON Ltd.; P. O. Box 36; Guthlaxton Street; Leicester LE2 OSL; England
- Dividing head including bed
  This measuring instrument will serve as secondary standard of ESA and should be used instead of dividing table OKT 500 /which can be sold/. It will serve for the same purpose as dividing table did and beside it also for verification, calibration and checking of clinometers, heavy frame levels, angle gauges and cam shafts. Bed of dividing head will be used for purchased dividing head and for verification of other dividing heads.
  Recommended type: Pl - Carl Zeiss Jena
  Producer: JENOPTIK Jena GmbH; AUSSEN HANDELS BETRIER; 6900 JENA; Carl Zeiss Str. 1 ; Democratic RG
  or: Recommended type: PTK 1
  Producer: E.LEITZ
- Set of angle gauges
  A set of angle gauges should serve as secondary standard of ESA, and for calibration and checking of different ordinary instruments, especially protractors.
  Recommended type: CIZ, 33pieces
  Producer: USSR; 117049 Moscow; Leninskij Prosp. 9; GOSSTANDARD; DR. Isaev
  or: HOMMELWERKE; D68 Mannhein 41; postfach 181; FRG; KARL FRANK; See later
  Do not order narrow angle gauges /working face lower than 5mm/, e.g. from Poland or from Sweden /Johnsson/.

- Clinometer
  This measuring instrument will serve for checking the angles and fittings from -120° to $+120^{\circ}$. It is necessary for checking of inclination scale of dividing heads.
  Recommended type: 2 x 120° Carl Zeiss Jena
  Producer: JENOPTIK JENA GmbH; AUSSEN HANDLES BETRIB;
  6900 Jena; Carl Zeiss Str. 1 ; DDR
  or: 2 x 90°; OPTION FEINTECHNIK
- 4 laboratory thermometers 18 - 24°C
  Thermometers will hang close to measuring instruments in the laboratory, and sense temperature of measuring instruments.
  Producer: THERMOSCHNEIDER; Postfach 58;
  D - 6980 WERTHEIM/MAIN 1 ; FRG
- 1 thermohygrograph - 7 days /or 24 hours/, 0 + 40°C
  will sense and record working conditions in the laboratory.
  Recommended type: LT-68-5137
  Producer: LABOTEC GmbH; D2300 KIEL;FRG
  or: VEB FEINGEROTEBAN; 9830 DREBACH/ERG; GDR
- Stand for surface plate 1000 x 800mm or
  Table for surface plate 1000 x 630mm
  Recommended type: Tubular stand 8082-2A /working height 846-922mm/
  Producer: C. E. JOHANSSON A. B.; J 631 81 ESKILSTUNA; SWEDEN
  or: Unterschrank 107 AS/1, Nr.221065
  Producer: Carl Mahr; Postfach 147; D 7300 ESSLINGEN A.N; FRG
- All devices and equipment listed in requisitions 87/15 and 87/20
  - granite plates
  - coincidence level
  - vernier calliper
  - micrometer
  - knife straight edge
  - stainless steel square
  - dial gauge
  - dial gauge stand
  - adjustable support for long gauge blocks.

- Plaparallel glass plate -
  for checking of flatness of gauge blocks and other surfaces.
  Recommended type: 2 x Planglass 421, 45
  Postfach 147; D 7300 Esslingen a. N.; FRG
- 1 full set of gauge blocks 0.5 + 100mm;
  2nd class of accuracy; it will serve as working standard of ESA.
  Recommended type: 408/2, Nr. 800022
  Producer: Carl Mahr; Postfach 147; D 7300 Esslingen a. N.; FRG
  or: Karl Frank; Postfach 1320; 6940 Weinheim

b/ ADDITIONAL RECOMMENDED MEASURING INSTRUMENTS, AUXILIARY DEVICES AND EQUIPMENT

- End gauge block 1m, 1st class of accuracy;
  This 1m gauge block would be a part of primary standard of Ethiopia and would be used for verification of the reference standard of ESA.
  Producer: Karl Frank;
- End gauge block 1m, 2nd class of accuracy;
  This 1m gauge block would serve as reference standard and for the time being as working standard of ESA
  Producer: Karl Frank
- 1 full set of gauge blocks 0.5 + 100mm, 2nd class of accuracy;
  This will serve as spare set for working standard of ESA.
  Recommended type: 408/2, Nr. 800 022
  Producer: Carl Mahr or Karl Frank
- Remaining auxiliary equipment for SIP 1002;
  To enable to execute all common industrial measurements.
  Producer: SIP
- Goniometer;
  This measuring instrument could be a part of primary standard.
  With its help especially angle gauges would be verified.
  Recommended type: gonio B /gonio I/
  Producer: J. D. Möller - FRG.

6.2.2. Educational and Training Programme for Local Staff Abroad /PTB and CSMU/

Programme of scholarship in PTB and CSMU will be recommended by CTA.

Anyhow, according to my opinion, on the base of present knowledge of Mr. Getachew Yehualashet, present needs of Ethiopian national ecenomy and possibilities of PTB and CSMU I recommended following programme for him:

- verification of line gauge blocks - PTB
- verification of measuring tapes - PTB
- verification of gauge blocks especially 200-1000mm - PTB
- calibration and checking of common ordinary instruments for length - CSMU
- calibration and checking of common ordinary instruments for angle - CSMU
- brief visit of laboratories of length and angle in Prague and Liberec - CSMU

Duration of his stay: 3 - 4 months - PTB
1 month - CSMU

After his arrival to ESA he should be able to execute all measurements on present measuring instruments. In the case the device for verification of line gauge blocks and for measuring tapes will be not jnstalled, he should be able to provide its finishing, installation and start verification without help of CTA or foreign consultant.

