MITTATEKNIIKAN KESKUS

CENTRE FOR METROLOGY AND ACCREDITATION

Julkaisu J2/2000

FINNISH NATIONAL STANDARDS LABORATORIES
FINMET

ANNUAL REPORT 1999

Kansallinen mittanormaalilaboratorio • FINMET •

Helsinki 2000

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1. INTRODUCTION

The aim in maintaining and developing the National Measurement System is to support the competitiveness of the Finnish industry and the economy, to fulfil the needs of consumers and the society, and to integrate the Finnish metrological infrastructure with the European and international infrastructures.

Organisation of the National Measurement Standards System was launched by a Government Decree in 1978, considering especially the growing needs of industrial metrology. National standards were established for most of the basic units and some derived units by the Council of State which appointed a number of public research institutions as National Measurement Centres.

In 1994, according to a new Law on Units of Measurement and the National Measurement Standards, the Ministry of Trade and Industry was authorised to decide for which basic and derived SI units National Measurement Standards are realised and maintained. The authority to designate the National Standards Laboratories was delegated to the Centre for Metrology and Accreditation (MIKES). The Finnish Organisation of National Standards Laboratories is called FINMET.

This publication contains general information on the Finnish metrological system and a summary of the activities of FINMET in 1999.

2. NATIONAL MEASUREMENT SERVICE

2.1 DEFINITION

The Finnish National Measurement Service consists of National Standards Laboratories (FINMET) and the calibration laboratories accredited by MIKES. FINMET is responsible for realisation of the SI system units, maintenance and development of the National Standards and the dissemination of the units determined within the National Measurement Standards to standards of lower accuracy. The services provided by the Accredited Calibration Laboratories are normally traceable to the National Measurement Standards maintained by FINMET.

2.2 NATIONAL MEASUREMENT STANDARDS AND TRACEABILITY OF MEASUREMENTS

The principal task of the National Measurement Service is to create prerequisites for the traceability of physical measurements. Traceable measurements are generally required in applications for which regulations, standards or agreements specify certain requirements for the verification of measurements. These requirements include verification of measurements in accordance with industrial quality system standards, laboratory standards or the ISO standards.

Traceability means a link between the measurement results and the International or National Measurement Standards, obtained through an unbroken chain of comparisons (Fig.1). Measurement standards can be instruments, devices or reference materials that are used to define, realise or maintain the measurement unit of a quantity or its multiples.

Primary standards represent the best metrological quality of standards. In practice, they are standards by which the units of measurement are realised according to their internationally accepted definitions. These primary standards are used to disseminate the unit of the measurement to a lower level of accuracy i.e. to the secondary, reference and working standards.

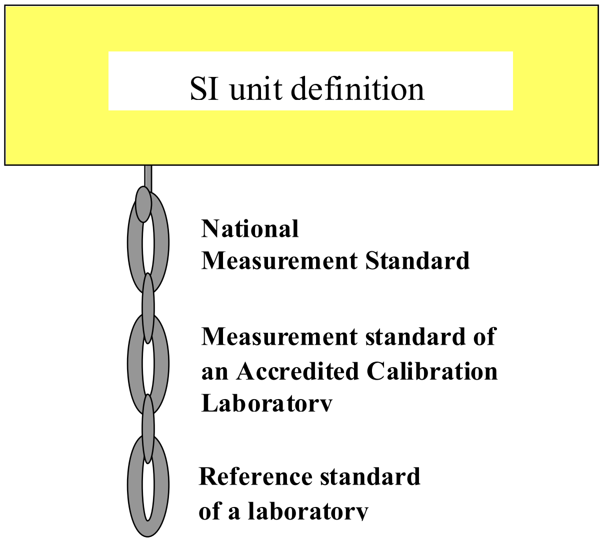

Fig. 1. Traceability chain

In practice, the unbroken chain of comparisons is obtained by calibrating the measuring instruments. Calibration means a comparison in which the uncertainty of the instrument to be calibrated is determined using a more precise instrument of known uncertainty.

The measurement standards of the basic and derived units of the SI-unit system are the cornerstones of the traceable physical measurements. The traceability chains of the measurement standards of derived units are based, either directly or indirectly, on the measurement standards of the basic units (metre, kilogram, second, ampere, kelvin, candela and mole).

All measurement results have a degree of uncertainty, which is an essential factor describing the quality of measurements as well as the quality of a measurement standard. National and international standards belong to the highest degree of accuracy. Accuracy requirements in various routine measurements are totally dependent on the particular measurement applications.

2.3 ORGANISATION OF THE MEASUREMENT SERVICE

The Finnish Measurement Service is from its organisational principle similar to the metrological systems in most European industrialised countries (Fig. 2). Its most essential duty is to arrange the traceability chains from the measuring instruments of the end users to the SI unit system.

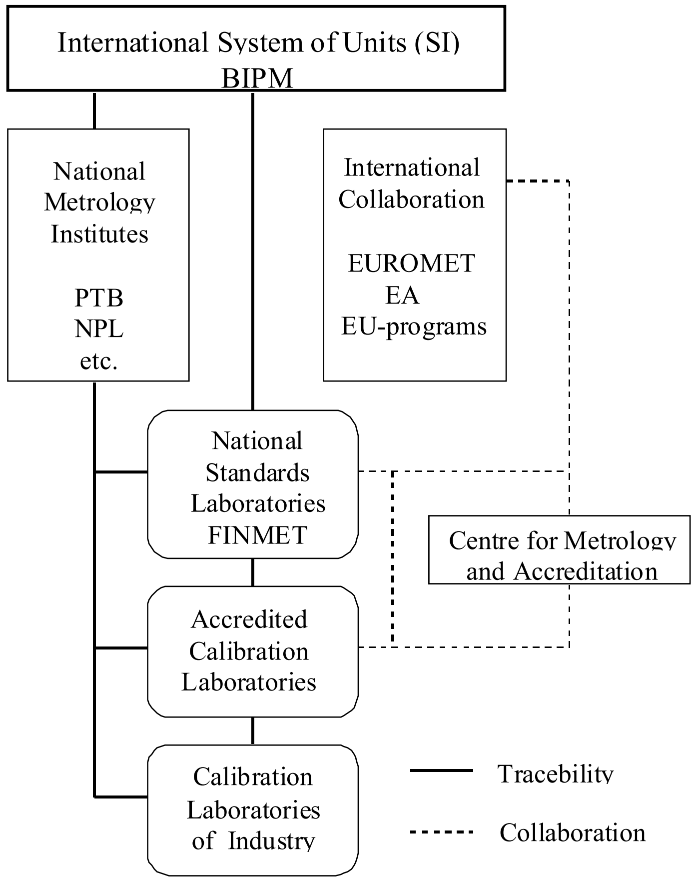

Fig. 2. Traceability to SI-units and collaboration concerning calibration activities

The Centre for Metrology and Accreditation (MIKES), subordinated to the Ministry of Trade and Industry, is the co-ordinating national body of the Measurement Service (Fig. 3). The Finnish National Measurement Standards System, FINMET, is a so called decentralised system, in which a number of research institutes act as National Standards Laboratories. The laboratories are responsible for the maintenance and development of the National Measurement Standards. MIKES designates the National Standards Laboratories included in FINMET and supervises their operations. Financing and international co-operation are also channelled through MIKES.

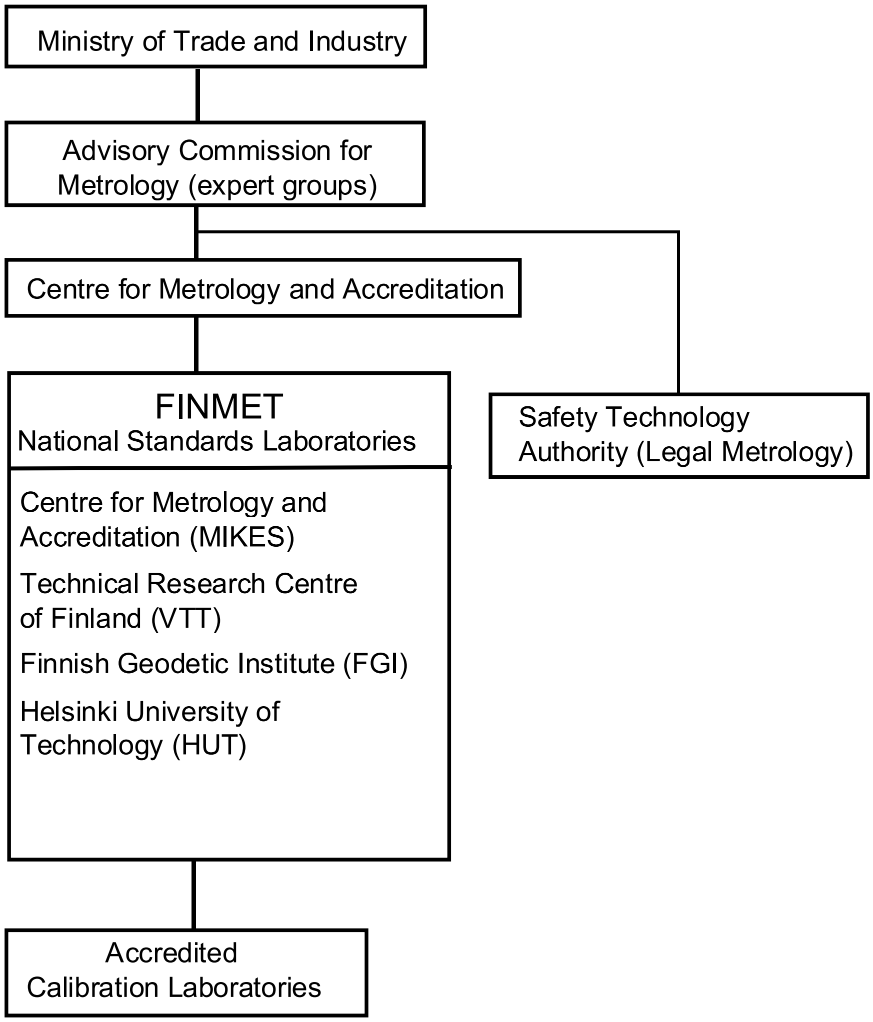

Fig. 3. Organisation of metrology in Finland

Finland currently has four National Standards Laboratories: the Technical Research Centre of Finland (VTT), the Finnish Geodetic Institute (FGI), Helsinki University of Technology (HUT), and MIKES. In accordance with a separate Decree, the Finnish Centre for Radiation and Nuclear Safety (STUK) is responsible for maintaining measurement standards for ionising radiation. The National Standards Laboratories are presented in Fig. 4.

A National Standards Laboratory is responsible for the National Measurement Standards of one or more quantities, and they represent the highest level of the traceability chain. The measurement standards may be either primary or secondary standards. In the latter case the traceability is achieved from the foreign (or international) standards laboratories. The National Standards Laboratories are also responsible for the traceability of measurement standards of the Accredited Calibration Laboratories within their range of measurement quantities. In addition, they offer calibration services directly to other clients.

There are Accredited Calibration Laboratories for measurement quantities for which there are no National Standards Laboratories. MIKES has made a contract with Tampere University of Technology (TUT, coordinate measurements) and Raute Precision Oy (force and torque) that they produce expert services, e.g., maintenance of traceability of their reference standards, guidance of industrial customers, international co-operation and organising of comparisons. The Contract Laboratories are presented in Fig. 5.

FINMET
NATIONAL STANDARDS LABORATORIES 31.12.1999

MITTATEKNIIKAN KESKUS
CENTRE FOR METROLOGY AND ACCREDITATION

NATIONAL STANDARDS LABORATORY	QUANTITIES	HEAD OF CALIB. LABORATORY	e-mail
Centre for Metrology and Accreditation POB 239, FIN-00181 Helsinki Tel. 358 9 616 761* Fax 358 9 6167 467	mass pressure length[1] temperature humidity	Kari Riski Markku Rantanen Antti Lassila Thua Weckström Martti Heinonen	kari.riski@mikes.fi markku.rantanen@mikes.fi antti.lassila@mikes.fi thua.weckstrom@mikes.fi martti.heinonen@mikes.fi

[1] Lasers, long gauge blocks and line scales

VTT Automation Measurement Technology Metrology Section POB 1304, FIN-02044 VTT Tel. 358 9 4561* Fax 358 9 456 7029	electric voltage (dc and ac) electric current (dc and ac) electric power and energy (dc and ac), resistance, capacitance time interval, frequency instant of time	Panu Helistö	panu.helisto@vtt.fi
VTT Manufacturing Technology, Production Engineering POB 1702, FIN-02044 VTT Tel. 358 9 4561* Fax 358 9 460 627	length, angle flatness, straightness roundness, cylindricity surface roughness	Heikki Lehto	heikki.lehto@vtt.fi
Finnish Geodetic Institute Geodeetinrinne 2 FIN-02430 Masala Tel. 358 9 295 550* Fax 358 9 2955 5200	acceleration of free fall geodetic length	Jussi Kääriäinen	jussi.kaariainen@fgi.fi
Helsinki University of Technology High Voltage Institute POB 3000, FIN-02015 HUT Tel. 358 9 4511* Fax 358 9 451 2395	dc voltage, ac voltage (50 Hz) capacitance (50 Hz), loss factor inductance (high voltage reactors) lightning impulse voltage switching impulse voltage, other impulse voltages, impulse current impulse energy, impulse charge	Martti Aro	martti.aro@hut.fi
Helsinki University of Technology Metrology Research Institute POB 3000, FIN-02015 HUT Tel. 358 9 4511* Fax 358 9 460 224	luminous intensity, illuminance luminance, spectral irradiance spectral radiance, colour coordinates, colour temperature optical power, transmittance, reflectance, spectral responsivity optical wavelength	Erkki Ikonen	erkki.ikonen@hut.fi

Position of Finnish Centre for Radiation and Nuclear Safety is based on the relevant legislation.

Finnish Centre for Radiation And Nuclear Safety POB 14, FIN-00881 Helsinki Tel. 358 9 759 881* Fax 358 9 7598 8450	air kerma air kerma rate absorbed dose (water, soft tissue, on the surface of tissue) dose equivalent (photon-, beta- and neutron radiation) surface emission rate	Hannu Järvinen	hannu.jarvinen@stuk.fi

Fig. 4. The National Standards Laboratories of Finland

MITTATEKNIIKAN KESKUS
CENTRE FOR METROLOGY
AND ACCREDITATION

CONTRACT LABORATORIES 31.12.1999

CONTRACT LABORATORY	QUANTITIES	HEAD OF CALIB. LABORATORY	e-mail
Raute Precision Oy Force and Mass Laboratory POB 22, FIN-15801 Lahti Tel. 358 3 829 4275 Fax 358 3 829 4101	force, torque	Aimo Pusa	aimo.pusa@rauteprecision.fi
Tampere University of Technology Institute of Production Engineering POB 589, FIN-33101 Tampere Tel. 358 3 365 2719 Fax 358 3 365 2753	coordinate measurement coordinate measuring machines	Heikki Tikka	heikki.tikka@pe.tut.fi

Fig 5. The Contract Laboratories

The Advisory Commission for Metrology, appointed by the Council of State, acts as an expert body in an advisory capacity. The Commission is divided into three sections: Measurement Service, Verification and Chemical Metrology. In addition, a number of expert working groups operate under these sections. Regarding the Measurement Service Section there are working groups corresponding to various quantity groups i.e. mass, electricity/time, length, temperature, radiometry and photometry, flow and acoustics.

The Accredited Calibration Laboratories offer calibration services directly to the end users. The calibration certificates given by them belong to the scope of the multilateral agreement of the organisation for the European co-operation for Accreditation (EA). The Finnish Accredited Calibration Laboratories can be found on the Internet pages of MIKES, www.mikes.fi/finas.

Legal metrology or verification is also closely connected with the field of the National Measurement Service. The primary scope of verification in Finland is focused on the measures and measuring instruments used in commercial transactions. The Safety Technology Authority (TUKES) is the national authority that supervises and controls the field of legal metrology and contributes to the drafting of relevant legislation.

2.4 INTERNATIONAL CO-OPERATION

MIKES is responsible of the general international co-operation concerning the Measurement Service and metrology. In addition, the National Standards Laboratories take care of the international connections in their special areas. Intercomparisons of National Measurement Standards of different countries are an essential means of co-operation, through which the international competency and consistence can be shown.

The principal forums of co-operation are: CGPM/CIPM/BIPM based on the Metre Convention, EUROMET collaboration between the European National Metrology Institutes, EA and NORMET co-operation among the Nordic countries. In legal metrology the main organisations are WELMEC, for western European co-operation and OIML, for international co-operation.

At a meeting held in Paris on 14 October 1999, the directors of the National Metrology Institutes (NMIs) of thirty-eight Member States of Metre Convention signed a mutual recognition arrangement (MRA) drawn up by the CIPM, related to national measurement standards and calibration and measurement certificates issued by NMIs. Finland singed MRA so that MIKES, VTT and HUT are part of the arrangement. Also the contract laboratories Raute Precision Oy and TUT are included in MRA. So far FGI and STUK decided to opt out of the arrangement.

The technical basis of the MRA is a set of key comparisons of national measurement standards identified by the Consultative Committees of the CIPM and executed at the highest level by the BIPM, the Consultative Committees and the regional metrology organisations. NMIs should have quality systems and demonstrations of competence. The outcome of the MRA is a database which includes statements of the measurement capabilities of each NMI. The database will be publicly available on the Internet. The present calibration and measurement capabilities of FINMET are presented in Appendix 1. The text of the MRA is available on the BIPM Internet page, www.bipm.fr.

3. ACTIVITIES OF THE NATIONAL STANDARDS LABORATORIES IN 1999

3.1 CALIBRATIONS

Table 1. The number of Accredited Calibration Laboratories and the number of calibration certificates issued by National Standards (NSL) and Accredited Calibration Laboratories (ACL).