6.3. Mass, Density and Viscosity Laboratory

6.3.1. Measuring Instruments

For the next development of national metrological centre of ESA, in the sense of increasing accuracy of standards and measuring results, and in the sense of measuring ranges increasing of instruments calibrations it is necessary to procure following instruments and auxiliaries:

6.3.1.1. Mass Metrology

A. For enabling of secondary mass standards and ordinary weights calibration, it is necessary to procure:
- means for cleaning of weights /Pure Etanol - 96% without metylalcohol; cotton wool; white gloves; washleather; linen cloth; hair brushes/
- means for manipulation and for temporary storage during measurement /glass bell jars; base plates for glass covers; pincers with horn tips or of plastic - without electrostatic charge/
- thermometer 10°C to 30°C, d = 0.1°C
- psychrometer
- sets of weights: OIML F1 range 1mg to 10kg /1 set/
  OIML F2 range 1g to 10kg /2 sets/
  Producer: KERN & SOHN

B. For increasing the accuracy of primary working mass standards calibration /and in consequency for better utilizing of existing comparator balances/ it is necessary to procure:
- Standard balance of reproducibility better than 10^{-8} /relative error/ for 100g to 1kg mass standards calibration and for comparison of 1kg working standard to national mass standard.
  Producer: Czechslovak Institute of Metrology, Bratislava

C. For increasing the range of measurement /for calibration of ordinary weights of lower accuracy classes F_2, M_1/:
- two-pan three-knife-edge balance, capacity 50kg, reproducibility ± 3mg, scale division d = 50mg.
  Producer: SAVTER,

6.3.1.2. Viscosity Metrology

As, for the time being, the national metrology centre of ÚSA has no devices for viscosity measurement, I recommended /for oil rafinery, pharmacy and chemistry industry development/ to establish fully equipped laboratory for viscosity instrument calibration. Following list specifies all the necessary instruments and auxiliaries for viscosity laboratory:
- two sets of working standard viscometers,
  Nominal sizes: 0, 0c, 1, 1c, 2, 2c, 3, 3c, 4, 4c, 5;

Length of capillary 90mm.
Production: Schott

- thermostat bath; volume 30 l ; temperature range 10- 60°C, temperature stability ± 0.01°C
  Producer: Lavda, Model CD30,or
  Schott, Model CT 1150/2, Nr. 55900
- viscometer holders /stands for viscometers of stainless steel/
  Producer: Schott
- set of calibration /reference/ liquids; each 500ml;
  Producer: PTB
  Type: 1000A, 2000A, 5000B, 10000B, 20000B, 50000B, 100000B, 200000B.
- rotational viscometer;
  Producer: Hanke
- illumination of the bath;
  Producer: Atherman Dgol
- cleaning means /chromid acid - 5 l, etanol - 5 l/
- stopwatch /time measurement device/
- thermometers: /19°C to 21°C/, d = 0.01°C
  /10°C to 30°C/, /20°C to 50°C/, d = 0.05°C
  /24°C to 25°C/, /39°C/, d = 0.01°C
- throughflow cooler /cooling of thermostat/
  Producer: Lauda
  or: Schott
- suction or press pump /filtered air/
- drying oven
  Producer: Hearaeys
- laboratory glass /funnels, beakers, volumetric flasks, glass filter funnel, bottles for storing refraction oils, filtering flask/.

The accuracy of the calibration can be increased significantly and operator work simplified, when complete measuring automatic device with electronic time measuring instruments are procured, e.g. Schott - West Germany supplies:

- complete glass capillary viscometer sets
- complete viscometer thermostatic bath with auxiliaries /holders, cooler, thermometers/

- automatic device for simultaneous operating of 4 viscometers /repeating measurement and time measurement/
- electronic time measuring device.

6.3. 1.3. Density Metrology

A. For purposes of hydrometers calibration by method of hydrostatic weighing /excluding calibration abroad, the hydrostatic weighing is the only possibility for standard hydrometers calibration/, the following instruments are necessary:
- analytical balance, capacity 300g, readibility 0.1mg;
  Producer: Sartorius R300S /capacity 302g, readibility ±0.1mg/
- set of weights, OIML E_2, range 1mg to 200g;
  Producer: Kern & sohn
- solid body density standard /kwartz body, or zerodur ball/;
  Producer: PTB
- thermostat bath
  volume 70 litres, temperature stability ± 0.01°C
  Producer: TAMSON TMVA70
- throughflow cooler /LAVDA/
- calibrating liquid - n nonan - 5 litres
- means for cleaning /chromid acid - 5 l, etanol - 5 l, pure benzine - 3 l/
- measuring cylinder 60 x 500 mm
- Quartz bidistillation apparatus /Quartz/
  Producer: Heraeus
- laboratory glass /beakers, funnels, bottles for reference liquid, graduated glass cylinders/
- thermometers 18°C to 25°C d = 0.01°C /liquid/
  10°C to 30°C d = 0.1°C /air/
- barometer d = 1mm Hg
- psychrometer
- means for storage of hydrometers
- hydrostatic suspension + auxiliaries
  Producer: ESA Workshop.

B. For direct comparison method of ordinary instruments calibration:
- test liquids /measuring liquids/ - petrol, pentane, ethanol,

sulfusprit/; quantity: 500 l
Producer: PTB /Liquid of Defined Density/
- measuring cylinders 70 x 600 mm; quantity: 40 pieces
- cleaning means /chromid acid, ethanol, benzene, each 10 l/
- thermometers d = 0.1°C, 10 to 30°C
- magnifying glass
- micrometer /for stem diameter mea /
- trays from plastic materials /resistive to measuring test liquids/ - 10 pieces
- laboratory glass /beakers, funnels, glass rods, weighing glasses with lids, pipettes, glass filter funnel/
- means for storage of test liquids, measuring cylinders and hydrometers

C. For measuring with picnometers:
- analytical balance, capacity 160g, readibility ± 0.01mg
  Producer: Sartorius 2004 MP6, 160g ± 0.1mg
  Note: the balance is used also for mass laboratory, as mass laboratory has no balance /only mass comparators/
- filling means.