	Certificates (NSL)				ACL				
						Certificates			
	-96	-97	-98	-99	Number 1999	-96	-97	-98	-99
MIKES (temp.)	250	210	149	167	5	657	963	1449	1444
MIKES (mass)	174	180	126	134	6	2 276	2 887	3920	4168
MIKES (pressure)	126	116	124	112	6	788	1 043	985	1018
MIKES (humidity)	49	48	35	41	1	10	18	70	61
MIKES (length) **VTT MT (dimensional quant.)**	7 383	5 452	19 410	9 450	6	3 314	3 135	2823	2675
VTT Automation (electrical quant., time)	82	52	100	63	9	1 644	1 654	1713	1836
**SONERA (sound press., hf electrical quant.) ** **	33	32	41				4		
FGI (g and geodetic length)		2	4	4					
HUT (optical quantities)	17	34	29	37	2		32	4	182
HUT (high voltage)	17	21	47	28					
STUK (ionising radiation)	76	72	63	65					
Force and torque					3			476	550
Flow and volume					3			342	265
Chemistry					1				86
SUM	**1 214**	**1 224**	**1147**	**1110**	**28***	**8 689**	**9 736**	**11 782**	**12 285**

*Some Accredited Calibration Laboratories are operating in several different fields.

** Sonera was a NSL until 31 December 1998.

3.2 INTERNATIONAL COMPARISONS

Table 2. The number of international comparisons participated by National Standards Laboratories. The year refers to the publishing date of the final report.

	Year -91	Year -92	Year -93	Year -94	Year –95	Year -96	Year -97	Year -98	Year -99	SUM
MIKES (temp.)	3	1			1		1			**6**
MIKES (mass)	1	1		1		1	1		1	**6**
MIKES (pressure)		3	2		1		3		4	**13**
MIKES (humidity)		1	1		1		1			**4**
MIKES (length)					3	1	3	1		**8**
VTT MT (dimensional quant.)		2	2	2		1		1	1	**9**
VTT Automation (electr. quant., time)	6	5	2	1		1		1	2	**18**
SONERA (sound press., hf electrical quant.) *		2		2	2					**6**
FGI (g and geodetic length)	2	2	1	1	1					**7**
HUT (optical quantities)						1	1	2	1	**5**
HUT (high voltage)						2	1	1	3	**7**
STUK (ionising radiation)	2		2	2	3	1	1	1	1	**13**
SUM	**14**	**17**	**10**	**9**	**12**	**8**	**12**	**7**	**13**	**102**

* Sonera was a NSL until 31 December 1998.

3.3 PARTICIPATION IN THE EUROMET-PROJECTS

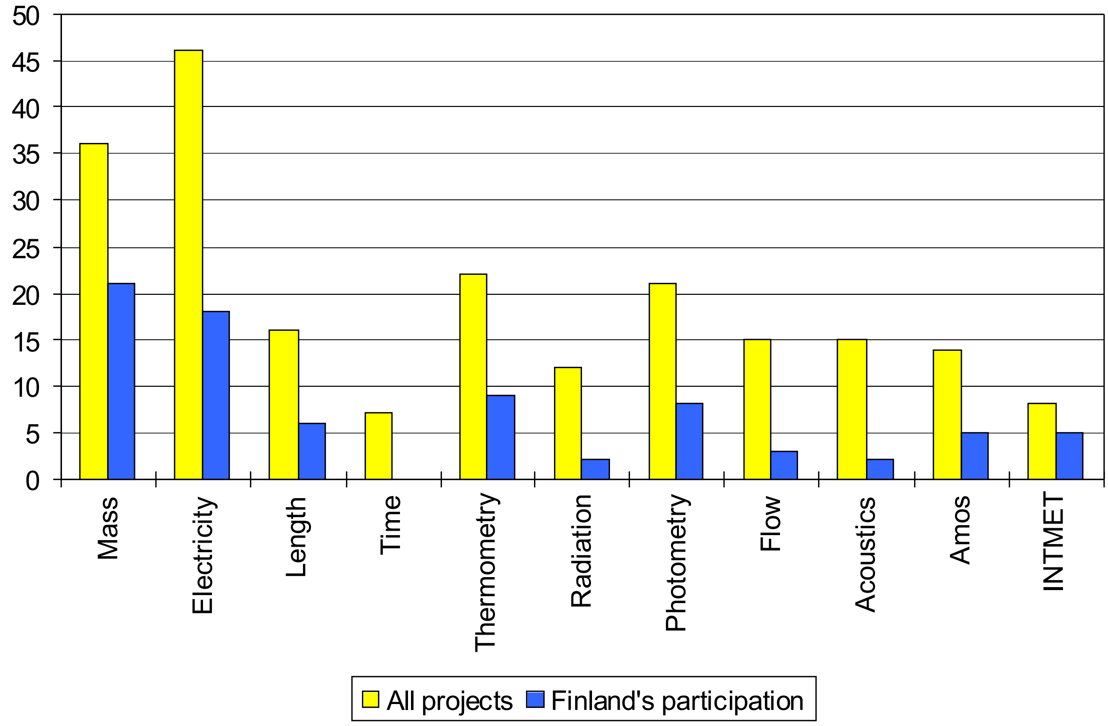

Fig. 6. Agreed and proposed projects March/2000 [1]

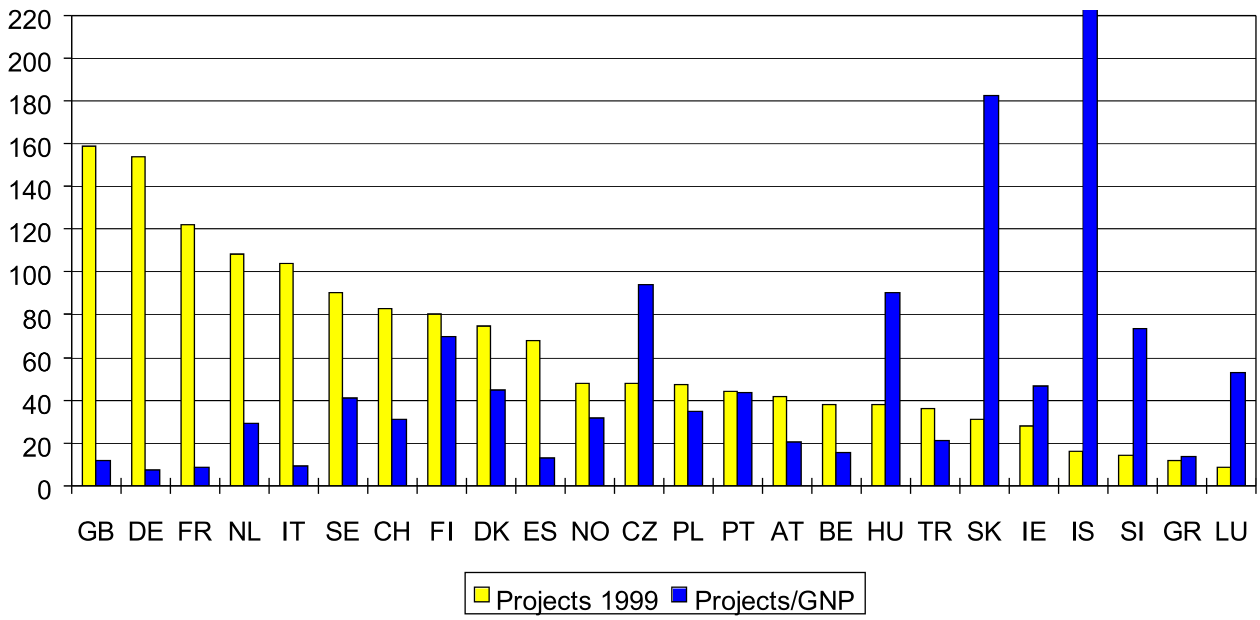

Fig. 7. Agreed and proposed projects March/2000 [1]

List of country abbreviations:

AT	Austria	ES	Spain	IE	Ireland	PL	Poland
BE	Belgium	FI	Finland	IS	Iceland	PT	Portugal
CH	Switzerland	FR	France	IT	Italy	SE	Sweden
CZ	Czech Republic	GB	United Kingdom	LU	Luxembourg	SI	Slovenia
DE	Germany	GR	Greece	NL	Netherlands	SK	Slovakia
DK	Denmark	HU	Hungary	NO	Norway	TR	Turkey

Reference:

1 The Internet pages of EUROMET, www.euromet.org, March 2000.

3.4 DEVELOPMENT PROJECTS

Table 3. Development and maintenance projects in 1999. The table does not include the projects of the Finnish Geodetic Institute and the Finnish Centre for Radiation and Nuclear Safety. MIKES' funding indicates the amount of money which was allocated to the project.

				FIM 1000	
ELECTRICITY				**MIKES' Funding**	**Total Costs**
VTT Aut:	Development of Resistance in 1999			376	537
VTT Aut:	Development of Measurement Site for 50 Hz Power and Current			463	658
VTT Aut:	Development of AC Current Step-up Set-up			182	260
VTT Aut:	Development of DC Voltage in 1999			177	253
VTT Aut:	Development of Calibration Service for Small AC Currents and Voltages			239	340
VTT Aut:	Monitoring of YLE Time Signal			30	43
VTT Aut:	Rf-metrology Survey			160	160
VTT Aut:	Improvement of Measurement Facilities for Small Resistances and Voltages			167	167
VTT Aut:	Maintenance Project			1400	1400
		VTT Aut Total:	27,0 %	3194	3818
HUT HVl:	Development of National Standards for High Voltage			400	531
HUT HVl:	Maintenance Project (high voltage)			290	351
		HUT HVl Total:	5,8 %	690	882
		Electricity Total:	**32,8 %**	**3884**	**4700**
LENGTH					
MIKES:	Development of Calibration of Linear Displacement at Nanometric Scale			250	377
MIKES:	Development of the Calibration Service for the Quartz Meter			120	307
MIKES:	Development of an Iodine Stabilised Diode Laser			180	304
MIKES:	Development of an Iodine Stabilised Nd:YAG Laser			180	257
MIKES:	Maintenance Project *)			360	360
		MIKES Total:	9,2 %	1090	1605
VTT MT:	2D Optics			763	817
VTT MT:	Measurement of Temperature of Air in Real-time in Laser Measurements			222	270
VTT MT:	Maintenance Project (dimensional quantities)			420	420
		VTT MT Total:	11,9 %	1405	1507
		Length Total:	**21,1 %**	**2495**	**3112**
OPTICS					
HUT MRI:	Development Project of Optical Quantities			800	1151
HUT MRI:	Purchase of a Transfer Standard Spectrometer for Regular Transmittance Calibrations			296	423
HUT MRI:	Maintenance Project (optical quantities)			480	1239
		Optics Total:	**13,3 %**	**1576**	**2813**
MASS					
MIKES:	Development of the National Standard Laboratory for Mass			200	394
MIKES:	Investigation of the New Methods for the Realisation of the Kilogram			140	260
MIKES:	Purchase of a 1 kg Mass Comparator			300	345
MIKES:	Maintenance Project (mass and density) *)			200	200
MIKES:	Maintenance Project (pressure) *)			440	440
		Mass Total:	**10,8 %**	**1280**	**1639**

TEMPERATURE					
MIKES:	Development of the Humidity Standards			100	251
MIKES:	Replacement of the Calibration Furnaces			200	289
MIKES:	Closed Fixed Point Cells			55	76
MIKES:	Maintenance Project (temperature) *)			430	430
MIKES:	Maintenance Project (humidity) *)			320	320
		Temperature Total:	**9,3 %**	**1105**	**1366**
CONTRACT LABORATORIES					
Raute (ACL):	Torque Standard Machine with Transfer Transducers for the Range 0,01–20 Nm			120	268
Raute (ACL):	Torque Transducers for EA Intercomparison T2			63	63
Raute (ACL):	Nordic Intercomparison of Uniaxial Material Testing Machines			114	130
Raute (ACL):	Key Comparison for 0 – 10 kN			220	220
Raute (ACL):	Expert Services (force and torque measurements)			234	234
		Raute Total:	6,3 %	751	915
TUT (ACL):	WINISIP-update			200	396
TUT (ACL):	Polygon, 24-faces			70	171
TUT (ACL):	Use a Ball Plate to Calibrate a CMM			169	238
TUT (ACL):	Expert Services (coordinate measuring machines)			241	241
		TUT Total:	5,8 %	680	1046
		Contract Laboratories Total:	**12,1 %**	**1431**	**1961**
OTHER SUPPORT					
TUT:	Co-ordination of Flow Calibrations			37	37
		Flow Total:	**0,3 %**	**37**	**37**
SUPPORT TO ACLS WHICH OPERATE WITHOUT SERVICES OF NSL		**Total:**	**0,3 %**	**30**	**30**
		TOTAL:		**11838**	**15658**

*) Financed from the operating costs budget of MIKES

3.5 CENTRE FOR METROLOGY AND ACCREDITATION, MASS LABORATORY

1. NAME OF THE NATIONAL STANDARDS LABORATORY

Centre for Metrology and Accreditation, Mass laboratory

2. QUANTITIES

Mass, density

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

134

3.2 Number of accredited calibration laboratories

6

3.3 Number of official calibration certificates given by accredited calibration laboratories

4168

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

Pt-Ir prototype kilogram No 23.

4.2 Maintenance

The mass scale in the range 1 mg - 10 kg has been established.

4.3 Development projects

Purchase of a 1 kg mass comparator. A 1 kg mass comparator (Sartorius CC1000S-L) has been bought, tested and taken into use. The repeatability of the comparator is about 1 µg.

Investigation of the new methods for the realisation of the kilogram. A feasibility study of the new methods for the realisation of the kilogram has been made. A method where the mechanic energy of a levitating superconducting body and the electromagnetic energy supplied to the levitating field are compared has been taken into a closer investigation.

Investigation of balances and mass comparators. The magnetic fields inside the mass comparators and balances of the mass laboratory has been measured with a fluxgate magnetometer. In all cases the magnetic field due to the balance was less than the earth's magnetic field (about 50 µT). Two balances were tested at different air densities with three different loads. The measurements were made in a pressure chamber down to about 600 hPa. The results could be explained with a model developed.

Development of a silicon based micro-balance. The development is made in co-operation with VTT Automation. The aim of the project is to make a prototype balance from a single silicon chip. The production of the first chips has been successful. Electronics for detecting the deformation of the chip due to load has been developed. Preliminary tests has been made. The project will continue in the year 2000.

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

A comparison of 1 kg and 10 kg weights (M3) has been carried out. Three accredited calibration laboratories were participating the comparison. The E_n values of all laboratories were less than 1.

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

4.4.3 International comparisons

A comparison of the density of a 1 kg weight has been made with SP (Sweden). The results showed a relative difference of about $3 \cdot 10^{-5}$ which is somewhat larger than expected but still within the expanded uncertainties.

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

5.2 Conferences

H. Kajastie and K. Riski, “Investigation of mass comparators with weight handlers”, Proceedings of IMEKO XV World Congress, 13 - 18 June 1999, Osaka, Japan.

5.3 Reports

Heikki Kajastie, “Automaattisten punnustenvaihtimien suunnittelu, toteutus ja käyttö”, Mittatekniikan keskuksen julkaisusarja J2/1999 (in Finnish).

5.4 Lectures

K. Riski: Näytteenotto ja mittauksen epävarmuus; Mittausepävarmuuden arvioinnin perusteet, EUROLAB-FINLAND, 16 March 1999 (in Finnish).

K. Riski: Laboratoriolaitteiden kalibrointi ja laadussapito; Punnukset, vaa'at, dimensio-mittaukset, AEL, 21 April and 13 December 1999 (in Finnish).

K. Riski: Mittausepävarmuuden arviointi; Mittausepävarmuuden arviointi julkaisun EA-4/02 (EAL-R2) mukaisesti, MIKES, 9 June 1999 (in Finnish).

K. Riski: Kalibroinnista mittausten hallintaan; Mittauslaitteiden jäljitettävä kalibrointi ja mittausepävarmuuden arviointi, IIR, 23 September 1999 (in Finnish).

K. Riski: ISO 9000 ja kalibroinnit; Kalibrointipalvelujen saatavuus ja jäljitettävyyden hankkiminen, MIKES, 17 November 1999 (in Finnish).

5.5 Other activities

H. Kajastie participated in IMEKO XV World congress, 13 - 18 June 1999, Osaka, Japan.

H. Kajastie has visited the mass laboratory of NRLM, 21 June 1999, Tsukuba, Japan.

H. Kajastie has participated in OIML Workshop on Weights, 13 - 15 November 1999, SP, Borås, Sweden.

K. Riski has participated in the work and a meeting of EA Task Force for measurement uncertainty (Revision of WECC Doc. 19-1990), 4 - 5 February 1999, Swedac, Borås, Sweden.

K. Riski has participated in EA "Mechanical Measurements" Expert Group meeting, 3 - 4 June 1999, IMGC, Turin, Italy.

K. Riski has visited the mass and force laboratory of IMGC, 4 June 1999, Turin, Italy.

K. Riski has taken part in the work of the Advisory Commission for Metrology.

CENTRE FOR METROLOGY AND ACCREDITATION, LENGTH LABORATORY

1. NAME OF THE NATIONAL STANDARDS LABORATORY

Centre for Metrology and Accreditation, Length laboratory

2. QUANTITIES

Length

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

9

3.2 Number of accredited calibration laboratories

3.3 Number of official calibration certificates given by accredited calibration laboratories

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

The Finnish primary standard for length is realised by three iodine stabilised 633 nm helium-neon lasers operated according to the recommendations given by CGPM and CIPM. The expanded uncertainty of the realisation is $5 \cdot 10^{-11}$. In addition the metre is realised at 543,5 nm wavelength with two iodine stabilised green He-Ne lasers. These lasers form the basis for traceable length measurements in Finland.

4.2 Maintenance

Three iodine stabilised lasers at 633 nm have been maintained in the qualified conditions. The correct operation of the lasers is ensured by regular participation in international comparisons. The calibration service at 543,5 nm is started. The reliability of this service is tested by a bilateral comparison with DFM. Interferometers for calibration of long gauge blocks and line scales have been maintained in operation condition. Several technical procedures and devices has been developed to ensure the correct adjustment of the optics of the gauge block interferometer. New absolute surface roughness scale traceable to measurements made at the length laboratory has been established.

4.3 Development projects

Development of the calibration service for the quartz meter. In a co-operation project of MIKES, FGI (Finnish Geodetic Institute) and NIM (National Institute of Metrology, China) a method for calibration of quartz bars have been established. A standard uncertainty of 36 nm has been achieved in calibrations of 1-m quartz bars. This calibration service allows continuation of baseline measurements with Väisälä interferometer by FGI.

Development of calibration of linear displacement at nanometric scale. A project for creating calibrated device for short high accurate displacements is started. A digital piezo system has been acquired and a research for traceable calibration of the displacement is started. This project enables accurate calibration of linear transducers used with e.g. roundness measuring machines, mechanical comparators or surface profilometers with uncertainty ~1 nm.

Development of an iodine stabilised diode laser at 633 nm. The research with iodine stabilised 633 nm diode laser has been continued. This is a joint project of MIKES and HUT. In the beginning of year HUT/MIKES participated into an international comparison at BIPM. The results of the device were very good for a microlense diode laser. With a new setup that uses an external transmission grating cavity aim is to reach similar or better performance what is attainable with 633 iodine stabilised He-Ne laser.

Development of an iodine stabilised Nd:YAG laser. Recently was started a project for researching the realisation of a metre with an iodine stabilised Nd:YAG laser. These lasers are promising candidates for realisation of the meter with smallest uncertainty. Their several good properties make them very versatile and allow e.g. distribution of realisation of meter through optical fibres. First stage of project is to do optical, mechanical and electrical design for the laser.

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

4.4.3 International comparisons

Euromet project 413: Phase correction measurements in gauge block metrology. Participants were CEM, CMA, DFM, IMGC, IPQ, LNE, NMS, NPL, OFMET and PTB. A draft report has been distributed to the participants. The results of MIKES had slight offset of -8 nm to the mean of the comparison. The offset was in agreement with estimated uncertainty.

Euromet project 462: Intercomparison of $^{127}I_2$ stabilised 633 nm He-Ne lasers locked by 5th harmonic method. The comparison was performed at MIKES 7–11 September 1998. The participating laboratories were BIPM, CMI, VNIIM, NIM and MIKES. A draft version of the report of the comparison has been written. The results clearly show that with 5th harmonic locking the reproducibility is better than with traditional 3rd harmonic locking.

An international comparison of diode lasers stabilised on $^{127}I_2$ at λ=633 nm was carried out at BIPM in January 1999. Participants were BIPM, PTB, BNM-INM, COPL, ISI, NPL, MIKES/HUT and DFM. MIKES and HUT participated in this comparison with a diode laser using microlense setup. The results of Finnish laser reached same very high performance level than most of lasers although other lasers used external grating cavity which theoretically should guarantee better characteristic. The performance of the iodine stabilised diode lasers were close to that of red iodine stabilised He-Nes. The draft version of the comparison report is distributed.

A bilateral comparison of frequencies of the iodine stabilised 543,5 nm He-Ne lasers of DFM and MIKES was carried out at Denmark in December 1999. The observed frequency difference was 10±2 kHz, which a very good result for green He-Nes. The draft report is in the making.

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

P. Toivanen, F. Manoochehri, P. Kärhä, E. Ikonen and A. Lassila, Method for characterisation of filter radiometers, Applied Optics 38 (1999) 1709 - 1713.

M. Merimaa, H. Talvitie and E. Ikonen, Iodine-stabilized diode laser at 633 nm: Effects of optical feedback, IEEE Transactions on Instrumentation and Measurement, vol. 48, pp. 587 - 591, 1999.

A. Zarka, A. Abou-Zeid, D. Chagniot, J.-M. Chartier, J.-F. Cliché, O. Cip, C. Edwards, F. Imkenberg, P. Jedlicka, B. Kabel, A. Lassila, J. Lazar, Y. Millerioux, M. Merimaa, H. Simonsen, M. Tetu, and J.-P. Wallerand, International comparison of eight semiconductor lasers stabilized on $^{127}I_2$ at λ=633 nm, submitted to Metrologia.

A. Lassila, K. Riski, J. Hu, T. Ahola, S. Naicheng, L. Chengyang, P. Balling, J. Blabla, L. Abramova, Yu. G. Zakharenko, V.L. Fedorin, A. Chartier and J.-M. Chartier, International comparison of He-Ne lasers stabilized with $^{127}I_2$ at $\lambda \approx 633$ nm: Use of the FIFTH or the THIRD Harmonic-locking techniques compared, submitted to Metrologia.

5.2 Conferences

M. Merimaa, P. Kokkonen, K. Nyholm and E. Ikonen, A compact iodine stabilized external-cavity diode laser at 633 nm with a novel transmission grating, submitted to Conference on Precision Electromagnetic Measurements, Sidney, Australia, May 14–19, 2000.

5.3 Reports

5.4 Lectures

A. Lassila, Lasermittaus, Mittaukset konepajassa –seminaari, 27–28 May 1999 Lappeenranta, Laatukeskuksen metrologiajaos, 19 p. (in Finnish).

A. Lassila, Mittausepävarmuuden määrittäminen pituusmittauksissa, Mittausepävarmuuden arviointi –seminaari, Mittatekniikan keskus, 9 June 1999 (in Finnish).

5.5 Other activities

A. Lassila, CCLs Working Group for Dimensional Metrology (WGDM).

Advisory Commission for Metrology, Expert group in length metrology, Antti Lassila (member, secretary), Kari Riski (member).

Visits by the laboratory personnel:

A. Lassila, to BIPM 18–22 January 1999.

A. Lassila, to BIPM 21–22 September 1999.

K. Nyholm, to DFM (Denmark) 6–10 December1999.

Guest researcher:

Mrs Xu Jie, National Institute of Metrology, Beijing China, 23 August 1999 – 31 December 1999.

Visits to the laboratory:

Rein Miilius and Riho Vendt, Tartu Standardization and Metrology Centre, Estonia, 14 June 1999.

CENTRE FOR METROLOGY AND ACCREDITATION, PRESSURE LABORATORY

1. NAME OF THE NATIONAL STANDARDS LABORATORY

Centre for Metrology and Accreditation, Pressure laboratory

2. QUANTITIES

Pressure

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

112

3.2 Number of accredited calibration laboratories

6

3.3 Number of official calibration certificates given by accredited calibration laboratories

1018

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

In the range 1 kPa to 500 MPa the unit of pressure is realised using a set of pressure balances. The effective areas are traceable to BNM-LNE, France, completed with dimensional measurements of VTT Manufacturing Technology for one piston/cylinder unit in the range 20 kPa to 800 kPa. In the low absolute pressure range 0,2 Pa to 1 kPa the reference standards are two capacitance manometers. They are traceable to PTB via MKS, Germany.

4.2 Maintenance

In 1998, two piston/cylinder units were calibrated at BNM-LNE, the unit for the range 2 to 200 MPa, oil pressure and the unit for the range 0,02 to MPa, gas pressure. The capacitance manometers for the ranges 0 to 130 Pa and 0 to 1300 Pa were calibrated at MKS, Germany, in May 1999.

4.3 Development projects

Determination of the pressure balance effective area based on dimensional measurements. The dimensional measurements on the ceramic 35 mm diameter piston/cylinder unit were made both at VTT Manufacturing Technology, Finland and at CMI, Czech Republic. The results are compared to the results of pressure measurements at NMi (NL) in 1997, at FFA (SE) in 1998, and at CEM (SP) and at CMI (CZ) in 1999. The co-operation is registered as an EUROMET project (No. 445).

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

The measurements in the intercomparison P12 in the absolute pressure range 95 kPa to 105 kPa were made in 1998, and the final report was published in early 1999 (M. Rantanen: Nordic intercomparison in the barometric pressure. Julkaisu J1/1999 MIKES). The comparison started as a joint national comparison in Finland and Sweden. Later six laboratories from Denmark, Norway and the Netherlands joined in. The results from all the four Finnish pressure laboratories accredited in the barometric range were in a good agreement with the reference values.

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

The final report on the EA intercomparison Pr 6 was published (Jäger, J. & Jeschek, M.: Calibration of a capacitance manometer in the gauge pressure range up to 1,25 kPa. DKD/PTB Braunschweig). One laboratory from Finland participated, making the measurements already in 1996. The results were in a good agreement with the reference values.

4.4.3 International comparisons

The MIKES measurements in EUROMET No. 389 (a key comparison in the range 10 to 100 MPa oil pressure) were made in July 1997. The report will be published by the pilot laboratory NPL in early 2000.

Five national pressure laboratories (MIKES/FI, FFA/SE, FORCE/DK, NMi/NL and NPL/UK) participated in 1998 in the Nordic intercomparison in barometric pressure in addition to the accredited laboratories. The results of MIKES, FFA, FORCE and NMi were in a very good agreement with each other and with the low-uncertainty results from NPL. The final report: (M. Rantanen: Nordic intercomparison in the barometric pressure. Julkaisu J1/1999 MIKES).

A comparison between MIKES and SP/FFA was arranged in gauge pressure range 32 – 132 kPa in May 1998. The results, showing a good agreement, were presented as a MIKES report. (S. Ban and M. Rantanen: Intercomparison of gauge pressure measurements between SP/FFA and MIKES in the range 32 kPa to 132 kPa. Julkaisu J3/1999 MIKES).

A pressure comparison between MIKES and CMI in the gauge pressure range 50 kPa to 350 kPa was made in April 1999 in Brno. The comparison was a part of the EUROMET project 455. J. Verbeek presented the results in the CCM pressure conference in Torino (J.C.G.A. Verbeek, M. Rantanen and J. Tesar: Intercomparisons of pressure balances of NMi, MIKES and CMI in the range 50 kPa to 350 kPa. 3rd CCM International Conference Pressure Metrology from Ultra-High Vacuum to Very High Pressures. Torino, Italy, 3–7 May 1999).

Two comparisons between MIKES and Justervesenet (NO) were arranged in 1999, one in the gauge pressure range 1 MPa to 50 MPa and the other in the range 50 kPa to 350 kPa. The results were presented in the Nordic Metrology conference (M. Pilkuhn and M. Rantanen: Pressure comparisons between Justervesenet and the Centre for Metrology and Accreditation. 21st Nordic conference on Measurements and calibration. Gardermoen, Norway, 22–23 November 1999).

The MIKES measurements in EUROMET No. 442 (a key comparison in the absolute pressure range 0,1 Pa to 1000 Pa) were made in August and September 1999. The project will take approximately two years, and the final report will be published only when all the participants have made their measurements.

Measurements in a comparison between MIKES and CMI in the range 20 MPa to 500 MPa were performed in October 1999. The results will be reported in 2000.

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

M. Perkin, C. Rendle, J. Jäger, P. Deken, K. Eldred, E. Woodhead, G Härne, M. Rantanen, M. Thrane, J Le Guinio and M. Sardi: Comparison of European differential pressure standards in the range 3 Pa to 1000 Pa. Metrologia 36 (1999) 1 – 7.

5.2 Conferences

J. C. G. A. Verbeek, M. Rantanen and J. Tesar: Intercomparisons of pressure balances of NMi, MIKES and CMI in the range 50 kPa to 350 kPa. 3rd CCM International Conference Pressure Metrology from Ultra-High Vacuum to Very High Pressures. Torino, Italy, 3–7 May 1999.

M. Pilkuhn and M. Rantanen: Pressure comparisons between Justervesenet and the Centre for Metrology and Accreditation. 21st Nordic conference on Measurements and calibration. Gardermoen, Norway, 22–23 November 1999.

5.3 Reports

M. Rantanen: Nordic intercomparison in the barometric pressure. Julkaisu J1/1999 MIKES.

S. Ban and M. Rantanen: Intercomparison of gauge pressure measurements between SP/FFA

and MIKES in the range 32 kPa to 132 kPa. Julkaisu J3/1999 MIKES.

M. Rantanen: Nordic intercomparison in the barometric pressure. Vaisala News 151 (1999) 29–31.

5.4 Lectures

M. Rantanen: Painemittareiden kalibrointi, AEL-INSKO, Kalibrointi – tarve ja suoritus käytännössä, 27 May 1999, Riihimäki, and 28 October, Tampere (in Finnish).

M. Rantanen: Paineen mittaus ja painemittareiden kalibrointi. Momentin ja paineenmittauskoulutuspäivä. Pohjois-Karjalan Ammatillinen Aikuiskoulutuskeskus, 8 December 1999, Joensuu (in Finnish).

5.5 Other activities

In addition to EUROMET projects mentioned above, MIKES participated in No. 499: Bulletin board on concerns, problems and experiences.

M. Rantanen participated in the EUROMET Mass Contact Persons Meeting in Istanbul 15–19 February 1999 and in the EA Pressure Experts Group Meeting at NMi, Delft 16–17 September 1999.

M. Pilkuhn from the pressure laboratory of Justervesenet (NO) visited MIKES 26–28 January 1999.

J. Tesar and Z. Krajicek from the pressure laboratory of CMI (CZ) visited MIKES 11–15 October 1999.

M. Rantanen visited in 1999 five pressure laboratories in other countries: UME, Istanbul, Gebze, 19 February, CMI, Brno, 21–23 April, IMGC, Torino, 7 May, Justervesenet, Kjeller, 15–18 June and NMi, Delft, 17 September.

M. Rantanen is a secretary in the Expert Group on Mass and Derived Quantities of the Advisory Commission for Metrology in Finland.

CENTRE FOR METROLOGY AND ACCREDITATION, THERMOMETRY LABORATORY

1. NAME OF THE NATIONAL STANDARDS LABORATORY

Centre for Metrology and Accreditation, Thermometry laboratory

2. QUANTITIES

Temperature

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

167

3.2 Number of accredited calibration laboratories

5

3.3 Number of official calibration certificates given by accredited calibration laboratories

1444

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

The International Temperature Scale of 1990 (ITS-90).

4.2 Maintenance

The temperature standards (standard platinum resistance thermometers, Pt100 working thermometers and S-type noble metal thermocouples) were calibrated.

4.3 Development projects

Replacement of the calibration furnaces. Within this project the old furnaces in the laboratory are replaced by new ones with heat-pipes. The first furnace has been tested with a fixed point cell and a thermometer coupled to the bridge. The electrical noise that is present when using the old furnaces is now removed.

Closed fixed point cells. The laboratory has recently had trouble with the open fixed point cells, as the vacuum system for evacuation of the cells has not been working as it should. Thus, a closed Zinc and a closed Copper cell have been purchased.

Surface thermometers. A heat-plate device for calibrating surface thermometers has been constructed.

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

A national intercomparison of calibrating a noble metal thermocouple (type S) was carried out. The results are published in the report series of the Centre for Metrology and Accreditation.

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

4.4.3 International comparisons

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

5.2 Conferences

A. Haapalinna and T. Weckström, A compact device for measuring the linearity of an optical pyrometer, Tempmeko ’99, Delft 1–3 June 1999, Proceedings pp. 573-575.

5.3 Reports

T. Weckström, Lämpötilan vertailumittaus L10, S-tyypin termoelementin vertailu, Mittatekniikan keskuksen julkaisu J7/1999 (in Finnish).

5.4 Lectures

T. Weckström: Lämpömittareiden epävarmuuden laskenta EA:n ohjeiden mukaisesti, MIKESin Mittausepävarmuuden arvointi –kurssi, 9 June 1999 (in Finnish).

5.5 Other activities

T. Weckström participated in the EUROMET meeting of contact persons for Thermometry 9–10 March 1999 at Ulusal Metroloji Enstitüsü, Kocaeli, Turkey and the EA Temperature and Humidity Experts Group meeting 9–10 September 1999 at Justervesenet, Oslo, Norway. Before the meeting in Kocaeli T. Weckström attended a workshop on development of common criteria for calculating uncertainties of intercomparisons.
T. Weckström also participated in the Mid-Term Meeting of TRIRAT 16–19 March 1999 at CNR-IMGC, Torino, Italy.

The Tempmeko '99 conference was held in Delft, the Netherlands in June 1–3, 1999. T. Weckström presented a poster on the linearity measurements of an optical pyrometer. Before the conference, T. Weckström attended a workshop on Surface Thermometers held at NMi in Delft, where she gave a talk on Surface Thermometry in Finland. After the conference she attended a workshop on new Eutectic Fixed Point Blackbodies.

T. Weckström visited the National Standard Laboratory in Lithuania 4–13 October 1999 for a PRAQIII Fast project and an intercomparison of thermometers.

On November 11–12 T. Weckström attended an EUROMET 504 Workshop on Statistical Analysis of Interlaboratory Comparisons, held by SSfM at NPL, Teddington, Great Britain. On November 15th she visited Isothermal Technology Ltd in Southport to pick up two new fixed point cells.

T. Weckström is the secretary of the Expert Group on Temperature and Derived Quantities of the Advisory Commission for Metrology in Finland.

Two courses on how to calibrate thermometers and how to calculate the corresponding uncertainties were held at MIKES on September 7th and September 14th by T. Weckström and G. Bergström from Fortum Oy.

CENTRE FOR METROLOGY AND ACCREDITATION, HUMIDITY LABORATORY

1. NAME OF THE NATIONAL STANDARDS LABORATORY

Centre for Metrology and Accreditation, Humidity laboratory

2. QUANTITIES

Dew-point temperature
Relative humidity

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

41

3.2 Number of accredited calibration laboratories

1

3.3 Number of official calibration certificates given by accredited calibration laboratories

61

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

The dew-point temperature scale and the relative humidity scale are realised using a two-temperature generator system.

4.2 Maintenance

The relative humidity scale was investigated by comparing the relative humidity generator with salt solutions. A new relative humidity calibrator has been developed and a distilling apparatus was bought for supplying pure water.

4.3 Development projects

Development of the humidity standards. A dew-point comparator has been developed for the range from –40°C to +75°C. The results of the project was presented in the Tempmeko ’99 conference and published in Measurement Science and Technology.

A doctoral thesis on humidity standards was completed. The Helsinki University of Technology approved the thesis after a public examination.

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

Intercomparison on the calibration of relative humidity hygrometersm.

Intercomparison on the calibration of saturated salt solutions.

Intercomparison of humidity calculation methods.

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

4.4.3 International comparisons

MIKES co-ordinated the EUROMET 511 project in which humidity generators at six laboratories are compared. The first phase of the project was completed.

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

M. Heinonen, A humidity generator with a test chamber system, Measurement 25 (1999) pp. 307 - 313.

M. Heinonen, A new comparison method for dew-point generators, Meas. Sci. Technol. 10 (1999) pp. 1260 - 1265.

5.2 Conferences

M. Heinonen, An apparatus for comparing humidity generators, in: J. F. Dubbeldam, M. J. de Groot (ed.), Proc. Tempmeko ’99, vol 1, Delft, NMi Van Swinden Laboratorium 1999, pp. 217 - 222.