6.3.2. Educational and Training Programme for Local Staff Abroad

6.3.2.1. Mass Metrology

For Ethiopian specialist Mr. Challa Bekele I recommended practical training in the field of mass standards, ordinary weights and balance calibration for 2 months, including the mass measuring instruments construction study.

6.3.2.2. Viscosity Metrology

For the Ethiopian specialist Mr. Lulu Mebrahtu I recommended practical training in the field of viscosity standards and ordinary instruments /glass capillary viscometers/ calibration for 1 month.

6.3.2.3. Density Metrology

As at the time of UNIDO experts stay in Ethiopia, teh National Metrological Centre of ESA had no means for

hydrometers calibration, the methods of hydrometers calibrations were explained theoretically and they were demonstrated by means of instrument not suitable for such works.

Because of this, it is necessary for the Ethiopian specialist Mr. Challa Bekele to go through more thoroughful practical training for 2 months in the following activities:

- hydrometer calibration by hydrostatic weighing
- hydrometer calibration by direct comparisom method.

6.4. Time and Frequency Laboratory

6.4.1. Measuring Instruments Needed to Complete the First Stage of the Project

To complete the first stage of the project in order to have the laboratory ready to function, the following equipment have to be delivered:

- 1 pc Crystal Oscillator XSDZ - 3.000 US $
- 1 pc Power Supply XSRM-Z - 2.800 US $
- 1 pc YT Recorder ZSGZ - 1.000 US $
- 1 pc 19" Cabinet XSRM-Z - 500 US $
- 1 pc Filterplate board VAROS, 123 KHz - 200 US $

Producer: Rohde Schwartz, West Germany.

It takes about a year to investigate the "Omega"system signals reception. This will be possible after having all previously ordered items. Propagation investigation have to reveal season's and month's and so on time propagation variations and this can give an opportunity to keep and to compare frequency within 10^{-11} limit.

Having "Omega" system channel for time and frequency comparison, one may compare abroad and to set more correct rubidium clock time. The presence of comparison channel enable us to keep this time safely for a long period.

The second phase of project may be recommended to perform a forsaid investigations and to train the staff in verification of frequency and time devices and in keeping Ethiopian time scale.

To ensure proper verification level Time and Frequency Laboratory facilities have to be expanded according to the following list and significant attention has to be paid to ensure and develop time and frequency transmission ability via different communication means.

- 2 pcs Frequency convertor XSRM-Z; Rohde Schwartz; 2x1700 US $
- 1 pc Quarz-Oscillator XSD Z; Rohde Schwartz; 4200 US $
- 1 pc Frequency counter PH6654; Phillips; 4900 US $
- 1 pc Frequency synthesizer PM5193; Phillips; 5000 US $
- 1 pc YT Recorder PM8251A; Phillips; 1000 US $
- 1 pc Oscilloscope PM3254; Phillips;
- 1 pc Oscilloscope PM3206; Phillips ;
- 1 pc Power supply unit PM1542; Phillips; 300 US $
- 1 pc Power supply unit PE1536; Phillips;
- 1 pc AC voltage stabilizator PE1610/01; Phillips;
- 1 pc AC voltmeter PM2554; Phillips;
- 1 pc Frequency comparator CH7-12; USSR; 3000 US $
  /1 and 5MHz comparison 10^{-10} resolution for 1 secon Built the phase comparator/
- 1 pc System Voltmeter 2519/51; Phillips; 1200 US $
- 1 pc Short wave receiver "Satellite"; Grundig; 500 US $

TOOLS:

- 2 pcs Soldering station; Weller; 2x 100 US $
- 2 pcs Tool box for electronics 1750; Bernstein; 2x 200 US $
- 2 pcs Special device; Bernstein; 2x 100 US $
- 2 pcs Enlargers with cold light LFM102; Luxo; 2x 100 US $
- 2 pcs Analog multimeters "MAIH"; BBC; 2x 50 US $
- Various electronic components; 1000 US $

6.5. Electrical Units

6.5.1. Suggestion on Establishing of National Primary Standards of Electromotive Force and Electrical Resistance

6.5.1.1. Prepare routine measurements procedure for state national primary standards of electromotive force /voltage/ and electrical resistance.

6.5.1.2. Investigation to carry out and determine value of electromotive force and stability of standard cells, value of resistors and stability of resistors.

6.5.1.3. Determination of the composition of the national primary standard group cells and of the national primary standard group of electrical resistors.

6.5.1.4. Carrying out an international intercomparison of national primary standards of electromotive force /voltage/ and electrical resistance for determination of actual values of electromotive force of cells and electrical resistance and uncorrected bias for the standards.

6.5.1.5. The documents prepared will confirm the state national primary standards of electromotive force and electrical resistance.

6.5.1.6. National primary standards of electromotive force . and electrical resistance will be approved.

6.5.1.7. Establishment of the national primary standards of electromotive force /voltage/ and electrical resistance in Ethiopia will give the following advantages:

- the national primary standards of electromotive force /voltage/ and electrical resistance are the basic and extremely essential preconditions for the development of the whole national economy and for progress in industrial efficency of national and international trade and commerce;
- accuracy of the measurement of voltage and resistance will be high;
- all instruments of electrical measurement DC voltage and resistance will be calibrated in Ethiopia and will not be exported for calibration to other countries;
- it may be possible to calibrate instruments of electrical measurements of other countries in the electrical laboratory of ESA.