5.3 Reports

M. Heinonen, National basis for traceability in humidity measurements, Julkaisu J10/1999, Helsinki, Centre for Metrology and Accreditation 1999.

5.4 Lectures

5.5 Other activities

M. Heinonen was a member of the Expert Group on Temperature Measurements, Advisory Commission for Metrology.

M. Heinonen participated in the meetings of the International Working Group on Humidity Measurements, 2 - 3 June 1999.

M. Heinonen participated in the Tempmeko ’99, The 7th International Symposium on Temperature and Thermal Measurements in Industry and Science, 1 - 3 June 1999.

M. Heinonen acted as a referee for the Measurement Science and Technology.

M. Heinonen acted as a referee for the Tempmeko ’99 Proceedings.

The following persons visited the laboratory:

Marianne Pilkuhn, Justervesenet, Norway, 29 January 1999.

Robert Benyon, INTA, Spain, 28 October 1999.

Peter Huang, NIST, USA, 1 - 2 December 1999.

The laboratory personnel made the following visits:

M. Heinonen, VNIIM, Russia, 12 - 15 April 1999.

M. Heinonen, NMi Van Swinden Laboratorium, The Netherlands, 4 June 1999.

3.6 VTT AUTOMATION, ELECTRICAL QUANTITIES

1. NAME OF THE NATIONAL STANDARDS LABORATORY

VTT Automation

2. QUANTITIES

DC voltage and current, resistance, AC voltage and current, electric power and energy, capacitance

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

53

3.2 Number of accredited calibration laboratories

7

3.3 Number of official calibration certificates given by accredited calibration laboratories

1718

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

DC voltage: Weston and Zener standards, Josephson voltage standard. **Resistance:** resistance standards and quantum-Hall standard. **AC voltage:** multi-junction and Fluke 540B thermal AC/DC converters. **AC current:** multi-junction and Fluke 540B thermal AC/DC converter and A40 shunt resistors. **Power:** HEG power comparator. **Capacitance:** Andeen-Hagerling and GenRad capacitance standards.

4.2 Maintenance

DC voltage: The range of the new VTT Josephson voltage standard was extended to 10 V level with a 10-V Josephson array from PTB. Noise in Zener standards was studied in the range of 10^{-6} to 10^{3} Hz in terms of spectral density and Allan variance. Maintenance calibration of Zener and standard cell voltages were done monthly. Calibration of resistive voltage dividers against the VTT divider, the Josephson standard and the CCC was started. DC voltage uncertainties decreased substantially, especially in the 1-10 V region.

DC current: The DC current uncertainties decreased by up to an order of magnitude due to improved control of DC voltage and resistance.

Resistance: Two QHR measurements were performed in 1999 to calibrate our 100 Ω standards, estimate their drift rates, and disseminate the SI values to the secondary and working standards. Frequency coefficients for different standard resistors and parameters of the measuring circuit were studied and defined. Transport properties of the 100 Ω transfer standard were measured. The DCC bridge spent autumn 1999 in warranty repair and installation of a low resistance measurement option. The resistance oil bath broke down and was repaired. Low value AC/DC resistance calibration facilities were improved. Both the primary and customer calibration uncertainties decreased due to major improvements during 1999.

AC voltage: We remeasured the 3 V ac voltage comparison, EUROMET #274 and succeeded well. The acdc measurement computer and acdc relay interface was replaced. A new acdc measurement program was developed. Extensive tests were made to ascertain the new program. The acdc voltage stepup (1.5 V - 1000 V) was done between August 1999-January 2000, partly with the old program. As a result, we expect a substantial decrease in the AC/DC voltage transfer uncertainty in the beginning of 2000.

AC current: Some maintenance measurements were done for ac current.

Capacitance: The results of the capacitance key comparison, EUROMET #345 were published in a NPL report CEM7 and will be published in Metrologia. Our results are quite satisfactory, though there is an unexplained ratio error. Some internal comparisons for our ten capacitance standards were made during 1999. Two of our capacitance standards (10 pF, 100 pF) were sent to NPL for calibration to determine the reason for the ratio error. To ascertain our high capacitance values two of our capacitors (10 nF and 100 nF) were sent to SP for calibration. The calculation of the comparison results is still under work.

Power: A new sampling wattmeter was taken into use at the end of 1999. Uncertainty calculations will be finished in 2000. The old primary power standard (HEG K2004) suffered considerable damage during transportation to PTB for calibration. A coaxial high current measurement setup was designed and partly constructed in 1999. Its testing will start in early 2000.

General: An optical network with a limited number of connections between the shielded laboratories and the server was established. Two old surveillance computers had to be replaced due to faults in 1999. Some work has been done in planning the new building for metrology and accreditation. The organisational transfer of VTT and Emcec electricity metrology to MIKES in 2000 has caused substantial amount of administrational work in 1999. Calibration and measurement capability (CMC) tables (appendix C to the mutual recognition agreement) were prepared. The preparation has caused a lot of additional work during the last quarter of 1999. The work will continue in 2000.

4.3 Development projects

Low ac voltages. A calculation model for coaxial resistive voltage dividers was developed.

The project was partly used for the imperative but unscheduled Euromet CMC data project.

Low ac currents. Two low current (3 mA) MJTCs (Multijunction thermal converters) were bought from PTB, one of them with current traceability.

Development of a 10 V Josephson standard for the maintenance of dc voltage. A 10 V Josephson array was obtained from PTB in 1999 and tested in the VTT Josephson standard setup. A setup for measuring the frequency error caused by the 70 GHz phase lock electronics was developed and the frequency error measured.

Development of a DC voltage in 1999. The uncertainty components of the VTT Josephson voltage standard were measured. The contribution of Zener noise to the calibration uncertainty was studied extensively. A setup for calibration of dc voltage ratio was developed. Results of three independent methods (Josephson, CCC, direct RVD comparison) agree to within few parts in 10^{-7}.

Development of calibration services for fast oscilloscopes. Calibration proceduces based on the Fluke 5800A oscilloscope calibrator were developed in collaboration with Nokia.

Resistance development in 1999. Scheme of measuring circuit and the connections and design of secondary sets of resistors in big oil bath were prepared. Coaxial cables and BNC connectors were obtained. CCC resistance bridge was improved. New PC was installed and used in measurements and a new CCC was constructed. Systematic errors in our CCC bridge measuring circuit were determined.

50 Hz power. A new source (Fluke 5520A calibrator) was bought for the wattmeter, which is based on sampling voltmeters. A service kit developed by the manufacturer reduced the originally high phase noise. The voltmeters turned out to cause substantial measurement error due to temperature instability. Several other sources of uncertainty components were traced and an uncertainty level of about 20 ppm was reached in 1999. A coaxial high current measurement site, based on Rogowski's rings was designed and partly constructed in 1999. Some essential components of the system were delayed until 2000. Testing will start in early 2000.

Use of a temperature and pressure stabilized 100 Ω resistance standard as a transfer standard: organisation of a EUROMET intercomparison.

Development of a programmable Josephson voltage standard (ProVolt). First batch of arrays was tested. The critical current was as expected. Rf-induced steps were observed. The shunt resistance turned out to be too high. A revised design, based on inductive shunting, was chosen for the next round, which will be ready and tested in 2000.

Development of micromechanical standards for metrology. The sensor group further developed electronics for new secondary voltage and mass standards, based on highly stable micromechanical silicon devices, in 1999. Preliminary tests were performed.

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

Beamex Oy: 100 Ω and 10 kΩ comparison.

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

VTT-Metrosert (Estonia) 1 and 10 V DC voltage comparison. Measurements were done in October 1999.

EL-26 50 Hz power comparison.

4.4.3 International comparisons

EUROMET #274 (key comparison): Acdc transfer difference at 1.5 V voltage level was measured in February 1999 with good results. The comparison was finished in 1999.

EUROMET #345 (key comparison): The final results of 10 pF and 100 pF international capacitance comparison were reported. VTT results were within reported uncertainty. Unexplained 1-ppm ratio error (within uncertainty) was found.

EUROMET #385 (key comparison): 50 Hz power measurements were repeated at VTT in November 1999 and they will be reported in early 2000.

EUROMET #429 (key comparison): 10 V Zener voltage. Measurements at VTT were performed in June 1999. The comparison will be finished in 2000.

EUROMET #435 (supplementary/key comparison: In the long-term intercomparison of five 100 Ω standards, VTT measured the resistances in April 1999. Measured values for the two stable transfer standards are in good agreement with the expected value of the comparisons.

EUROMET #449 (key comparison): DC voltage ratio. Measurements at VTT were done in October 1999.

EUROMET #487 (VTT pilot laboratory): Results of the intercomparison of a temperature and pressure stabilized 100 Ω standard were calculated. The participants in the intercomparison were BIPM, BNM-LCIE (France), PTB (Germany) and VTT Automation (Finland) - pilot laboratory. The results agree in terms of R_{K-90} to 4 parts in 10^{-9} with a relative combined standard uncertainty $u_c = 1 \times 10^{-9}$.

VTT - SP: 50 Hz power comparison. Measurements were done in October - November 1999.

Capacitance intercomparison between NPL and VTT Automation, 10 pF and 100 pF in December 1999.

Capacitance intercomparison between SP and VTT Automation, 10 nF and 100 nF in November-December 1999.

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

H. Seppä, A. Satrapinski, M. Kiviranta and V. Virkki: Thin-film cryogenic current comparator, IEEE Trans. Instr. Meas. 40, (1999) 365 - 369.

P. Helistö, J. Hassel, and H. Seppä: Josephson voltage standard development at VTT Automation. Proc. XXXIII Annual Conf. of the Finnish Physical Society. 1999 p. 8.7.

A. Satrapinski, H. Seppä and P. Helistö: Quantum Hall measurements of a temperature and pressure stabilized resistance standard. Proc. XXXIII Annual Conf. of the Finnish Physical Society. 1999. p 8.41.

J. Hassel, H. Seppä, M. Kiviranta: A New Way to Realize a Programmable Josephson Voltage Standard, Proc. 22nd International Conference on Low Temperature Physics, August 4 - 11, 1999.

5.2 Conferences

J. Hassel: Josephson voltage standard development at VTT Automation, XXXIII Annual Conf. of the Finnish Physical Society, 4–6 March 1999 Turku (talk).

A. Satrapinski: Quantum Hall measurements of a temperature and pressure stabilized resistance standard, XXXIII Annual Conf. of the Finnish Physical Society, 4–6 March 1999 Turku (poster).

J. Hassel: A New Way to Realize a Programmable Josephson Voltage Standard, 22nd International Conference on Low Temperature Physics, August 4–11, 1999, Espoo (poster).

Seven extended summary papers were submitted to CPEM'2000.

5.3 Reports

Certificates of calibration VTT99KM001 - VTT99KM061.

5.4 Lectures

P. Helistö gave a talk: "Sähkösuureiden kalibrointien järjestäminen (Calibration of electricity standards)" in VTT testing forum, 19 January 1999.

R. Rajala gave a talk: "Epävarmuuslaskelmat sähkömetrologiassa (Uncertainty calculations in electricity)" in MIKES measurement uncertainty seminar, 9 June 1999.

5.5 Other activities

H. Seppä:
BIPM, Consultative Committee for Electricity and Magnetism (CCEM), member.
CPEM'2000, member of program committee.
MNK (Advisory Commission for Metrology), member.
MNK Strategy Working Group, member.

BIPM, CCEM working group meeting on key comparisons, Paris, June 6–7, 1999.

P. Helistö:
Euromet JAVS and QHE Experts meeting, Oslo, June, 1999.
Euromet Electricity Contact Persons meeting, Oslo, October, 1999.
Euromet Electricity Contact Person.
MNK-S (Advisory Commission for Metrology, electricity), member.

A. Satrapinski:
Euromet JAVS and QHE Experts meeting, Oslo, June, 1999.

T. Mansten:
Acdc experts meeting, AREPA, Silkeborg, Denmark, June 1–3, 1999.
EA low frequency electricity experts meeting, Justervesenet, Oslo, Norway, November 8–9, 1999.
MNK-S member.

P. Immonen:
MNK-S member.

Visitors
Oliver Power, NML, Enterprise Ireland, September 29, 1999.

VTT AUTOMATION, TIME AND FREQUENCY

1. NAME OF THE NATIONAL STANDARDS LABORATORY

VTT Automation

2. QUANTITIES

Time and frequency

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

10

3.2 Number of accredited calibration laboratories

4

3.3 Number of official calibration certificates given by accredited calibration laboratories

118

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

Time: Cs-clock, 4 GPS receivers, 2 Loran-C clocks (NELS&RNS). **Frequency:** Cs-clock, two rubidium oscillators, several OCXO:s (Oven Controlled Crystal Oscillators).

4.2 Maintenance

4.3 Development projects

Environmental stability study of Cs-clocks. Continuous monitoring of Cs-clocks of Telecom Finland, TV&GPS-monitoring. Comparison of different GPS-receivers. 25 MHz time signal/standard frequency transmitter preliminary tests. GPS-common view tests with zero baseline and with SP/Borås. Monitoring of YLE time signal started in July 99. New GPS receivers were bought and software development for time comparison according to Common View protocol was finished in 1999.

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

During annual inspections of accredited laboratories a comparison measurement is performed and the result is reported at the final statement.

Fortum Oy: 10 MHz frequency comparison.

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

4.4.3 International comparisons

Time comparison with SP, started 6 December 1999, was finished in 1/2000. According to the preliminary results, Finnish time lags UTC by 150 ± 30 (sd) ns.

Frequency comparison with METROSERT Estonia was performed 9/1999 via TV-common view.

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

K. Kalliomäki, T. Mansten, “Comparison of Distant Cs-clock Monitoring Methods”, Proceedings of 1999 Joint Meeting EFTF-IEEE IFCS, Besancon 1999, pp. 309 - 311.

J. Mannermaa, K. Kalliomäki, T. Mansten, “Timing performance of various GPS-receivers”, Proceedings of 1999 Joint Meeting EFTF-IEEE IFCS, Besancon 1999, pp. 287 - 289.

5.2 Conferences

K. Kalliomäki and T. Mansten attended to the EFTF13 Conference in Besancon in April 1999, where they presented the papers above.

5.3 Reports

Monthly reports on the line frequency and of the frame synchronisation phase of the Finnish TV broadcasting company (YLE), the average frequency of the Cs-clocks of TELE, and the phase of the Loran-C signals (RNS & Sylt).

5.4 Lectures

5.5 Other activities

K. Kalliomäki:
Euromet Time and Frequency Contact Person.
Session chairman in 1999 Joint Meeting EFTF-IEEE IFCS, Besancon 1999.

3.7 VTT MANUFACTURING TECHNOLOGY, DIMENSIONAL QUANTITIES

1. NAME OF THE NATIONAL STANDARDS LABORATORY

VTT Manufacturing technology

2. QUANTITIES

Length, angle, flatness, straightness, roundness, cylindricity and surface roughness

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

450

3.2 Number of accredited calibration laboratories

6

3.3 Number of official calibration certificates given by accredited calibration laboratories

2675

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

Length:
HP-Laser-Interferometers and frequency-stabilised lasers (red and green) are calibrated with Ion-stabilised laser. Gauge blocks are calibrated interferometrically with the red and green lasers.

Angle:
Angle polygons are calibrated with two autocollimators. Autocollimators and the angle options of the Laser-interferometers are calibrated with tangential bar and length measuring instruments. Angle tables are calibrated with polygon and autocollimators using the error separation method.

Flatness:
Optical flats are calibrated by comparing them to each other and rotating them 90° with natrium light. Surface plates are calibrated with HP Laser -interferometer (angle options) by measuring straightness in three directions.

Straightness:

Straightness normal is calibrated like flats.

Roundness:
Roundness normal (glass ball, flick standards and the oval standards) is calibrated with the roundness measuring machine (using the error separation method), length measuring instruments and form measuring instruments. The roundness measuring machine is calibrated with the roundness standards and using the laser-interferometer as scale for the sensor.

Cylindricity:
Cylidricity unit is based to the roundness and straightness measurements. The standards are calibrated by using error separation method (straightness).

Surface roughness:
The surface roughness measuring machine is calibrated with gauge blocks, optical flats, laser-interferometer and PTB roughness standards.

4.2 Maintenance

All the standards and measuring machines are calibrated and maintained according to the documented routines.

4.3 Development projects

Calibration instructions
The aim of the VTT/Industry project is to harmonise the measuring procedures which are used for calibrations of different measuring devices.

Cylindricity
The aim of this VTT/MIKES project is to improve the accuracy of the cylindricity and roundness measurements by buying new instrument and developing programs for error-separation (3/99).

Dilatometer 2
The aim of this VTT/MIKES project is to continue the developing work for measurements of the expansion coefficients of different materials (2/99).

Dial indicators
The aim of this VTT/MIKES project is to develop VTT´s potential for automatical calibration instrumentation by using the image processing technique (4/00).

Optical flats
The aim of this VTT/MIKES project is to develop or take in use calibration instrumentation for calibration of optical flats (12/00).

2D-Optics
The aim of this VTT/MIKES project is to develop a measuring and calibration instrument for calibration of optical 2d- standards (12/01).

Multibeam
The aim of this EU-projects is to develop calibration instruments and methods for machine-tool calibration (12/00).

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

Intercomparison D3 for extensometers (1/00).

Intercomparison D5 for ring gauges (5/00).

Bilateral comparisons in some special cases.

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

M21 Step gauges. Reporting.

M20 Micrometer and dial indicator. Final report.

Nordic intercomparison for force and extensometers.

4.4.3 International comparisons

EUROMET 371 (L-K3) comparison on optical polygons, reporting.

EUROMET 384 (L-K4) comparison on cylindrical diameter standards, reporting.

EUROMET 372 (L-K5) comparison on step gauge (only inoffical), reporting.

EUROMET 471 (L-K1) comparison on gauge blocks, measurements.

EUROMET 533 comparison on roundness measurement. Organising and reporting the comparison.

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

5.2 Conferences

5.3 Reports

Björn Hemming, Heikki Lehto, Petri Saari, EA Interlaboratory Comparison M20 Conventional measuring instruments micrometer and dial indicator, FINAS, September 1999, Helsinki, 70 p.

Heikki Lehto, Measurement report of Philips MF machining tests, VTT, 14 October 1999, Espoo, 44 p.

5.4 Lectures

Heikki Lehto, Optinen pinnankarheuden ja muodon mittaus, Mittausepävarmuuden hallinta seminaari, Tampere, 21– 22 January 1999, AEL-INSKO, 9 p., (in Finnish).

Heikki Lehto, Mittausepävarmuuden määrittäminen sekä optimoidut kalibrointijaksot, ISO 9000 ja kalibroinnit, Helsinki, 17 November 1999, Mittatekniikan keskus 12 p., (in Finnish).

Heikki Lehto, Kalibroinnit tasolla, AEL, Mittausvälineiden huolto, tarkastus ja kalibrointi, 24 May 1999, Helsinki, 5 p., (in Finnish).

Heikki Lehto, Kalibroinnit ilman kalibrointilaitteita, AEL, Mittausvälineiden huolto tarkastus ja kalibrointi, 24 May 1999, Helsinki, 7 p., (in Finnish).

Heikki Lehto, Kalibrointilaitteiden kalibrointi, AEL, Mittausvälineiden huolto tarkastus ja kalibrointi, 24 May 1999, Helsinki, 7 p., (in Finnish).

Heikki Lehto, Mittausvirheet ja mittausepävarmuus, Etelä-Karjalan Ammattikorkeakoulu, Lappeenranta, 22 January 1999, 22 p., (in Finnish).

Heikki Lehto, Pituusmittalaitteiden kalibrointi, Etelä-Karjalan Ammattikorkeakoulu, Lappeenranta, 22 January 1999, 14 p., (in Finnish).

Heikki Lehto, Mittausepävarmuus, vertailumittaukset ja kalibroinnin toteutus, Puolustusvoimat, Lievestuore, 16 March 1999, 14 p., (in Finnish).

Heikki Lehto, Virhelähteet kalibroinnissa, Pohjois-Karjalan Ammatillinen Aikuiskoulu-tuskeskus, Joensuu, 27 April 1999, 8 p., (in Finnish).

Heikki Lehto, Vertailumittaukset, Pohjois-Karjalan Ammatillinen Aikuiskoulutuskeskus, Joensuu 27 April 1999, 3 p., (in Finnish).

Heikki Lehto, Jäljitettävyyden edellyttämä kalibrointi, Pohjois-Karjalan Ammatillinen Aikuiskoulutuskeskus, Joensuu, 27 April 1999, 6 p., (in Finnish).

Heikki Lehto, Mittausepävarmuus kuntoon, järki käteen, Mittaukset konepajassa seminaari, Lappeenranta, 27 May 1999, Etelä-Karjalan Ammattikorkeakoulu, Suomen Laatuyhdistys, 1999, 9 p., (in Finnish).

Heikki Lehto, Erillaiset mittausepävarmuuslaskelmat, ENE mittausepävarmuus-seminaari, Jyväskylä, 21 September 1999, VTT Energiatekniikka, 9 p., (in Finnish).

Heikki Lehto, Mittausepävarmuuslaskelma nippivoimalle, ENE mittausepävarmuus-seminaari, Jyväskylä, 21 September 1999, VTT Energiatekniikka, 4 p., (in Finnish).

5.5 Other activities

EUROMET: The meeting of Expert Group ”Dimensional Metrology” in Prague, 25–27 October 1999.

EA: The meeting of Expert Group ”Dimensional Metrology” in Paris, 14–15 June 1999.

Other Groups for co-operation: IMEKO, SLY, SFS, AEL, MIKES.

Visitors from industry and metrology laboratories from Finland and different foreign countries (Co-operation with Estonia and other Baltic countries).

3.8 FINNISH GEODETIC INSTITUTE, ACCELERATION OF FREE FALL

1. NAME OF THE NATIONAL STANDARDS LABORATORY

Finnish Geodetic Institute

2. QUANTITIES

Acceleration of free fall

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

3.2 Number of accredited calibration laboratories

3.3 Number of official calibration certificates given by accredited calibration laboratories

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

The Finnish Geodetic Institute has two absolute gravity meters, JILAg-1 and JILAg-5 based on the free falling corner cube in the vacuum chamber.

4.2 Maintenance

4.2.1 The absolute gravimeter JILAg-5 has been used at Metsähovi on 12–13 January, 4–5 March, 9–11 March, 13–16 April, 12–13 May, 11–18 November, 12–13 December and 16–17 December.

In addition absolute gravity measurements have been done in Virolahti during 25–27 January, in Joensuu during 1–3 December and in Vaasa at two stations during 8–9 December and 12–13 December.

4.2.2 The frequency of the two mode laser (Laseangle RB-1 no.18 of JILAg-5 was compared with he meter laser of the Helsinki University in the Kumpula accelerator laboratory on 20 January, 3 February and 27 October.

The rubidium frequency standards of the JILAg-5 and JILAg-1 (Efratom FRK-L nos 8533 and 8514 respectively) were compared with the hydrogen maser oscillator of the Helsinki University of Technology on 13 January, 13 May, 9 June, 11 November and 20 December. They were also compared with each other at every absolute measurement in Metsähovi.

4.2.3. Relative measurements with LCR-gravimeters nos G-55 and G-600 have been performed on the gravimetric calibration line Masala-Vihti and between the absolute gravity stations Metsähovi-Tromsö during 13–18 July. In this comparison also one Scintrex-gravimeter of the Geological Survey of Finland was used.

4.2.4 The superconducting gravimeter SG20 has recorded variations in gravity at the Metsähovi station through the year. One of the main interest has been the influence of groundwater, soil moisture and snow cover onto the gravity.

4.2.5 To densificate the existing 5 x 5 km gravity network altogether 550 new gravity points are measured by relative gravimeters.

4.2.6 As an internordic project the existing gaps of gravity values in the Baltic Sea were filled using air borne gravity techniques. The flights were done during 23 August – 10 September from the airports of Mariehamn, Oskarshamn and Rønne.

4.3 Development projects

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

4.4.3 International comparisons

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

D. Crossley, J. Hinderer, G. Casula, O. Francis, H.-T. Hsu, Y. Imanishi, G. Jentzsch, J. Kääriäinen, J. Merriam, B. Meurers, J. Neumeyer, B. Richter, K. Shibuya, T. Sato and T. van Dam (1999): Network of Superconducting Gravimeters Benefits a Number of Disciplines. EOS, Transactions, American Geophysical Union, Vol 80, No 11, 125 - 126.

5.2 Conferences

J. Kääriäinen (1999): On the geodetic studies for understanding the structure and behaviour of Fennoscandian crust. In: Precambrian Crustal Structure Interpreted from Potential Field and Seismic Studies. EAGE99 Conference. Workshop W7, June 7. Helsinki. Ed. Juha V. Korhonen. Geological Survey of Finland, Espoo.

J. Kostelecký, Z. Šimon, J. Šimek and J. Mäkinen (1999): Checking the calibration of a tidal gravimeter by comparing synthetized tides with the record of an absolute meter. European Geophysical Society, XXIV General Assembly. The Hague, 19–23 April 1999. Geophysical Research Abstracts, Volume 1, Number 1, 1999, p. 206. (Abstract).

C. Lázaro, J. Osório, L. Bastos, J. Mäkinen and G. Hein (1999): Precise gravity measurements in the Azores islands. IUGG XXIII General Assembly, Birmingham, 19–30 July 1999 (Abstract).

J. Mäkinen, J. Hinderer, N. Florsch, M. Amalvict (1999): Calibrations of the SG T005 in Strasbourg 1988-1994 with JILAg-5. Evidence for a time change in calibration factor? Joint GGP, ETC WG5 and IGC WG7 meeting, 24–26 March 1999, Luxemburg.

J. Mäkinen (1999): Unigrace Copernicus Programme. Progress Report 1998 for Finland. Proceedings of the 2nd Unigrace Working Conference Warsaw, Poland, 22–23 February 1999. Warsaw University of Technology, Reports on geodesy 2(43), pp. 37–39.

Qiu Qi-Xian, J. Mäkinen, Dai Qi-Chao and Jin Yi-Sheng (1999): Variation in subsurface water storage at the Xi´an absolute gravity station. European Geophysical Society, XXIV General Assembly. The Hague, 19–23 April 1999. Geophysical Research Abstracts, Volume 1, Number 1, 1999, p. 200 (Abstract).

E. Reinhart, B. Richter, H. Wilmes, J. Sledzinski, I. Marson, E. Erker, D. Ruess and J. Mäkinen: UNIGRACE (Unification of gravity systems in Central and Eastern Europe), Preliminary results of the absolute gravity campaign 1998. IUGG XXIII General Assembly, Birmingham, 19–30 July 1999 (Abstract).

E. Reinhart, B. Richter, H. Wilmes, J. Sledzinski, I. Marson, E. Erker, D. Ruess and J. Mäkinen: UNIGRACE - a European project for the unification of gravity systems in Central and Eastern Europe. European Geophysical Society, XXIV General Assembly. The Hague, 19–23 April 1999. Geophysical Research Abstracts, Volume 1, Number 1, 1999, p. 207 (Abstract).

H. Virtanen and J. Kääriäinen (1999): Effect of groundwater level on gravity observed by super-conducting gravimeter at Metsähovi, Finland. European Geophysical Society, XXIV General Assembly. The Hague, 19–23 April 1999. Geophysical Research Abstracts, Volume 1, Number 1, 1999, p. 200.

5.3 Reports

J. Jokela, J. Kääriäinen, J. Mäkinen ja M. Takalo (1999): Geodeettinen laitos geodeettisten suureiden mittanormaalilaboratoriona. Maanmittaustieteiden Seuran julkaisu 36, pp. 25–41 (in Finnish).

J. Kääriäinen (1999): Gravimetric works and Earth Tides. In: Geodetic Operations in Finland 1995 - 1999. Kirkkonummi.

5.4 Lectures

5.5 Other activities

Jussi Kääriäinen is the member of the Advisory Commission for Metrology (ACM) and a member of the expert group for mass and derived quantities within ACM.

Jaakko Mäkinen is a member of the expert group for mass and derived quantities within ACM.

FINNISH GEODETIC INSTITUTE, GEODETIC LENGTH

1. NAME OF THE NATIONAL STANDARDS LABORATORY

Finnish Geodetic Institute

2. QUANTITIES

Geodetic length

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

4

3.2 Number of accredited calibration laboratories

3.3 Number of official calibration certificates given by accredited calibration laboratories

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

4.1.1 Absolute calibrations of quartz gauges using internationally recommended laser wavelength standards (PTB).

4.1.2 Maintenance of quartz gauge system by comparisons (Tuorla observatory, University of Turku).

4.1.3 Interference measurements with the Väisälä comparator (Nummela Standard Baseline).

4.2 Maintenance

4.2.1 Comparisons of quartz gauges nos. 49, 51, 55 and 57 were made in the Tuorla Obervatory.

4.2.2 Gödöllő Standard Baseline in Hungary was remeasured in September - November.

4.2.3 The instrumentation and programmes of the vertical rod comparator have been further improved. Levelling rods from Latvia and Lithuania have been measured and their thermal coefficients determined.

4.3 Development projects

FGI is participating in the project to calibrate quartz gauges. This project is established by MIKES and NIM (China).

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

4.4.3 International comparisons

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

5.2 Conferences

J. Jokela (1999): The new standard baselines measured by the FGI. IUGG99, Birmingham, UK, July 19–30, 1999; Abstracts p. A.413.

5.3 Reports

J. Jokela (1999): Metrology of geodetic length. An appendix to Geodetic Operations in Finland 1995 - 1999, edited by Juhani Kakkuri, 3 p.

J. Jokela, J. Kääriäinen, J. Mäkinen and M. Takalo (1999): Geodeettinen laitos geodeettisten suureiden mittanormaalilaboratoriona. Maanmittaustieteiden Seuran julkaisu 36, pp. 25–41 (in Finnish).

J. Jokela, P. Petroškevičius and V. Tulevičius (1999): Kyviðkës Calibration Baseline. Rep. of the FGI 99:3, 15 p.

M. Takalo (1999): Verification of automated calibration of precise levelling rods. Rep. of the FGI 99:7, 36 p.

5.4 Lectures

5.5 Other activities

Jorma Jokela is a member of the Expert Group for length within ACM.

3.9 HELSINKI UNIVERSITY OF TECHNOLOGY (HUT), METROLOGY RESEARCH INSTITUTE

1. NAME OF THE NATIONAL STANDARDS LABORATORY

Helsinki University of Technology (HUT), Metrology Research Institute

2. QUANTITIES

The following optical quantities: luminous intensity, illuminance, luminance, spectral irradiance, spectral radiance, colour co-ordinates, colour temperature, optical power, transmittance, reflectance, spectral responsivity, optical wavelength.

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

37

3.2 Number of accredited calibration laboratories

2

3.3 Number of official calibration certificates given by accredited calibration laboratories

182

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

The primary standard of optical power measurements is a cryogenic absolute radiometer operated with laser sources. Trap detectors and a pyroelectric radiometer are used as transfer standards to other wavelengths and power levels. Units of luminous intensity and illuminance are realised with a reference photometer constructed from a trap detector, a $V(\lambda)$-filter and a precision aperture. Unit of luminance is realised by measuring the luminous intensity of an integrating sphere source with known output area. Unit of spectral irradiance is realised with an absolutely characterised filter radiometer, with inter-changeable band-pass filters. Values between the discrete wavelengths are interpolated using physical models. Spectral radiance, colour co-ordinates and correlated colour temperature are derived from spectral irradiance measurements. Regular spectral transmittance of filters, regular spectral reflectance of optical components, and spectral responsivity of detectors are calibrated using a reference spectrometer. Measurements of regular spectral reflectance are made by using a dedicated apparatus in the reference spectrometer. Spectral responsivity measurements are made with a trap detector as a reference. Optical wavelength is measured with a Fourier transform wavemeter, traceable to the iodine stabilised laser of the Centre for Metrology and Accreditation.

4.2 Maintenance

The realisations of the quantities mentioned above were maintained. In addition, setups for measuring linearity and spatial uniformity of detectors, and areas of apertures, were maintained. Preparations for the mutual recognition arrangement within EUROMET and CCPR have required an exceptionally high amount of travelling and work, which has also been financed by the maintenance budget.

4.3 Development projects

Realisation of the luminous flux unit using an absolute integrating sphere method.
The 1,6-m integrating sphere has been received, assembled, and characterised. Preliminary measurements of luminous flux have been carried out.

Calibration facility for spectral diffuse reflectance.
A setup for relative diffuse reflectance measurements has been constructed and tested.

Calibration facility for fibre optic power meters.
Laser sources for 1550 and 1310 nm wavelengths have been built and tested. Detectors have been purchased.

Purchase of a transfer standard spectrometer for regular transmittance calibrations.
The new spectrophotometer has been purchased and tested. The instrument is now operational for calibrations at an uncertainty level of 0,4 %.

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

4.4.3 International comparisons

CCPR-K2.a International comparison of spectral responsivity in the NIR region.
The measurements for this intercomparison were carried out by HUT in 1999.

CCPR-K3.b International comparison of luminous responsivity.
Draft B of the final report has been published [R. Köhler, M. Stock, and C. Garreau, An international comparison of luminous responsivity, Draft B, BIPM, March 19, 1999]. The final result (-0,33 % deviation from the reference value with an uncertainty of 0,18 %) agrees well with the measurement uncertainty 0,6 % of HUT. (All measurement uncertainties are given at 95 % confidence level).

CCPR-S3 International comparison of cryogenic radiometers.
Draft B of the final report has been published [R. Goebel, M. Stock, and R. Köhler,

Report on the international comparison of cryogenic radiometers based on transfer detectors, Draft B, BIPM, 1999]. HUT made their measurements in 1996. The final results (-0,008…+0,016 % deviation from the reference value with an uncertainty of 0,027 %) agree well with the measurement uncertainty 0,05 % of HUT.

Bilateral intercomparison of spectral irradiance with PTB, Germany.
The final report has been submitted [K.D. Stock, K.-H. Raatz, P. Sperfeld, J. Metzdorf, T. Kübarsepp, P. Kärhä, E. Ikonen and L. Liedquist, "Detector-stabilized FEL lamps as transfer standards in an international comparison of spectral irradiance", Metrologia (submitted)]. In this intercomparison, the spectral irradiance scale of HUT was compared with the spectral irradiance scale of PTB in the wavelength region 290 - 900 nm. The measurements of HUT were made in February 1999. The agreement of the scales (< 2,5 % throughout the wavelength region) is well within the uncertainty of the intercomparison.

Bilateral intercomparison of luminous intensity with NPL, UK.
The final report has been published [T.M. Goodman, P. Toivanen, H. Nyberg, and E. Ikonen, "International comparison of luminous intensity units between the NPL (UK) and the HUT (Finland)", Metrologia 36, 15-18 (1999)]. The two units agree within 0,27 % with an uncertainty of 0,56 %.

Improving the accuracy of ultraviolet radiation measurement.
In this project funded by the SMT-programme of the EU, novel filter radiometer techniques developed by HUT are used to compare various ultraviolet calibration facilities in France (BNM), Finland and UK (NPL). HUT acts as the pilot laboratory in the intercomparison and measures all filter radiometers used twice, before and after the measurements by other participants. During 1999, HUT designed and built 9 of the 18 filter radiometers used, characterised 9 filter radiometers, and sent them further to NPL to be measured.

International comparison of Iodine-stabilised diode-lasers.
HUT participated in an intercomparison of I_2-stabilised diode lasers in collaboration with MIKES. In this comparison 8 different laser systems were compared. The laser used by MIKES has been constructed at HUT in a collaboration project. During 1999, the measurements were carried out, and the final report [A. Zarka et al., "International comparison of eight semiconductor lasers stabilized on $^{127}I_2$ at $\lambda \approx$ 633 nm", (submitted)] was written.

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

P. Toivanen, F. Manoocheri, P. Kärhä, E. Ikonen and A. Lassila, "Method for characterization of filter radiometers", Appl. Opt. 38, 1709 - 1713 (1999).

T. Niemi, S. Tammela, T Kajava, M. Kaivola and H. Ludvigsen, "Temperarure-tunable silicon-wafer etalon for frequency chirp measurements", Microwave and Optical Technol. Lett. 20, 190 - 193 (1999).