6.5.2. Furnishing of Laboratories of Electrical Quantities

- Thermal transfer standard Fluke 540B /0.5 + 1000/V /0.01% to 0.1%/ - 1 pc; f = /5Hz to 1MHz/;
  or: Thermal transfer standard AC-DC voltage , type MHTD-6; 1 pce, USSR; /0.1 to 30/V /20 to 3.10^7/Hz = /0.01% to 0,1%/
  and DC voltage standard Fluke 5440B, 1pc = 0.001%; /0 to 1100/V
  and 14 shunts Fluke A40 + A40A
  These instruments serve for calibration of AC voltage.
- Multi-value current shunt gudeline, 1 pc, 9211A /10 to 300/A DC current = 0.01%
  or Precision DC current shunt type 357 -- pce-USSR /0.01 to 10/A = 0.005%
  These instruments serve for calibration of DC current.
- Precision shunt Fluke model Y5020 1 pc to 20A = 0.01% DC current
  = 0.035% AC current to 5KHz
  These instruments serve for calibration of AC current.
- Push button selector switch guideline model 9145 -1pc
- Thermal interconnecting cable, type SCW - 30m /for calibration standard cells and resistors/

Additional recommended measuring instruments that could be useful in the future:

- Standard resistors, type P325 1 - 10 pcs - USSR
  instability ± 0.0005% = 0.002%
  resistance is also necessary to have contrasting instability opposite signs.
  or: Standard resistors 1 ohm, Thomas type 4210-B Leeds & Northrup 2 pieces
- Resistance comparator, type 3015 -1 pc - USSR
  /10^{-2} to 10^7/ = 0.0001% to 0.01%
  or: Resistance measuring system, ESA, -1 pc, model 242 D
  These instruments will be used to establish national standard of electrical resistance.

- AC differential voltmeter 931 Fluke - 1 pc, 30Hz to 10KHz resolution 1 KV /0 to 2C/V DC ± 0.05%
  or: AC differential voltmeter , type BD-1 -1 pc , USSR
  /20Hz to 200KHz/ = 0.03% to 0.5 /0 to 100/V
  for calibration at AC voltage /0 to 1/V.

- Oscilloscope, type C1-72 -1 pc, USSR /0 to 10MHz/
  for measurement ripple and noise.

- Bridge for measurement capacitance, inductance, resistance, type E7-10 -1 pc, USSR
  /0.01 PF to 100 F/; /0.1 H to 1000 H/; /0.001 to 10 MHz/; = C.1%
  or: High voltage capacitance and inductance bridge,
  model 9910A,Guideline, 1 pc /70 MH to 7H/ = ± 15ppm
  /100pF to 1000F/ = ± 10ppm
  and Digital teraohmmeter, model 6500 Guideline 100K to 10^{16} -1 pc
  = /0.025 to 0.5/%
  These instruments serve for measurement of resistance, capacitance and inductance.

- AC source for calibration meters of electrical energy, type Y1134M, 1 pc, USSR
  /0.5 to 50/A /150 to 600/V f = 50Hz
  /for calibration meters of electrical energy/

- Standard resistors - USSR
  type P4064 10M = 0.01% - 1 pc
  type P4065 100M = 0.01% - 1 pc
  type P4066 1000M = 0.02% - 1 pc
  type P4067 10000M = 0.05% - 1 pc
  or: Standard resistor Guideline,model 9930 10M, -1 pc
  /for assurance of uniformity of measurements resistance/

- Master Volt Ratio Box Guideline, model 9700 PL, - 1pc
  /0 to 1500/V DC = ± 0.0005% of ratio
  /for calibration of DC voltage/

- Instrument for measurement of high voltage, type C136, - 1 pc, USSR;
  /0 + 30/KV DC Voltage = 0.5%
  /0 + 30/KV DC Voltage 20 Hz to 14MHz = 0.5%
  /for calibration instruments high voltage/

- Distortion analyzer sound technology ST 1700B - 1 pc
  /50Hz to 50KHz/ = 0.01%
  /for measurement AC distortion and noise/

NOTE: Instruments produced in USSR can be ordered through the following address: 117049 Moscow; Leninskij prospect 9; Gosstandard, Metrology dept.

6.5.3. Education and Training Programme for Local Staff

The content of the lectures should embrace the following topics:

Basic questions of metrology:
Verification chain, standards and reference standards of electrical quantities, type of measurements /direct determination, indirect determination/
Different types of methods of measurements / differential, null balance, substitution/
Different types of electrical measuring instruments, metrology parameters measuring instruments of electrical quantities /basic error, additional error, dispersion of indications, accuracy class/
Absolute accuracy and relative accuracy, type of errors, systematic and random accuracy
Theory and principles of establishing national primary standard of electromotive force and electrical resistance application result of measurements
/1 month/

Considering present needs of Ethiopian national economy, the following programme for practical training is recommended:

- Calibration of Thermal transfer standards
- Calibration of DC voltage standards
- Calibration of AC differential voltmeters
- Calibration of instruments for measurements of resistance, capacitance, inductance and high voltage

- Calibration of meters of electrical energy
- Calibration of oscilloscopes
- Calibration of distortion analyzer f to 1MHz
- Calibration of generators f to 10MHz
/2 months/

6.5.4. Programme for Elaboration of National Standards of Electrical Quantities

In the future it is necessary to elaborate the following national standard for calibration:

- Voltmeters AC-DC voltage f to 10MHz
- Amperemeters AC-DC current f to 5KHz
- Powermeters f to 5KHz
- Thermal transfer standards f to 100KHz
- Meters of electrical energy
- Direct current potentiometers
- Bridge for measurement capacitance, inductance and resistance
- Standard cells
- Standard resistors
- Ohmmeters, resistance boxes
- Shunts for AC and DC current f to 5KHz
f to 50KHz for voltage
f to 5KHz for current
- Digital multimeters f to 10MHz
- DC standards to 1000V
- Power supply /0 to 100/A, /0 to 100/V
- Oscilloscope f to 10MHz
- Generators f to 10MHz
- Distortion analyzer f to 1MHz.

6.6. Temperature and Volume

6.6.1. Measuring Instruments

Temperature:

For establishing proper links with local industry, a number of items for on-the-spot assembling of a limited quantity of basemental thermocouple sesors have been ordered on the requisition form 87/19, pages 1 and 2. Through these complete industrial sensors NMC could realize a number of technical evaluations in industrial technologies and by this way promote and encourage industrial metrology.

Thus the NMC assistance in enhancing quality control in economy could be considerably strengthened. A training of NMC staff in this field is strongly recommended and should be included into the second phase of the project.