M. Merimaa, H. Talvitie, J. Hu, and E. Ikonen, “Iodine-stabilized diode laser at 633 nm: Effects of optical feedback”, IEEE Trans. Instrum. Meas. 48, 587 - 591 (1999).

F. Manoocheri, L. Palva, E. Garam and E. Ikonen, “Characterization of a multipoint measuring system of photosynthetically active radiation”, Instrum. Sci. Technol. 27, 45 - 58 (1999).

A. Haapalinna, F. Manoocheri and E. Ikonen, “High-accuracy measurement of specular spectral reflectance and transmittance”, Analytica Chimica Acta 380, 317 - 325 (1999).

A. Haapalinna, T. Kübarsepp, P. Kärhä and E. Ikonen, “Measurement of the absolute linearity of photodetectors with a diode laser”, Meas. Sci. Technol. 10, 1075 - 1078 (1999).

F. Manoocheri, P. Kärhä, L. Palva, P. Toivanen, A. Haapalinna and E. Ikonen, “Characterization of optical detectors using high-accuracy instruments”, Analytica Chimica Acta 380, 327 - 337 (1999).

T. M. Goodmann, P. Toivanen, H. Nyberg and E. Ikonen, “An intercomparison of luminous intensity units between the NPL, (UK) and the HUT, (Finland)”, Metrologia 36, 15 - 18 (1999).

K. Jacobs, I. Tittonen, H. M. Wiseman and S. Schiller, “Quantum noise in the position measurement of a cavity mirror undergoing Brownian motion”, Phys. Rev. A 60, 538 - 548 (1999).

I. Tittonen, G. Breitenbach, T. Kalkbrenner, T. Müller, R. Conradt, S. Schiller, E. Steinsland, N. Blanc and N. F. de Rooij, “Interferometric measurements of the position of a macroscopic body: towards observation of quantum limits”, Phys. Rev. A 59, 1038 - 1044 (1999).

P. Kärhä, T. Kübarsepp, F. Manoocheri, P. Toivanen, E. Ikonen, R. Visuri, L. Ylianttila and K. Jokela, “Portable detector-based primary scale of spectral irradiance”, J. Geophys. Res. (in press).

K. Jokela, L. Ylianttila, R. Visuri, P. Kärhä and E. Ikonen, “Intercomparison of lamp and detector-based UV-irradiance scales for solar UV radiometry”, J. Geophys. Res. (in press).

T. Kübarsepp, P. Kärhä and E. Ikonen, “Interpolation of the spectral responsivity of silicon photodetectors in the near ultraviolet”, Appl. Opt. (in press).

M. Merimaa, H. Talvitie, P. Laakkonen, M. Kuittinen, I. Tittonen and E. Ikonen, “Compact external-cavity diode laser with a novel transmission geometry”, Opt. Comm. (in press).

5.2 Conferences

5.2.1 International conference proceedings

T. Lindvall, I. Tittonen, A. Pietiläinen and E. Ikonen, “Spectroscopy of rubidium atoms in a magneto-optical trap”, in Abstracts of the XXII International Conference on Low Temperature Physics, Helsinki, Finland, August 4 - 11, 1999, p. 293.

K. Nera, O. Hahtela, M. Kujala, K. Lahti, T. Lamminmäki, K. Ruokonen, V. Voipio and I. Tittonen, “High-Q micromechanical silicon oscillators”, in Abstracts of the XXII International Conference on Low Temperature Physics, Helsinki, Finland, August 4 - 11, 1999, p. 616.

M. Merimaa, I. Tittonen, E. Ikonen, H. Talvitie, P. Laakkonen and M. Kuittinen, “Compact external-cavity diode laser at 633 nm with a transmission grating”, in Proceedings of Advanced Semiconductor Lasers and their Applications, Santa Barbara, USA, July 18-23, 1999, OSA, Technical Digest pp. 38 - 39.

T. Kübarsepp, P. Kärhä and E. Ikonen, “Interpretation of UV-effects on the internal quantum efficiency of silicon photodetectors”, Third Workshop of the Thematic Network for UV-Measurements, Teddington, UK, September 8 - 10, 1999, UVNews, Issue 3/1999, p. 18.

V. Voipio, K. Nera, K. Ruokonen, T. Lamminmäki and I. Tittonen, “Approximating circles by polygons in anisotropic etching of {100} silicon”, in Proceedings of Eurosensors XIII, The Hague, The Netherlands, September 12 - 15, 1999, pp. 531-532.

T. Niemi, G. Genty, S. Tammela and H. Ludvigsen, “Fiber grating nonidealities in dispersion compensation CATV links”, in Proceedings of the 5th Optical Fibre Measurement Conference, Nantes, France, September 22 - 24, 1999, pp. 157-160.

T. Niemi, S. Tammela and H. Ludvigsen, “Real-time frequency chirp measurements of optical transmitters”, in Proceedings of the 5th Optical Fibre Measurement Conference, Nantes, France, September 22 - 24, 1999, pp. 79-81.

G. Genty, A. Gröhn, H. Talvitie, M. Kaivola and H. Ludvigsen, “Analysis of the linewidth and continuos tuning range of a grating cavity”, in Abstracts of OSA Annual Meeting/ILS-XV, Santa Clara, CA, USA, September 26 - 30, 1999, p. 57.

T. Kübarsepp, P. Kärhä and E. Ikonen, “Interpretation of UV irradiation effects on the responsivity of silicon photodetectors”, in Abstracts of Newrad '99, Madrid, Spain, October 25 - 27, 1999, p. 15.

K.D. Stock, K.H. Raatz, T. Kübarsepp, P. Kärhä, E. Ikonen and L. Liedquist, “Detector stabilized FEL lamps as transfer standards in an international comparison of spectral irradiance”, in Abstracts of Newrad '99, Madrid, Spain, October 25 - 27, 1999, p. 25.

P. Toivanen, F. Manoocheri, P. Kärhä, E. Ikonen and A. Lassila, “Measurements of irradiance responsivity and aperture area by direct optical method”, in Abstracts of Newrad '99, Madrid, Spain, October 25 - 27, 1999, p. 19.

P. Toivanen, J. Hovila, P. Kärhä and E. Ikonen, “Realisation of the units of luminance and spectral radiance at the Helsinki University of Technology”, in Abstracts of Newrad '99, Madrid, Spain, October 25 - 27, 1999, p. 20.

K. Lahti, J. Hovila, P. Toivanen, I. Tittonen and E. Ikonen, “Realisation of the luminous flux unit using the absolute integrating sphere method”, in Abstracts of Newrad '99, Madrid, Spain, October 25 - 27, 1999, p. 31.

F. Manoocheri, S. Nevas, P. Kärhä, P. Toivanen and E. Ikonen, “Determination of uncertainties due to spectral transmittance measurements in filter radiometry”, in Abstracts of Newrad '99, Madrid, Spain, October 25 - 27, 1999, p. 32.

P. Kärhä, T. Kübarsepp, F. Manoocheri, S. Nevas, P. Toivanen and E. Ikonen, “Extension of the trap-detector-based spectral irradiance scale into the ultraviolet region”, in Abstracts of Newrad '99, Madrid, Spain, October 25 - 27, 1999, p. 39.

E. Ikonen, “Measurement of optical quantities at high accuracy and low cost”, in Proceedings of the 21st Nordic Conference on Measurements and Calibration, November 22 - 23, Paper No. 8, 14 p.

5.2.2 National conference proceedings

K. Lahti, I. Tittonen and E. Ikonen, “Realization of luminous flux scale using the absolute integrating sphere method”, in Proceedings of the XXXIII Annual Conference of the Finnish Physical Society, Report Series TURKU-FL-L28, 1999, paper 1.11.

I. Tittonen, “Considerations for defecting quantum noise in an optical cavity”, in Proceedings of the XXXIII Annual Conference of the Finnish Physical Society, Report Series TURKU-FL-L28, 1999, paper 2.2.

P. Toivanen, A. Lassila, F. Manoocheri, P. Kärhä and E. Ikonen, “A laser-based method for determination of irradiance responsivity of filter radiometers”, in Proceedings of the XXXIII Annual Conference of the Finnish Physical Society, Report Series TURKU-FL-L28, 1999, paper 2.5.

G. Genty, T. Niemi and H. Ludvigsen, “Characterization of WDM components”, in Proceedings of the XXXIII Annual Conference of the Finnish Physical Society, Report Series TURKU-FL-L28, 1999, paper 2.6.

T. Niemi, S. Tammela and H. Ludvigsen, “Real-time frequency chirp measurements of optical signals”, in Proceedings of the XXXIII Annual Conference of the Finnish Physical Society, Report Series TURKU-FL-L28, 1999, paper 2.11.

T. Kübarsepp, P. Kärhä and E. Ikonen, “Interpolation of the quantum yield of silicon in the near UV”, in Proceedings of the XXXIII Annual Conference of the Finnish Physical Society, Report Series TURKU-FL-L28, 1999, paper 2.19.

K. Ruokonen, T. Lamminmäki, K. Nera, V. Voipio and I. Tittonen, “Finite element method simulations on micromechanical sensors”, in Proceedings of the XXXIII

Annual Conference of the Finnish Physical Society, Report Series TURKU-FL-L28, 1999, paper 10.18.

T. Lindvall, J. Toivonen, I. Tittonen, A. Pietiläinen and E. Ikonen, “Spectroscopy of rubidium atoms in a magneto-optical trap”, in Proceedings of Finnish Optics Day 1999, Joensuu 1999, p. 15.

M. Merimaa, H. Talvitie, I. Tittonen, P. Laakkonen and E. Ikonen, “Compact external-cavity diode laser at 633 nm with a transmission grating”, in Proceedings of Finnish Optics Day 1999, Joensuu 1999, p. 17.

T. Niemi, G. Genty, S. Tammela and H. Ludvigsen, “Performance degradation of fiber optic CATV links by nonideal characteristics of linearly chirped fiber Bragg gratings”, in Proceedings of Finnish Optics Day 1999, Joensuu 1999, p. 19.

J. Hovila, P. Toivanen, P. Kärhä and E. Ikonen, “Characterization of a spectroradiometer used in the realization of the unit of spectral radiance”, in Proceedings of Finnish Optics Day 1999, Joensuu 1999, p. 5.

M. Merimaa, J. Casado, T. Niemi and H. Ludvigsen, “An absolute frequency reference for WDM communication systems”, in Proceedings of Finnish Optics Day 1999, Joensuu 1999, p. 16.

T. Niemi, G. Genty, S. Tammela and H. Ludvigsen, “Using dispersion compensation to improve the performance of fiber optic CATV links”, in Proceedings of Finnish Optics Day 1999, Joensuu 1999, p. 20.

5.3 Reports

S. Metsälä, Patentti no. 732510-USA: Hienomekaaninen säätölaite, 1999, 11 p. (in Finnish).

I. Tittonen (editor), Annual report 1998, Metrology Research Institute, Helsinki University of Technology, Espoo 1999, Metrology Research Institute Report 13/99, 58 p.

E. Häkkinen, K. Fallström, A. Haapalinna and P. Kärhä, Häiriökysymykset - Häiriöt mittauksissa, 4th edition, TKK, Espoo, 1999, 36 p. (in Finnish).

P. Kärhä (editor in chief), UVNews, The official newsletter of the Thematic Network for Ultraviolet Measurements, Issue 2, Espoo 1999, 60 p.

P. Kärhä (editor in chief), UVNews, The official newsletter of the Thematic Network for Ultraviolet Measurements, Issue 3, Espoo 1999, 28 p.

A. Pietiläinen and M. Merimaa, Mittaustekniikan perusteiden laboratoriotyöt, 6th edition, Espoo 1999, 107 p. (in Finnish).

T. Kübarsepp, P. Kärhä, F. Manoocheri, S. Nevas, L. Ylianttila and E. Ikonen, Absolute spectral irradiance measurements of quartz-halogen tungsten lamps in the spectral range 290 - 900 nm, Metrology Research Institute, Helsinki University of Technology, Espoo 1999, Metrology Research Institute Report 14/99, 13 p.

E. Ikonen, Optiikan perusteet, Espoo 1999, 81 p. (in Finnish).

T. Kübarsepp, Optical radiometry using silicon photodetectors, Metrology Research Institute, Helsinki University of Technology, Espoo 1999, Metrology Research Institute Report 15/99, 37 p.

5.4 Lectures

5.5 Other activities

5.5.1 Conferences and meetings

The personnel participated in the following conferences and meetings:

NRC Expert Seminar “Laser diodes in optical communications: state of the art and future trends”, Helsinki, Finland, January 12, 1999; Hanne Ludvigsen and Goëry Genty.

Laser Comparison Meeting, Paris, France, January 17 - 24, 1999; Mikko Merimaa.

Key Comparison Meeting, Paris, France, January 18 - 20, 1999; Erkki Ikonen.

Conference on Microsystems Modeling, Espoo, Finland, January 28, 1999; Ilkka Tittonen, Ville Voipio, Markku Kujala, Tuomas Lamminmäki and Kaius Ruokonen.

Creativity Forum 1999, Espoo, Finland, January 28, 1999; Ilkka Tittonen.

Euromet Rapporteurs Meeting, Delft, The Netherlands, February 4, 1999; Erkki Ikonen.

2nd UICEE Annual Conference on Engineering Education, Auckland, New Zealand, February 10 - 13, 1999; Pekka Wallin.

Steering Group Meeting of the Fiber Optic Technology Network at NPL, London, UK, February 15, 1999; Hanne Ludvigsen.

OFC’99 Conference, San Diego, California, USA, February 19 - 27, 1999; Hanne Ludvigsen.

XXXIII Annual Conference of the Finnish Physical Society, Turku, Finland, March 4 - 6, 1999; Goëry Genty, Miika Heiliö, Toomas Kübarsepp, Kristian Lahti, Thomas Lindvall, Tapio Niemi, Kaius Ruokonen, Ilkka Tittonen, Pasi Toivanen, Eero Vahala and Pekka Wallin.

Optical Fibre Measurement Course, NPL, London, England, March 8 - 10, 1999; Hanne Ludvigsen.

Meeting of CCPR, Paris, France, March 23 - 28, 1999; Erkki Ikonen.

3rd Hermann von Helmholtz Symposium, “Precision Measurement of Electromagnetic Radiation”, PTB, Berlin-Charlottenburg, Germany, March 30, 1999; Petri Kärhä.

Inauguration of the PTB Synchrotron Radiation Laboratory at BESSY II, PTB, Berlin-Adlershof, Germany, March 29, 1999; Petri Kärhä.

Euromet Contact Persons Meeting, Delft, The Netherlands, April 11 - 13, 1999; Erkki Ikonen.

Optics Day 1999, Joensuu, Finland, April 23 - 24, 1999; Goëry Genty, Jari Hovila, Erkki Ikonen, Kristian Lahti, Thomas Lindvall, Mikko Merimaa, Tapio Niemi and Ilkka Tittonen.

Kick-off meeting of EUROMET project 515, Copenhagen, Denmark, May 10, 1999; Erkki Ikonen.

Work Package Manager Meeting of the EU-project "Improving the Accuracy of Ultraviolet Radiation Measurement", London, UK, May 17 - 18, 1999; Petri Kärhä.

Euromet Committee Meeting 13, Prague, Checz Republic, May 19 - 21, 1999; Erkki Ikonen.

Minisymposium on Cold Atoms and Bose-Einstein Condendation, Stockholm, Sweden, June 2, 1999; Ilkka Tittonen and Thomas Lindvall.

Seminar of Fiberoptic Communication Technology, Tampere, Finland, June 8, 1999; Hanne Ludvigsen.

CIE Division 2 TC2-47 meeting, Warsaw, Poland, June 28 - 30, 1999; Petri Kärhä.

TMR School on "Quantum Computation and Quantum Information Theory," Torino, Italy, July 12 - 23, 1999; Thomas Lindvall.

Advanced Semiconductor Lasers and Applications, Santa Barbara, USA, July 18 - 23, 1999; Mikko Merimaa.

22nd International Conference on Low Temperature Physics, Helsinki, Finland, August 4 - 11, 1999; Thomas Lindvall, Kaisa Nera, Kaius Ruokonen and Ilkka Tittonen.

Meeting on Optical Fibre Systems based on RCLED's and VCEL's, Tampere, Finland, August 17, 1999; Hanne Ludvigsen.

Training Course of the Thematic Network for UV-Measurements, NPL, Teddington, UK, September 6 - 8, 1999; Petri Kärhä.

Third Workshop of the Thematic Network for UV-Measurements, NPL, Teddington, UK, September 8 - 10, 1999; Erkki Ikonen and Petri Kärhä.

Eurosensors XIII, The Hague, Netherlands, September 12 - 15, 1999; Ilkka Tittonen, Markku Kujala and Ville Voipio.

Optical Fibre Measurement Conference, Nantes, France, September 22 - 24, 1999; Hanne Ludvigsen, Goëry Genty and Tapio Niemi.

COST 265 meeting, Nantes, France, September 25 - 26, 1999; Hanne Ludvigsen.

OSA Annual Meeting/ILS-XV, Santa Clara, CA, USA, September 26 - 30, 1999; Goëry Genty.

Conference on Quantum Optics, Mallorca, Spain, October 2 - 7, 1999; Ilkka Tittonen.

7th International Confererence on New Developments and Applications in Optical Radiometry NEWRAD99, Madrid, Spain, October 25 - 27, 1999; Erkki Ikonen, Petri Kärhä, Farshid Manoocheri, Pasi Toivanen and Toomas Kübarsepp.

Winter Graduate School on Atom Traps, Ion Traps and Optical Tweezers, Solbacka, Stjärnhov, Sweden, November 2 - 5, 1999; Thomas Lindvall.

ANSYS Heat Transfer Course, Helsinki, Finland, November 16 - 17, 1999; Tuomas Lamminmäki and Kaius Ruokonen.

Work Package Manager Meeting of the EU-project “Improving the Accuracy of Ultraviolet Radiation Measurement”, Paris, France, November 16 - 17, 1999; Petri Kärhä.

21st Nordic Conference on Measurements and Calibration, Oslo, Norway, November 22 - 23, 1999; Erkki Ikonen.

Euromet contact persons meeting, Braunschweig, Germany, December 12 - 14, 1999; Erkki Ikonen and Petri Kärhä.

5.5.2 Visits by the laboratory personnel

Jari Hovila to Elektronik/EP’99 Trade, Stockholm, Sweden, January 19 - 22, 1999.

Tomi Blomgvist to SP Swedish National Testing and Research Institute, Borås, Sweden, March 5 - 6, 1999.

Petri Kärhä to PTB-Berlin and OMTEC GmbH, Berlin, Germany, March 27 - 28, 1999; LNE, Paris, France, November 17, 1999.

Erkki Ikonen to NMi-VSL, Delft, The Netherlands, April 13, 1999; DFM Optics Laboratory, Copenhagen, Denmark, May 10, 1999; CMI, Prague, Czech Republic, May 20, 1999; JV, Oslo, Norway, November 23, 1999.

Toomas Kübarsepp to the Observatory of Tarto, Estonia, October 6 - 7, 1999.

Kaj Nyholm to Danish Institute of Fundamental Metrology DFM, Denmark, December 9 - 10, 1999.

5.5.3 Research work abroad

Maria Uusimaa, Institut National de Sciences Appliquées de Lyon, Lyon, France, January 1 - March 31, 1999.

Markku Vainio, Lund University of Technology, Lund, Sweden, September 1 - December 31, 1999.

5.5.4 Guest researchers

José Ramón Casado Dominguez, Centro Politécnico Superior, University of Zaragoza, Spain, January 1 - March 31, 1999.

Saulius Nevas, University of Kaunas, Kaunas, Lithuania, January 1 - May 31, 1999.

Masaki Takada, Kyoto University, Kyoto, Japan, June 10 - August 8, 1999.

Anne-Claire Dupart, Institut National Des Telecommunications, Paris, France, June 28 - August 31, 1999.

5.5.5 Visits to the laboratory

Dr. Volker Bentlage, OMTEC GmbH, Germany, January 11, 1999.

Mr. Leif Liedquist, SP Swedish National Testing and Research Institute, Borås, Sweden, April 8, 1999.

Prof. Åsa Lindberg and Pawel Kluczynski, University of Umeå, Sweden, June 4, 1999.

Dr. J. F. Clare, Measurement Standards Laboratory, Industrial Research Limited, New Zealand, June 21, 1999.

Dr. Jian Guo Zhang, Asian Institute of Technology, School of Advanced Technologies, Thailand, June 30, 1999.

Dr. George Eppeldauer, National Institute of Standards and Technology, USA, October 30 - November 3, 1999.

Dr. Peter Huang, National Institute of Standards and Technology, USA, December 2 - 6, 1999.

Prof. Martin Min, Tallinn Technical University, Estonia, December 9 - 11, 1999.

Dr. Uno Veismann, Department of Physics, Tartu University, Tartu, Estonia, December 10 - 11, 1999.

Prof. Wolfgang Heering, University of Karlsruhe, Karlsruhe, Germany, December 9 - 12, 1999.

Dr. Magnus Ljungström, Gamma Optronik AB, Uppsala, Sweden, December 14, 1999.

Dr. Mackillo Kira, KTH Stockholm, Sweden, December 22, 1999.

5.5.6 Memberships

Helsinki University of Technology, Metrology Research Institute (represented by Erkki Ikonen) is a member laboratory of the Comite Consultative Photometrie et Radiometrie (CCPR).

EUROMET, Photometry and Radiometry, Erkki Ikonen (Rapporteur and Contact person).

European Cooperation for Accreditation (EA), Task Force: Photometry and Radiometry, Petri Kärhä (Member).

Advisory Commission for Metrology, Pekka Wallin (Member).

Advisory Commission for Metrology, Optical quantities expert group, Pekka Wallin (Chairman), Erkki Ikonen (Member).

Advisory Commission for Metrology, Expert group in length metrology, Erkki Ikonen (Member).

COST Action 265, Measurement techniques for active and passive fibres to support future telecommunications standardisation, Hanne Ludvigsen (Contact person of Finland).

5.5.7 Thematic Networks funded by the SMT Programme

HUT is the co-ordinator of the Thematic Network for Ultraviolet Measurements.

HUT is a member and national co-ordinator of the Fibre Optic Technology Network (FOTON).

HELSINKI UNIVERSITY OF TECHNOLOGY (HUT), HIGH VOLTAGE INSTITUTE

1. NAME OF THE NATIONAL STANDARDS LABORATORY

Helsinki University of Technology, Department of Electrical and Communications Engineering, High Voltage Institute

2. QUANTITIES

Direct voltage	1 kV – 200 kV
Alternating voltage	50 Hz, 1 kV – 100 kV (rms), 1 kV – 140 kV (peak)
Capacitance	50 Hz, 1 kV – 100 kV, 10 pF – 100 µF
Loss factor tanδ	50 Hz, 1 kV – 100 kV, $1 \cdot 10^{-5} - 2 \cdot 10^{0}$
Inductance of high voltage reactors	50 Hz, 1 µH – 10 H
Lightning impulse voltage	50 mV – 600 kV
Switching impulse voltage	1 V – 200 kV
Other impulse voltages	1 V – 200 kV
Impulse current	1 A – 50 kA
Impulse energy	1 mJ – 500 J
Impulse charge	1 pC – 1 nC

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

28 (including 59 calibration tasks)

3.2 Number of accredited calibration laboratories

3.3 Number of official calibration certificates given by accredited calibration laboratories

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

Direct voltage	Voltage dividers, precision voltmeter, special software.
Alternating voltage	Standard gas capacitors, current comparator bridge, digitising precision voltmeter with special software, auxiliary divider.
Capacitance	Standard capacitors, current comparator bridge.
Loss factor tanδ	Standard capacitors, current comparator bridge, auxiliary resistors, unit for eliminating the effect of the measuring cable resistance.
Inductance of high voltage reactors	Standard capacitors, standard coil, current comparator bridge, two digitising precision voltmeters with special software, current shunts.
Lightning impulse voltage	Impulse calibrator, peak voltmeter, voltage divider, digital recorder with special software.
Switching impulse voltage	Impulse calibrator, voltage divider, digitising precision voltmeter with special software.
Other impulse voltages	Impulse calibrator, voltage divider, digitising precision voltmeter with special software.
Impulse current	Shunt resistors, digital recorder with special software.
Impulse energy	Shunt resistors, digital recorder with special software.
Impulse charge	Reference calibrator, calibrated resistor, digital recorder with special software.

4.2 Maintenance

Development and maintenance of quality system. Quality work in the Institute and in the University. Quality code as net version. Internal audits and control of the records of performance.

Monitoring of environmental conditions in laboratory rooms. Checks of the air conditioning of calibration rooms and adjusting its control system.

Maintenance and renewing of the computer network. Maintenance of measurement and office computers and related software. Improving and developing the software of the measurement systems.

Calibrations of auxiliary instruments in regular basis once a year.

Calibrations of all reference systems according to calibration schedule. Performance checks.

Additional performance checks of measuring systems e.g. for calibrations onsite and in clients premises as well as after tests in which reference systems had to be applied.

Monitoring of stability of reference systems. Condition monitoring and maintenance of reference systems. Reparations, amendments and modifications of equipment.

Amendments and modifications of documentation of reference measuring systems.

Planning, realisation, participation and reporting of six international comparisons. See Chapters 4.4 and 5.

Work in the National Metrology Service Section of the Advisory Commission for Metrology MNK-MPJ, in its working group for Electrical Quantities MNK-S and in the meetings of National Laboratories FINMET and related meetings. Metrology Days and Metrology Theme Days.

Work in CIGRE working group 33.03 (High Voltage Testing and Measuring Technique).

International standardisation work within IEC TC 42 High-voltage Testing Techniques and its working group WG 8 Digital Recorders.

Professional studies and learning of high-voltage measuring techniques and systems. Internal studies, learning and training. Studies and learning of computer applications and software. Quality studies and learning. Learning of languages.

Information activities, calibration marketing letters, information into Internet, home page updating.

Conference papers (ISH London) on impulse charge calibrations (together with PTB at al) and AC peak voltage measurements (together with SP and PTB).

4.3 Development projects

Development of reference measuring system for 200 kV DC voltage. A new 50 kΩ divider was calibrated and taken into use. The l.v. arm of the 200 kV divider was replaced with a more stable resistor. A new bridge circuit with special software for measurement of high-resistance resistors was established and taken into use.

Development of reference measuring system for AC voltage. The system for calibration of voltage transformers and AC voltage dividers was tested and calibrated. The new burdens were calibrated and two new burdens were constructed and tested preliminarily. A new precision voltmeter was purchased calibrated and taken into use. The new divider based on 150 kV compressed gas capacitor was finished and uprated to 200 kV. The phase error needs more studies.

Development of reference measuring system for capacitance. For further improving the uncertainty of measurement of high capacitance values new oil impregnated folio capacitors up to 50 μF were obtained. They have been calibrated and documented. Comparison with SP is going on. Measurement of high capacitances and their loss factors were performed with two independent methods: by means of the current comparator bridge (with resistance compensation) and with current/voltage method using advanced and sophisticated sampling techniques. The stability of the capacitance of different reference capacitors (air insulated, compressed gas, ceramic and oil impregnated) has been studied and recorded.

Uprating of capacitor M150. Extension of a voltage range of a compressed gas capacitor M150 from 100 kV to 200 kV for alternating voltage has been completed. Monitoring of the sensitive pressure sensor for high-resolution measurement of the gas leakage is provided for year 2000.

Development of reference measuring system for inductance. Characteristics of the air core coil were further studied and its stability was monitored. Measurements were performed with bridge and I/U method with advance sampling. Comparison measurements with SP are going on together with comparison of high capacitances. The final uncertainties will be estimated after the comparison.

Development of reference measuring system for AC current. Developing of the calibration system has been started. High-current shunt and Rogowski coil based current measuring system has been compared. High-current sources have been studied. Further studies and measurements are needed for reducing the uncertainty.

Measuring system for 400 kV lightning impulse voltage with optically isolated l.v. transmission system. The optical link of the l.v. arm was temporarily removed and further development of the system was discontinued. The l.v. arm was replaced with higher resistance for conventional use of this divider as an additional reference divider HUT 401a. The LI reference divider G600 is under reparations and the best divider HUT 400 is circulating as a part of reference system in international comparison of impulse voltage measuring system co-ordinated by HUT.

Reduction of the uncertainty of lightning impulse front time of impulse voltage calibrator. The studies of impulse calibrator construction and components has been continued for better uncertainty in front time evaluation. New calculable calibrator heads were introduced for fixed impulse shapes and for voltage range of 50 mV to 300 V. The uncertainty of front time could then be reduced down to 1 % and that of tail to 0,5 %. The uncertainty of peak voltage could be reduced down to 0,1 %.

Calibration system of digital recorders. Moving to a real time HPVEE based calibration system has been continued with digitisers Power Pro 610 and LeCroy 9384TM. The computer and software of the digitiser Strauss TR 100-10 was updated.

Calibration system for impulse current. A cable type step generator for current has been studied and tested up to 1 A. Developing a high current mercury wetted switch has been discontinued. A new multipurpose ESD/EMC/surge current/surge voltage generator has been purchased and taken into use. This also supports the development of ESD/EMC calibration (see below). Higher impulse currents will be generated by means of 800 kV (10 kA) and 2500 kV (50 kA) impulse generators although using these is quite expensive. Testing and calibration of the ferrite core Pearson coils for high-frequency and impulse current measurement has been started. Full calibrations, evaluations and documentation of the shunts and Pearson coils will be done in 2000.

Calibration system for impulse charge. The apparent charge calibration has to be performed before any partial discharge test and measurement. The HPVEE based calibration system for calibration of impulse charge calibrators is in use, and the calibration services have been started. In addition to improving the integration in impulse charge measurements, the next step will be development of the calibration services for partial discharge measuring instruments.

Calibration system for EMC and ESD pulses. The studies have been continued with the developed 50 Ω ceramic voltage divider and with purchased new components. The IEC type target for ESD has been purchased, assembled and studied by means of the new commercial EMC/EFT/ESD generator. New interleaving software was created for increasing the sampling frequency above the maximum value of the digitiser LeCroy 9384TM (10 GS/s). Starting full services for EFT and ESD impulse calibrations need some more studies and a new digitiser. Comparison of ESD generators is provided for the year 2000 after possible improving the analogue bandwidth of the impulse measurements up to 3 GHz.

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

4.4.3 International comparisons

Participation in intercomparison of apparent charge of partial discharges. Co-ordinator PTB, project SMT4-CT95-7501. Final Publication in ISH 99 London.

Starting and progressing of international world-wide intercomparison of high-voltage impulse measuring system with impulse calibrator and digitiser, to be co-ordinated by HUT HVI. EU project SMT4-CT98-2270, EUROMET project 488: Traceability and Mutual Recognition of Impulse Voltage Measurements.

LCIE/HUT comparison of National Measurement Standards for standard lightning impulse was performed at HUT in December 1998 (EUROMET project 494). Reporting in 1999.

SP/PTB/HUT comparison of AC peak voltage measurements. Final Publication in ISH 99 London.

NPL intercomparison of high AC current measurements around 1000 A (EUROMET project 473). Spring 2000.

NPL intercomparison of 100 kV DC measurements (EUROMET project 495). Spring 2000.

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

Martti Aro: Metrological Research and Development and Maintenance of National Standards at HUT High Voltage Institute in 1998. Finnish National Standards Laboratories FINMET. Annual Report 1998. Centre for Metrology and Accreditation, Publication J6/1999, pp. 70 - 79.

Marja-Leena Pykälä, V. Palva, Jari Hällström, Martti Aro, L. Satish (HUT/IIC): Transfer function of Power Transformers. Part IV. Additional Measurements on Test Winding. Helsinki University of Technology, High Voltage Institute, Report TKK-Sjt-36, Espoo 1999, 82 + 16 p.

Marja-Leena Pykälä, Veikko Palva, Jari Hällström, Martti Aro: Transfer function of Power Transformers. Part V. Evaluation of recent Results and Conclusions (in Finnish). Helsinki University of Technology, High Voltage Institute, Report TKK-Sjt-37, Espoo 1999, 66 p.

K. Schon, J. Hällström, J. Piiroinen et al: Intercomparison on PD calibrators and PD instruments. 11th International Symposium on High-Voltage Engineering (ISH-99), London UK, 22 - 27 August 1999, paper 1.5.S1, 4 p.

A. Bergman (SP), R. Marx and K. Schon (PTB), E-P. Suomalainen and J. Hällström (HUT): Intercomparison of AC peak voltage measurement. 11th International Symposium on High-Voltage Engineering (ISH-99), London UK, 22 - 27 August 1999, paper 1.9.S1, 4 p.

J. Hällström and J. Piiroinen (HUT), P. Gournay (LCIE): Intercomparison of reference measuring systems for high voltage lightning impulses between BNM-LCIE and HUT-HVI. Poster, Metrologie 99, Conference Bordeaux 18–21 October 1999.

Martti Aro: Know errors of your measurements (in Finnish). Sähkö&Tele 72(1999)8, p. 63.

Martti Aro: HUT High Voltage Institute. Annual Report 1999. Report TKK-Sjt-38, Helsinki University of Technology, High Voltage Institute, Espoo December 1999.

5.2 Conferences

ISH International Symposium on High Voltage Engineering, London 23–28 August 1999, E-P. Suomalainen, two papers.

CIGRE WG 33.03 (High Voltage Testing and Measuring Techniques) Weggis Switzerland on 2–5 September 1999, M. Aro and J. Hällström, four papers.

CIGRE Study Committee SC 33 (Power systems insulation coordination) Lucerne Switzerland 31 August 1999, M. Aro.

CIGRE Study Committee SC 33 Cooloquium Lucerne Switzerland 1–2 September 1999, M. Aro and J. Hällström.

IEC TC42 (High Voltage Testing Techniques) Kyoto 18–20 October 1999, J. Hällström, one paper.

Metrologie Conference Bordeaux 18–21 October 1999, J. Piiroinen, one paper.

5.3 Reports

Martti Aro: Traceability and mutual Recognition of Impulse Voltage Measurements. Publishable Project Summary PPS, project EU SMT4-CT98-2270. Helsinki University of Technology, High Voltage Institute 12 January 1999, 1 p.

Martti Aro: Puncture Testing of Insulators. Follow up Report. International Experiences in Applying IEC Type 2 Report 61211 (1994-06). CIGRE 33-99 (WG 03) 9, Weggis, September 2, 1999, 5 p.

Martti Aro: Traceability and mutual Recognizability of Impulse Voltage Measurements. A new worldwide intercomparison of impulse voltage measuring systems with digitizer and impulse calibrator. CIGRE 33-99 (WG 03) 10 IWD, Weggis, September 1, 1999, 4 p.

Z. Matyas, M. Aro: EMC Improvements of the Measuring System for Steep Front-Chopped Impulses. CIGRE 33-99 (WG 03) 11 IWD, Weggis, September 3, 1999, 15 p.

J. Hällström, M. Aro, J. Piiroinen, J. Tsekurov: Instrumentation and Measurement Program for Worldwide LI Intercomparison. CIGRE 33-99 (WG 03) 12 IWD, Weggis, September 1999, 10 p.

Martti Aro, Jari Hällström: Traceability and mutual Recognition of Impulse Voltage Measurements. IEC TC 42 (High voltage testing techniques) meeting in Kyoto 18–20 October 1999. Paper 42(Kyoto/Finland)2, October 1999, 3 p.

Jari Hällström: Electrical Calibration and Measurement Capabilities of Helsinki University of Technology, High Voltage Institute. Collection of Euromet National Metrological Laboratories, by Euromet contact person Panu Helistö, VTT Automation. October 1999, 1 p.

J. Hällström and J. Piiroinen (HUT), P. Gournay (LCIE): Comparison of high voltage lightning impulse measuring systems. Euromet project 494. Final Report September 1999, 20 + 45 p.

Martti Aro: Traceability and mutual Recognition of Impulse Voltage Measurements. Publishable Project Summary PPS, project EU SMT4-CT98-2270. Helsinki University of Technology, High Voltage Institute December 1999, 1 p.

5.4 Lectures

M. Aro (editor): Diagnostics and high-voltage testing on-site. Post graduate seminar. Sjökulla 4–14 October 1999. Seminar Proceedings. Helsinki University of Technology, High Voltage Institute, Espoo December 1999.

5.5 Other activities

M. Aro is member of CIGRE Study Committee 33 (Power systems insulation coordination), CIGRE Working Group 33.03 (High voltage testing and measuring techniques) and Finnish delegate in IEC TC 42 (High-voltage testing techniques).