A suitable DC power supply for thermocouple welding, to complete the equipment, may be donated to ESA by the Czechoslovak Metrological Institute in the second project phase.

With the present equipment in temperature, NMC is able to cover the calibration of all types of industrial sensors in the range -60°C up to 1100°C. To extend the range below -60°C, only liquid nitrogen is needed and a search for it around local industries is under progress. Above 1100°C, calibrated secondary B-type thermocouples are available, but there is no temperature generating and stabilizing equipment in NMC now.

Furthermore, by the current equipment, only the measurements can be made /and calibration performed/ when a sensor is in the direct contact with the medium, the temperature of which is measured. Thus it is highly advisable to complete the equipment by a furnace going up to 1600°C /such a design is now under research at Hereaus - see a copy of their letter in enclosure/ and by a portable infrared temperature measuring device /pyrometer/ Raynger II, as specified on requisition form 87/17.

Pyrometer will enable to perform direct measurements and evaluations in technologies /glass works, cement manufacturing

plants etc./ and to promote remote temperature measurement in industries whenever contact temperature sensors would not be used. At the same time the measuring range of the NMC equipment is thus extended above 2000°C.

When purchased with a Quinn nickel black body, the furnace can be used for verification and calibration of radiation pyrometers within its temperature range /for higher temperatures, a comparison at the place of application with the standard pyrometer Raynger could be employed/. In this way, the temperature equipment above 1100°C will present more or less logically interconnected system, both instruments being considered to be of the 2nd priority.

An extensive training of NMC staff in radiation thermometry is highly recommended /including the preparation of corresponding methodologies/.

As has been mentioned earlier, currently available liquid baths are inconvenient for the purposes of precise liquid-in-glass thermometry due to their low vertical depth and inability to create a constant temperature rise. While they could be used for other purposes /industrial thermocouples and resistance thermometers within their range, viscosity/, one sufficiently deep liquid bath is absolutely necessary.

Recommended instruments /the 1st order priority/:

- Liquid bath Tamson TMVA 70 - 230, with illuminator;
  Price: 3,000 US $ /+ 10m silicon tubing/
  Manufacturer: Tamson Laboratory Equipment; P. O. Box 208;
  2700 AE, ZOETERMEER; The Netherlands
- Through-flow cooler Lauda DLK 30, Order No. 3006
  Price: 7,000 DM
  Manufacturer: Messgeräte - Work Lauda; Postfach 1251;
  Pfarrstrasse 16/43; 6970 Lauda - Königshofen;
  West Germany; Telex 689523
- Silicon oil 100 l, type AP 200
  Price: 2,500 US $
  Manufacturer: Wacker Chemie, West Germany.

After these instruments are available, the training

in verification of most precise liquid-in-glass thermometers might be successfully concluded.

To fill in a gap in the temperature hierarchy scheme between primary resistance thermometers and ordinary instruments /the use of primary standards for common calibration work should be avoided - they are sensitive to mechanical shocks etc./, 3 secondary standard platinum resistance thermometers are recommended to be available /the 2nd order priority/:
Recommended type: Heraeus PW-EY 4 /pt 100/
Price: 4,500 US $
Manufacturer: W.C. Heraeus GmbH; Postfach 1553; D-6450 Hanau 1; West Germany
The thermometers should be delivered with PTB calibration certificates.

The temperature range below 0°C can be now covered only by a makeshift solution based on cooling ethanol in a Dewar flask by dry ice. For the most demanding applications, the method might prove to be inconvenient, the range down to -70°C being of vital importance for industry.
The recommended equipment /the 2nd order priority/:
Thermostat bath with cooling device /-70°C to +20°C/
Price: 9,000 US $
Manufacturer: Heake, West Germany
+ 100 l of ethanol for the above bath, Nr. 6008
Price: 200 US $
Manufacturer: Merck, West Germany

One of the most common and frequent tasks in every temperature laboratory is the preparation of water-ice slush /made of destilled water/ as a fixed-point bath /for reference junctions of thermocouples/ for triple-point bath /for reference junctions of thermocouples/, for triple-point cells etc.

While ice can be produced in the freezer of available fridge Bosch, a device called ice-shaver for crushing ice cubes into usable pieces is still missing, its purchase being considered necessary /the 1st order priority/.
Recommended instruments: Cat. No. 317/0252/00

Supplier: Baird and Tatlock Ltd.; P. O. Box 1; Romford RM11HA;
Essex; ENGLAND. Telex: 24225
+ demineralizer of destilled water Seratest SR 700
Price: 2,000 US $
Manufacturer: Seral, West Germany

The following Methodologies for industrial thermometers are considered to be important to complete the job in temperature metrology:

- a methodology for filled-system thermometers /especially vapor-pressure types/ and bimetallic thermometers
- a methodology for thermistor resistance thermometers.

An important part of these methodologies, sheduled for the second phase of the project, is the preparation of corresponding programmes for evaluation of measurements on the PC commodore 128D.

Volume:

As to volume metrology, the entire range of capacities of standard glass flasks, metal provers and pipettes /0.5ml to 20 l/ is now not fully covered by suitable balances to perform the gravimetric method for their calibration and verification.

Apart from balances recommended for mass metrology itself supposed to serve volume metrology purposes as well, the following one-pan electronic balances featuring sufficient sensitivity are absolutely necessary to complete the equipment / the 1st order priority/:

Type E 8100 P /up to 8.1 kg/; Price 2,000 US $
Type 3808 MP8 /up to 32.5 kg/; Price 2,800 US $
Manufacturer: Sartorius GmbH; P. O. Box 3243; D-3400 Goettingen;
West Germany

Only one-pan balance enable sufficient access to flask necks for adjusting the water level when calibrated and enable to avoid unwanted excentric loads typical for methods using two-pan balances. Their sensitivity make it possible to achieve accuracies required by international standards.