J. Hällström is member of IEC TC 42 Working Group 8 (Digital recorders for measurements in high-voltage impulse tests) and CIGRE Working Group 33.03 (High voltage testing and measuring techniques).

J. Hällström is responsible for the maintenance of IEC Standards 1083 (Digital recorders for high-voltage impulses).

M. Aro is chairman of Finnish National Committee of IEC TC 42 (High-voltage testing techniques).

Mr Zdenek Matyas from TU Eindhoven visited the Institute on 28 June – 27 August for research on EMC studies of fast 500 kV impulse voltage measuring system.

Prof. Ryszard Malewski (Canada) visited the Institute on 3–14 October 1999 for lessons in the post graduate seminar on Diagnostics and high-voltage testing on-site.

J. Piiroinen visited NPL on 22 October 1999 for discussions on ultra fast impulse calibrations and measurements, and calibration of fast and high-voltage digitisers.

3.10 FINNISH CENTRE FOR RADIATION AND NUCLEAR SAFETY (STUK)

1. NAME OF THE NATIONAL STANDARDS LABORATORY

Radiation and Nuclear Safety Authority (STUK)
Radiation Practices Regulation
Radiation Metrology Laboratory

2. QUANTITIES

Air kerma, reference air kerma rate, absorbed dose to water, ambient dose equivalent, directional dose equivalent, personal dose equivalent, surface emission rate

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

65

3.2 Number of accredited calibration laboratories

3.3 Number of official calibration certificates given by accredited calibration laboratories

4. MAINTENANCE AND DEVELOPMENT OF NATIONAL STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s)

Air kerma, absorbed dose to water, ambient dose equivalent, directional dose equivalent, personal dose equivalent: Secondary standard ionisation chambers with ^{60}Co and ^{137}Cs gamma sources and X-ray sources (10-320 kV X-ray equipment). Secondary standard beta ray sources, extrapolation ionisation chamber (primary standard; for dose equivalents of beta rays). Secondary standard neutron sources (for dose equivalents of fast neutrons).

Reference air kerma rate: (for brachytherapy sources of ^{60}Co, ^{192}Ir and ^{125}I): Secondary standard well-type ionisation chamber.

Surface emission rate: wide area secondary standard sources of beta nuclides (^{90}Sr/^{90}Y, ^{36}Cl, ^{14}C) and an alpha nuclide (^{241}Am).

4.2 Maintenance

The quality of all equipment used for calibration and testing was controlled regularly according to a documented quality control programme. The stability of secondary standards remained good. The established action levels for stability test results were not exceeded except for one case, where the reason turned out to be a cable fault.

4.3 Development projects

A number of **technical improvements of the calibration facilities** were completed. This includes, among other things, the installation of a new ^{60}Co gamma source in a multi-source gamma irradiation unit, a new calibration bench for the beta-ray irradiation equipment, a new software for the control of photon calibration facilities, new filters and radiation qualities for the calibration of dosemeters in radiodiagnostic applications, a new calibration jig for calibrations of therapy level plane parallel ionisation chambers in high-energy electron beams, and a new secondary standard (well-type ionisation chamber) for the calibration of brachytherapy sources.

The Quality System of the laboratory was developed in accordance with the general guidelines given by the International Atomic Energy Agency (IAEA) for the Secondary Standard Dosimetry Laboratories (SSDLs) of the IAEA/WHO international network of SSDLs (WHO: World Health Organisation). The laboratory participated in a Co-ordinated Research Program (CRP) of the IAEA (for 1997-1999), which aims at improving the quality of SSDLs through development of their quality systems. In the framework of this CRP, the Quality Manual of the laboratory was revised and the laboratory participated in preparing an international guide for establishing a quality system of an SSDL (to be published by the IAEA in 2000).

The methods of measurement and calibration, for boron neutron capture therapy (BNCT), were studied. The laboratory participated in an EU funded Shared Cost Action under the Standards, Measurement and Testing Program, for 1998-2001. The aim of the project is to develop a European Code of Practice for BNCT dosimetry. The results of the study on a twin-ionisation chamber method were published. The basic criteria for the methods of dose measurements was established, for the verification of the accuracy and suitability of selected methods (as the next step of the project).

Three other research projects related to radiation metrology deal with **dosimetry of irregular radiation fields** in radiotherapy (completed 1999), **development of comparative methods of measurements for radiotherapy** (1996-2001) and **quality assurance of electronic portal imaging devices** (EPID-systems; 1998-2001; in collaboration with radiotherapy department of Tampere University Hospital).

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

4.4.2 International (EA or other) intercomparisons for accredited calibration

laboratories

4.4.3 International comparisons

The laboratory participated in the routine annual intercomparisons organised by the IAEA, using mailed thermoluminescent dosimeters, for the accuracy of therapy level air kerma or absorbed dose measurements among the 72 SSDLs of the IAEA/WHO network. The deviations of the values given by the laboratory from the reference values of the IAEA were + 0.6 % (therapy level, ^{60}Co gamma beam) and from + 0.3 to + 1.2 % (therapy level, high-energy photon beams). All results are well within the action level of 3.5 % used by the IAEA.

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

A. Kosunen, M. Kortesniemi, H. Ylä-Mella, T. Seppälä, J. Lampinen, T. Serén, I. Auterinen, H. Järvinen, S. Savolainen, Twin ionization chambers for dose determinations in phantom in an epithermal neutron beam. Radiat. Prot. Dosim. 81, 187 - 194, 1999.

T. Seppälä, J. Vähätalo, I. Auterinen, A. Kosunen, DW. Nigg, FJ. Wheeler, S. Savolainen, Modelling of brain tissue substitutes for phantom materials in neutron capture therapy (NCT) dosimetry. Radiation Physics and Chemistry 55, 239 - 246, 1999.

5.2 Conferences

H. Järvinen, Dosimetry of beta rays and low energy photons for brachytherapy with sealed sources – review of an ICRU report under preparation. 5th Biennial ESTRO Meeting on Physics for Clinical Radiotherapy, Göttingen, Germany, 8 - 11 April 1999. Abstract. Radiotherapy and Oncology 51, Suppl.1 (1999), S15.

P. Sipilä, H. Järvinen, Practical experiences on quality audit in Finland. 5th Biennial ESTRO Meeting on Physics for Clinical Radiotherapy, Göttingen, Germany, 8 - 11 April 1999. Abstract. Radiotherapy and Oncology 51, Suppl.1 (1999), S31.

H. Järvinen, General approach to quality audit in radiotherapy. 5th Biennial ESTRO Meeting on Physics for Clinical Radiotherapy, Göttingen, Germany, 8 - 11 April 1999. Abstract. Radiotherapy and Oncology 51, Suppl.1 (1999), S57.

P. Sipilä, J. Vanhanen, H. Järvinen, QA of treatment planning systems in Finland. Workshop on Quality Assurance of Treatment Planning Systems, Göttingen, Germany, 6 - 7 April 1999. Abstract. Radiotherapy and Oncology 51, Suppl.1 (1999), 23.

H. Järvinen, Traceable calibrations for brachytherapy sealed sources. Poster. VI International Conference on Medical Physics, Patras, 1 - 4 September 1999.

A. Savolainen, I. Auterinen, C. Aschan, P. Hiismäki, M. Kortesniemi, A. Kosunen, P. Kotiluoto, J. Lampinen, T. Seppälä, T. Serén, V. Tanner, M. Toivonen, Dosimetry Chain for the Treatments of Glioma Patients in the Epithermal Neutron Beam at the Finnish BNCT Facility (FiR 1), 11th Nordic-Baltic Conference on Biomedical Engineering 6 - 10 June

1999, Tallinn, Estonia. Proceedings in Medical & Biological Engineering & Computing, 37 Supplement 1, 388 - 389, 1999.

I. Auterinen, P. Hiismäki, P. Kotiluoto, R. Rosenberg, S. Salmenhaara, T. Seppälä, T. Serén, C. Aschan, M. Kortesniemi, A. Kosunen, J. Lampinen, S. Savolainen, M. Toivonen, P. Välimäki, The new boron neutron capture therapy facility at the Finnish nuclear research reactor (FiR 1). 11th Nordic-Baltic Conference on Biomedical Engineering 6 - 10 June 1999, Tallinn, Estonia. Proceedings in Medical & Biological Engineering & Computing, 37 Supplement 1, 398 - 399, 1999.

5.3 Reports

R. Parkkinen, Aivoperfuusion kvantitatiivinen SPECT; ^{99m}Tc-HMPAO lasten epilepsia-tutkimuksissa. Lisensiaatin tutkimus. Kuopion yliopisto (1999) (in Finnish).

A. Kosunen, Metrology and quality of radiation therapy dosimetry of electron, photon and epithermal neutron beams. PhD Thesis, Department of Physics, University of Helsinki, Finland. Radiation and Nuclear Safety Authority-STUK Report A-164. 1999.

5.4 Lectures

H. Järvinen: The following teaching lectures at the IAEA Interregional Training Course of Calibration Procedures and Quality Assurance in SSDLs, Havanna, Cuba, 27 September - 8 October 1999:
Quality system for SSDLs.
Calibration equipment and facilities.
Design and type tests of dosimeters used in radiotherapy.
Design and type tests of dosimeters used in radiation protection.
Traceability chain for brachytherapy measurements.
Calibration of environmental dose rate meters.
Need of standards for measurements in X-ray diagnostic radiology.

5.5 Other activities

The laboratory is a member of the IAEA/WHO International Network of the SSDLs.

Antti Kosunen had a Ph.D. dissertation 22 October 1999, and Ritva Parkkinen a licentiate examination 10 September 1999.

Hannu Järvinen is the chairman of a Report Committee ”Beta rays for therapeutic applications” of the International Commission on Radiation Units and Measurements (ICRU).

Hannu Järvinen is a member of a Report Committee ”Dosimetric procedures in diagnostic radiology” of the ICRU.

Hannu Järvinen is a member of the Physics Committee of the European Society for Therapeutic Radiology and Oncology (ESTRO).

Petri Sipilä is a member of the International Electrotechnical Commission (IEC) 62C WG1 and Antti Kosunen a member of IEC 62C WG3.

Hannu Järvinen participated as a consultant in the IAEA meeting on ”Guidelines to SSDLs and Medical Physicists on calibration of brachytherapy sources”, Vienna 19 - 22 October 1999.

Hannu Järvinen participated as a partner of a Research Project in the IAEA Research Co-ordination Meeting on ”Development of the Quality Assurance Programme for SSDLs”, Vienna, 29 November - 3 December 1999.

Hannu Järvinen visited an SSDL of Vietnam 6 - 18 January 1999 as a technical assistance expert of the IAEA.

Hannu Järvinen and Petri Sipilä participated in the ESTRO Biennial Physics Meeting, Göttingen 5 - 11 April 1999.

Hannu Järvinen and Antti Kosunen participated in an IAEA Meeting on the Present Status of BNCT, Vienna, 12 - 18 June 1999.

Ilkka Jokelainen participated in an ESTRO teaching course on Physics for Clinical Radiotherapy, Leuven, 28 August - 2 September 1999.

Hannu Järvinen participated in the VI International Conference on Medical Physics, Patras, 1 - 4 September 1999.

The laboratory had a scientific visitor from Greece for one week, and a trainee from Greece for one month.

4. ACTIVITIES OF THE CONTRACT LABORATORIES IN 1999

4.1 RAUTE PRECISION, FORCE AND MASS LABORATORY

1. NAME OF THE CONTRACT LABORATORY

Raute Precision, Force and Mass Laboratory

2. QUANTITIES

Force, torque

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

Force 145, torque 55

4. MAINTENANCE AND DEVELOPMENT OF REFERENCE STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s), traceability

Force
The force scale is realised on the range 1 N …. 100 kN by dead weight standard machine, the range over 100 kN up to 1 MN is realised by hydraulic amplified machine, whereby the 100 kN dead weight standard machine is the reference machine. Realisation is based on the formula

$$F = m \cdot g_l [1 - (\rho_a / \rho_m)].$$

The traceability of masses leads to Centre for Metrology and Accreditation (MIKES) in Finland and to PTB (Physikalisch-Technische Bundesanstalt, Germany). The gravity constant is determinate by Finnish Geodetic Institute.

Torque
The torque is realised by force and length, $M = F \cdot l$. The traceability of forces is described in section before. The traceability in the length leads to VTT Manufacturing technology, which is the national laboratory for length.

4.2 Maintenance

Regularly internal comparison measurements have been made. Internal cross check and routine testing has indicated a normal condition of standards during the year.

4.3 Development projects

The practical work for key comparison project for force range 5 kN and 10 kN has been started on June, the preparation of force transducers including capability and stability tests. The project has a code CCM.F-K1.a (range 5 kN and 10 kN) and CCM.F.K1.b (5 kN).

The new torque standard for range less than 10 Nm is constructed and engineered, the testing for low range reference transducer is going on.

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

4.4.3 International comparisons

Regularly comparison with PTB, as well in force as in torque, has performed.

Intercomparison with IMGC, Italy on range 5 kN and 10 kN.

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

5.2 Conferences

IMEKO XV World Congress, Osaka, Japan.

5.3 Reports

Nordic intercomparison for calibration of uniaxial testing machine 1999.

5.4 Lectures

For AEL 4 lectures, subject calibration technology and uncertainty of calibration.

“Calibration of torque”, Lappeenranta, Quality in Metrology.

“Calibration of torque”, Joensuu, PKAKK.

“Conformity of software in metrology”, Automation 1999, Helsinki.

5.5 Other activities

Euromet mass contact persons meeting, 15 - 19 February, Istanbul.

CCM, key comparison Pilot-laboratories meeting, May, Paris.

ISO 7500 uncertainty working group, May, London.

ISO 7500 technical committee meeting, June, Prague.

EA-expert group for hardness, September, Copenhagen.

OIML-software seminar, September, Paris.

Assessor activities for FINAS.

BIPM Metre Convention, October, Paris.

4.2 TAMPERE UNIVERSITY OF TECHNOLOGY, INSTITUTE OF PRODUCTION ENGINEERING

1. NAME OF THE CONTRACT LABORATORY

Tampere University of Technology (TUT), Institute of Production Engineering

2. QUANTITIES

Dimensional quantities measured by Co-ordinate Measuring Machine (CMM) and site calibrations of CMMs.

3. CALIBRATION CERTIFICATES

3.1 Number of official calibration certificates given

The total number of certificates is 13 (1 certificate of site calibration of a CMM, 12 certificates for different kind of items, mostly reference normals for the industry).

4. MAINTENANCE AND DEVELOPMENT OF REFERENCE STANDARDS AND DISSEMINATION OF UNITS

4.1 Realisation of unit(s), traceability

The CMM is calibrated by step gauge in 15 locations every year. The calibration of reference Step gauge is done by DKD in Zeiss Oberkochen every two year. Gauge Blocks (200, 300, 400 and 500 mm) are also used as VDI/VDE and ISO standard require. The reference spheres and other reference objects are calibrated in Finland the national laboratory for length (MIKES).

4.2 Maintenance

The reference CMM SIP CMM5 is modernised by a new NC control and software WiniSIP.

4.3 Development projects

Project with the industry and TEKES foundation in Finland:

Gear check II "Quality insurance of Gear Manufacturing": Traceability of bevel gears, quality of grinding them as well measurement of standard helical gears by CMM are studied in 5 subprojects:
- Gear Trace. Traceability and uncertainty of Bevel gear measurement by a CMM.
- Bevel Expert. Better quality by Grinding parameters in Cyklo Palloid NC machine.
- Vibration. Effects of tooth geometry into vibration of an helix gear box.

- Single Flank: A new method based on single flank test to analyse and determine errors of manufacturing.
- Palloid: Calculate nominal surface points for the flank of Klingelnberg palloid.

Measurements for injection moulding. A new Multi Sensor CMM from Mahr with CCD camera and laser beam was installed year 1999. This CMM will be used for research and measurement of plastic parts. This industry research is still running and can not be published.

Calibration of a ball plate by swing around method and PTB PKAL program.

Use a ball plate to calibrate a CMM by PTB KALKOM-method.

Use a high precision autocollimator and 36 face polygon to calibrate the SIP Rotary table installed in the reference CMM5.

4.4 Intercomparisons

4.4.1 National intercomparisons for accredited calibration laboratories

4.4.2 International (EA or other) intercomparisons for accredited calibration laboratories

4.4.3 International comparisons

5. PUBLICATIONS, CONFERENCES, REPORTS, LECTURES AND OTHER ACTIVITIES

5.1 Publications

5.2 Conferences

Prague, Zech Republic 1–2 June 1999: International Workshop on Coordinate Measuring Machines Calibration at CMI: H. Tikka: Capability of Measuring Center. G. Szanti: Recent Developments in Bevel Gear Measurement.

5.3 Reports

TUT, Institute of Production Engineering Publication, Report no 46: Mittauskeskus - Multi Sensor Coordinate Measuring Machine, 53 pages, ISBN 952-15-0273-8.

TUT Publication no 280 (Dissertation) J. Hölsä: Method for Analysing Planar Machine Tool Measurements, ISBN 952-15-0329-7.

5.4 Lectures

Annual Seminar for Plastic Injection Industry in Hämeenlinna, Finland 3 - 4 June 1999: H. Tikka: Possibilities of Dimensional Measurements for Plastic Parts and Dimensional Metrology for Plastic Parts.

Seminar of the Surveying Sciences in Finland, 25 November 1999. H. Tikka: Coordinate Measuring Machine.

5.5 Other activities

H. Tikka and G. Szanti from TUT visited Czech Metrological Institute (CMI) in Prague 29 May – 2 June 1999.

Exchange of research people with CMI Prague. 9–20 August 1999 P. Skalnik visited TUT and 13–24 September 1999 G. Szanti CMI.

G. Szanti visited 4–6 October 1999 PTB Germany.

TUT organised an intercomparison of a Cone (tool holder) measurement with CMI in Prague and National office of Measures in Budapest.

A new Multi Sensor Coordinate Measuring Machine Mahr OMS 1000 is installed and taken into use.

H. Tikka is a member of IMEKO, Advisory Commission for Metrology (in Finnish: Metrologian neuvottelukunta, MNK) and The Center of Quality (in Finnish: Suomen laatukeskus, SLY).

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