For verification of volume measures by the volumetric method, the equipment must be completed by the following graduated pipettes /now only one-mark pipettes are available/:
Graduated pipettes, Class DIN - AS officially tested,

Cat. No.	3.510.910	25ml
	3.510.710	10ml
	3.510.505	5ml
	3.510.201	2ml
	3.510.101	1ml

+ Cleansing solution Witonex 30, 1 30 l canister, Cat.No. 5.200.030
+ Thermostatic drying oven, Cat.No. 6.324.200
with shelves, Cat.No. 6.342.200
Total price: 1,000 US $
Manufacturer: Witeg - Glassgeräte; Postfach 1663; Am Bildacker 16; D-6980 Wertheim/Main; West Germany.

For verification of pipettes and burettes no glass weighing bottles with stoppers are available. Two of the following set of weighing bottles are recommended to purchase /the 1st order priority/:

Capacity:		Cat.No.:
2ml		2.870.001
10ml		2.870.005
30ml	2	2.870.008
70ml		2.870.013
120ml		2.870.014

Price: 200 US $
Manufacturer: Witeg, West Germany /see above/

For calibration of fuel tank trucks a low-efficient and obsolete method based on fixed storage tanks and water as working liquid is now used by ESA officers. A more up-to-date method using a master flowmeter set-up is recommended to be employed offering the following assets:
- as a working liquid, the same or very similar liquid /with the same physical properties/ as that one being transported by a given truck, can be used, in this way greatly faciliating the application of corrections;
- a much more efficient method, easy to implement using normal truck filling facilities of fuel companies /no additional storage tanks are necessary/.

The idea consists in calibration of the flowmeter for all the liquids involved /e.g. at the PTB or at the manufacturer/ and then in using the calibration data for computer corrections of flowmeter readings to achieve required accuracies better than 0.1% of measured volume.

A computer controlled data acquisition system will also automatically compensate for physical properties of the liquid /temperature, density/different from certified values.

The corresponding schematic proposal was prepared by the consultant to be sent for finalization and price-setting to the manufacturer /Bopp-Reuther, West Germany/ - see the enclosure /the 1st order priority/. The implementation of this project should be negotiated in advance with concerned fuel companies. The corresponding methodology /for the time being to be considered as a draft/ was prepared in advance, as mentioned earlier.

On-the-job training in this calibration procedure is highly recommended after the installation of the equipment.

According to the Ethiopian Petroleum Company, the current standardization procedures at the oil terminal Assab based on regular topographical calibrations of fixed storage tanks by a foreign company are fully satisfactory with all involved parties /but no On-the-spot inspection of the procedures there has been organized/.

Among other fluid transportation measurements only cold watermeters used for determining consumption charges in national economy should be submitted to metrological controls including a build-up of the corresponding calibration facility in the ESA. They are of simple rotating type, their construction is covered by the National Standards ESA D5. 100, with nominal flowrates ranging from $3m^3/h$ to $30m^3/h$. A simple prover loop based on pumping water through a series of watermeters under test out of a suitable calibrated fixed tank into a sink may be employed for this purpose /the 2nd order priority/. The loop should also contain a strainer /filter + gas separator/ and a regulation valve with a regulation flowmeter /see the PTB Recommended design/.

A specification and a technical proposal for such a watermeter prover loop will be provided by Bopp-Reuther as a response to the request made by letter /see a copy in the enclosure/.

After the installation of the equipment, the corresponding methodology and on-the-job training for verification of cold water meters should be prepared /within the second phase of the project/. A theoretical guideline for flow measurements generally must be prepared, too.

6.6.2. Educational and Training Programme

A six-month training course in temperature metrology for the Ethiopian counterpart Lulu Mebrahtu is strongly recommended.

The training should be concentrated especially on liquid-in-glass and resistance thermometry /not fully completed from the point of view of practice due to a lack of some equipment/, on assembling thermocouple sensors and on practical industrial applications.

Recommended places: PTB Braunschweig, West Germany
or: CSMU Bratislava, Czechoslovakia.

6.7. Pressure and Force Laboratory

The following recommendations are based on information and experience received from the activities in NMC laboratories and in inspections of industry factories and enterprises.

While visiting in industry it was found that the equipment of pressure and force laboratory covers practically all industry instruments and equipment concerning the aspects of verification and calibration.

To complete the first stage of the project in order that pressure and force will be ready to functioning, the following equipment have to be delivered:

Pressure:

- 3 pcs Manovaccumeter, range /1.10^5.25.10^5/Pa,
  class accuracy 0.5; 1.
- 15 pcs Manometer, range /0 + 2500.10^5/Pa,
  class accuracy 0.25; 0.5.
- 1 pc Deadweight tester, range/400 + 4000/bor, model 07-17-01,
  Producer: Budenberg
  Price: 26,000 DM
- 2 pcs Manometer testing instrument, range /0 + 1200/bor,
  model 380
  Producer: Budenberg
- 1 pc Aneriod-Barometer, range 0.5 bor, model 485 B 985,
  Producer: W. Lambrecht
  Price: 650 DM
- 1 pc Vacuum gauge, model 000.16202
  Producer: Leybold Heraeus
  Price: 275 DM
- 1 pc Vacuum gauge, model 000.16202
  Price: 670 DM

Force:

- 1 pc Force standard machine , 1KN - 100KN
  Producer: Erichsen
  Price: 1,850,000 DM
  Dead-weight,range 100KN - 1MN
  Hydro alic Transmission
  Special tools
  Producer: Erichsen
  Price: 1,500 DM
- Set of strain resistor gauges, range: up to 320KN, type 1909DCT,
  accuracy 0.2 + 0.4%
  Producer: USSR.

7. CONCLUSION

According to the job description and to the working plan, all tasks of consultants related with the creation of National Metrology Centre /project DP/ETH/008/84/ were fulfilled.

The team of consultants carried out the following activities concerning the project:

- installation and putting into operation the equipment and measuring instruments purchased for this project.

  All the instruments were checked, calibrated and their metrological parameters were determined ;

- preparation of unified methodologies for calibration and verification of measuring instruments. Preparation of draft national standards, hierarchy schemes, instructions and guidelines for instruments operation ;

- training of local staff in the operation with present measuring instruments. Training of local staff in accordance with elaborated methodologies in performing the calibration, verification and certification of measuring instruments for length, angle, mass, density, viscosity, electrical units, time, frequency, temperature, volume, pressure and force;

- preparation of fundamental standards and long-term programme of development of basic standards and technical documents of state system for ensuring the uniformity of measurement;

- according to the visits to local enterprises and factories the recommendations for future development of metrological service in Ethiopia were prepared. Now, the laboratories of NMC are capable to carry out calibration and verification service in the following fields of measurements: length and angle, mass, density, viscosity, electrical units, time and frequency, temperature, volume, pressure and force.

To enhance the capabilities of all laboratories to cope with certain present and future demands, the completion of the equipment by the above mentioned orders /see chapter 6/ it is strongly recommended to prepare the ground for the second phase of the project.

* * * * * * * * *

During the period when the UNIDO team stayed at Addis Ababa, the consultants, their counterparts and management of Ethiopian authority for standardization worked together in the condition of closed cooperation, in the mutual understanding and helped each other to solve all the problems connected with the creation of the National Metrology Laboratory of EAS.

The consultants hope that their work helped to start the metrology service in Ethiopia at high accuracy level and express their best regards to:

Ato Akberom Tedla - General manager of ESA

Ato Yohannes Afework - Head of Technical Service Department

Ato Tafesse Muluneh

and to all counterparts
for their assistance and cooperation.

* * * * * * * * *

8. LIST OF UNIFIED METHODOLOGIES

DRAFT OF STANDARD GUIDELINES

8.1. Consultant on Establishment and Furnishing of Metrological Laboratories

has prepared the following documents:

- "State system for ensuring the uniformity of measurements. Basic regulation."
- "State supervision of measuring instruments. Basic regulations."
- "Verification of measuring instruments. Organization and procedure."
- "State tests of measuring instruments. Basic statements."
- "State tests of measuring instruments. Organization and procedure."
- "Normative-Technical documents for verification methods of measuring instruments."
- "Reference materials. Basic statements."
- "Metrological ensuring for preparation of production. General statements."
- "National hierarchy scheme for measuring instruments of time and ferquency."
- "National hierarchy scheme for means measuring voltage /1 to 1000/V in the range of frequencies of /50 + 4.10^3/Hz."
- "National hierarchy scheme for means measuring direct current."
- "National hierarchy scheme for means measuring alternating current /1.10^{-5} + 20/Af = /50 + 4.10^3/Hz."
- "National hierarchy scheme for means measuring electromotive force and electrical voltage."
- "National hierarchy scheme for means measuring electrical resistance."
- "National hierarchy scheme for pressure instruments in the range of /$0,7.10^5$ + 600.10^5/Pa."
- "National hierarchy scheme for means measuring temperature."

8.2. Consultant on Length and Angle Measurement

has prepared the following documents:

- Unified methodology in performing verification, calibration and certification of gauge blocks 0.5 + 100mm on present measuring instrument TESA and 125 - 1000mm on present Universal measuring Centre SIP 1002 M /18 pages/.
- Unified methodology in performing verification, calibration and certification of dividing heads and dividing tables with the help of present measuring instruments OKT 500. D. A. 200 and 12-sided polygon /21 pages/.
- *Unified methodology in performing verification, calibration and certification of visual and photoelectric autocollimators /11 pages/.
- *Unified methodology in performing verification, calibration and certification of goniometers with the help of present measuring instruments /dual axis photoelectric autocollimator D. A. 200 and 12-sided polygon/ /9 pages/.
- Guideline: Checking of micrometric measuring gauges /4 pages/.
- Guideline: Checking of dial gauges /3 pages/.
- Guideline: Checking of vernier callipers /2 pages/.
- Guideline: Autocalibration of gauge blocks, including computer programme /11 pages/.
- *Guideline: Calibration and certification of levels /10 pages/.
- Guideline: Calibration and certification of angle gauges /10 pages/.
- Guideline: Measuring of straightness and flatness /9 pages/.
- Proposal of Ethiopian Standard: Ethiopian Primary Standard and National Hierarchy Scheme for length measuring instruments /5 pages/.
- Proposal of periods of recalibrations of measuring instruments /length and angle/ /4 pages/.
- List of recommended English written literature /3 pages/.

8.3. Consultant of Mass, Density and Viscosity Measurement

has prepared the following documents:

- "Methodology of mass measuring instruments calibration". It consits of three parts:
  Part one: General theory and methods of measurement contains the following chapters: Definitions; measurement of mass; theory of balances; El. Mag. force compensation; methods of weighing; mass determination of standards; equation for the air density; The least squares calibration /50 pages/;
  Part two: Methods of calibration of balances contains: Calibration of two-pan balances; calibration of single-pan balances; calibration of El. Mag. force compensation balances; least-square calibration of built-in weights /32 pages/;
  Part three: Methods of calibration of weights and mass standards
  contains: Calibration of weights and mass standards; Ethiopian scheme of hierarchy; examples of calibration schemes; programme for computer; examples - numerical /85 pages/;
- "Methodology of viscosity measuring instruments calibration" contains the following chapters: Definitions; theory of capillary viscometers; rotational viscometer; falling sphere method; measurement of viscosity; methods of calibrations /Stepping up, direct comparison/; scheme of hierarchy /73 pages/;
- "Methodology of density measuring instruments calibration" /65 pages/.

8.4. Consultant of Time and Frequency Measurement

has prepared the following documents:

- "Unified methodology of performing verification of actual low precision frequency measures". This document involves the shedule of performing verification, necessary equipment

means, order of performing verification and issuing of final verification document.

- "Verification methodology in performing verification, calibration and certification of actual limited accuracy frequency measures". These measures cover frequency range 0.1 = 125 MHz and accuracy 10^{-6} * 5.10^{-9}.
- "Unified methodology in performing verification, calibration and certification of high accuracy frequency and time measures." This covers frequency range 0.1 + 10 MHz, time range 0.1ms + + 10^{8} s and accuracy 5.10^{-9} + 2.10^{-11} or higher.
- "The hierarchy scheme of time and frequency".

8.5. Consultant of Electrical Units Measurement

has prepared the following documents:

- Procedure for calibration of the direct current comparator potentiometer Guideline model 9930 /3 pages/
- Procedure for calibration of the DC Reference standard Fluke Model 732 A /4 pages/
- Procedure for calibration of the calibrator Fluke Model 5101B /14 pages/
- Procedure for calibration of the portable calibrator Fluke model 515 A /8 pages/
- Procedure for calibration of the precision power amplifier Fluke Model 5205 A /4 pages/
- Procedure for calibration of the transconductance Amplifier Fluke Model 5220 A /5 pages/
- Procedure for calibration of the constant temperature oil bath, Guideline Model 9732 VT /4 pages/
- Procedure for calibration of the powermeter siemens model B4301 /5 pages/
- Procedure for calibration of the portable meter test equipment LANDIS & GYR Model TVH4.322 /9 pages/
- Procedure for calibration of the DC power supply HEWLETT PACKARD Model 6260B /7 pages/

- Procedure for calibration of the standard resistors TINSLEY & CO LTD Type 5686, 5615, 5685, 5685B /5 pages/
- Procedure for calibration of the current shunt Fluke Model A90 /4 pages/
- Procedure for calibration of the transvolt standard all enclosure Guideline model 9154D /6 pages/
- Procedure for calibration of the volt ratio box GOYDO model VRSZ /4 pages/
- Procedure for calibration of the digital multimeter Fluke Model 8502 A /8 pages/
- Procedure for calibration of the digital multimeter Fluke Model 8840 A /13 pages/
- National primary standard and verification schedule for means measuring electromotive force and electrical voltage /4 pages/
- National primary standard and verification schedule for means measuring electrical resistance /4 pages/
- Standard for verification schedule for measuring direct current /3 pages/
- Standard for verification schedule for measuring alternating current /3 pages/
- Standard for verification schedule for the measuring means of AC voltage /3 pages/
- Reports of calibration of the following instruments:
+ direct current comparator, potentiometer guideline model 9930 /2 pages/
+ DC reference standard Fluke Model 732A N 3935013
+ Calibrator Fluke Model 5101B N 4050000 /5 pages/
+ Precision power amplifier Fluke Model 5205A N 4020009 /3 pages/
+ Transconductance amplifier Fluke Model 5220 N 3985013 /3 pages/
+ Portable calibrator Fluke Model 515A N 3970012 /5 pages/
+ Digital multimeter Fluke Model 8502A N 4075003 /7 pages/
+ Digital multimeter Fluke Model 8840A N 3997135 and N 4002056 /16 pages/
+ Constant temperature oil bath guideline model 9732VT N 54338 /2 pages/
+ Powermeter siemens model 64301 N 05025630 /2 pages/

+ Portable meter list equipment LANDIS & GYR Model TVH4.323 N57011450 /2 pages/
+ Standard resistors TINSLEY & CO LTD - types 5686, 5615, 5685, 5685B /2 pages/
+ Current shunt Fluke Model A90 N 3675024 and N 3675023 /6 pages/
+ Transvolt standard cell enclosure guideline model 9154D N54454 /2 pages/
+ Volt ratio box GOYDO Model VRSZ N 43223 /2 pages/
- National verification chart for measuring electrical resistance
- National verification chart for measuring voltage /1.10^{-3} to 1000/V in the range of frequencies /50 to 50.10^{3}/Hz
- National verification chart for means measuring electromotive force and electrical voltage
- Natinal verification chart for means measuring direct current
- National verification chart for means measuring alternating current 1.10^{-3}A to 20A f= 50Hz to 50.10^{3}Hz.

8.6. Consultant of Temperature and Volume Measurement

has prepared the following documents:

- A translation of the instruction manual for the cooler DLK 15 /originally in German/
- A copy of ASTM Standard: standard definitions of terms related to temperature measurement
- A copy of the International practical temperature scale 1968 /amended edition of 1975/
- An explanatory note on control systems in temperature equipment /3 pages/
- A theoretical guideline "The Thermodynamic Temperature Scale" /20 pages/
- A guideline "Liquid-in-glass Thermometers" /15 pages/
- A unified methodology for verification of liquid-in-glass thermometers /30 pages/
- A guideline for users of "Liquid-in-glass Thermometers" /3 pages/

- A guideline "Thermocouples" /21 pages/
- A unified methodology for calibration of thermocouples /17 pages/
- A theoretical guideline "Resistance Thermometers" /11 pages/
- A unified methodology for calibration of resistance thermometers /15 pages/
- A methodology for operations with a triple-point cell of water /5 pages/
- Provisional hierarchy schemes for temperature
- A theoretical guideline "Evaluation of errors in temperature measurement" /17 pages/
- A theoretical guideline "Numerical methods in temperature measurement" /11 pages/.

8.7. Consultant of Pressure and Force Measurement

has prepared the following documents:

- Unified methodology for verification, calibration of pressure instruments /57 pages/
- Draft of the Ethiopian state standard and the hierarchy scheme for measuring devices of pressure measurement within the range of 7.10^5 to 600.10^5Pa /4 pages/
- Draft of the Ethiopian state standard of dead-weight manometer methods verification /13 pages/
- Instruction on manufacture, graduation, measurement and verification of mercury barometer and manometer /14 pages/
- Instruction of the washing of glass manometer and barometer tubes and rubber hoses /2 pages/
- Instruction on graduation, measurement and verification of dynamometric bridles /Elastic proving devices/ with mechanic measuring instrument and optical microscope /14 pages/.