2) Management System for Measurement Standard

While the traceability system appears not to be clearly established, measuring instrument control is practiced.

3) Standards

Of the 13 standards owned by Usra, 11, including the calipers and height gauge, etc., are calibrated by the SIRIM Measurement Centre. The electric platform scale is calibrated by EMEC, a private calibration laboratory, while the granite surface table is calibrated in-house. The standards owned by Usra are listed in Table 6-13.

4) Shop Floor Instruments

All the measuring instruments used on the shop floor are calibrated in-house every 6 months.

5) Requests to the SIRIM Measurement Centre

The calibration accuracy of the SIRIM Measurement Centre is satisfactory. However, the time required for calibration, more than one month at present, should be shortened to some 2 weeks. The calibration charges are reasonable.

(3) Maica Laminates Sdn. Bhd. (Maica)

1) Company Outline

Maica was established in Penang in 1970 as a joint venture between a local company and Aica Industries, Japan. It has some 220 employees and manufactures melamine decorative boards, of which some 60% are exported to Australia and China, etc. The company is preparing to acquire registered status under the ISO 9000.

2) Management System for Measurement Standard

As few instruments are used, no traceability chart has been prepared. All the instruments are individually controlled.

3) Standards

No instruments have the grade of standard.

4) Shop Floor Instruments

The measuring instruments used on the shop floor are limited but include a viscometer, abrasion tester, thickness meter and micrometer. They are all calibrated once or twice a year by their respective manufacturers.

5) Requests to the SIRIM Measurement Centre

No specific request was made. It is expected that the company will probably request the SIRIM Measurement Centre's calibration of the hardness tester and tensile tester, etc. in the future.

6.3.4 Machine Industry

The survey team visited Mitutoyo in the machine industry which sells measuring instruments and provides a calibration service and Sankyo Seiki which manufactures musical boxes.

(1) Mitutoyo (Malaysia) Sdn. Bhd. (Mitutoyo)

1) Company Outline

Mitutoyo was established in 1988 as a subsidiary of Mitutoyo, Japan, a measuring instrument manufacturer. The parent company had previously established a subsidiary in Singapore to serve the region but decided to establish a new subsidiary in Malaysia to meet the increasing local demand.

Mitutoyo in Malaysia does not manufacture measuring instruments but assembles and adjusts those manufactured in Japan. In addition to the sale of assembled instruments, the company provides a calibration service. It has a total of 23 employees.

Mitutoyo is preparing to acquire registered status under the ISO 9000 and plans to set up an independent calibration room by the end of fiscal 1993. It is also preparing to obtain SAMM accreditation as a calibration laboratory.

2) Management System for Measurement Standard

Although the company is not engaged in manufacturing activities, it has a well established in-house traceability system because it is conducting calibration service.

3) Standards

Mitutoyo's 13 standards, including the coordinate measuring machine, profile projector, calipers, micrometer and dial gauges, are annually calibrated by the SIRIM Measurement Centre. The traceability of all measuring instruments sold by the company to the standards owned by the SIRIM Measurement Centre has been confirmed.

4) Requests to the SIRIM Measurement Centre

As the company sells measuring instruments, its requests are very concrete, probably reflecting the requirements of its own clients. The main requests are as follows.

- The calibration of spare gauges of over 300mm is hoped for.

- At present, the SIRIM Measurement Centre calibrates gauge blocks by means of comparison and is not capable of conducting absolute calibration. It is hoped that absolute calibration using light wave length will be introduced in the near future.

- Calibration of the flatness of surface tables is hoped for.

- It is hoped that the calibration of hardness testers and standard hardness pieces will be introduced.

- The present error of $\pm 2\mu$ for the coordinate measuring machine should be improved as much as possible.

- The SIRIM Measurement Centre's currently lengthy calibration time should be shortened. The SIRIM Measurement Centre's calibration charges are quite low compared to those of others.

(2) Sankyo Seiki (Malaysia) Sdn. Bhd. (Sankyo)

1) Company Outline

Sankyo was established in 1974 as a local joint venture with Sankyo Seiki, Japan. It has some 800 employees and manufactures small musical boxes at a rate of 7 million pieces/month. All the boxes are inspected prior to shipment. The company has already applied for registered status under the ISO 9002 and the final examination is expected to take place shortly.

2) Management System for Measurement Standard

The in-house traceability system is well established.

3) Standards

Such dimensional standards as block gauges, dial gauges, coordinate measuring machine and profile projector, etc. are annually calibrated by the SIRIM Measurement Centre and Mitutoyo. The calibration room has a controlled temperature of 20°C ± 2°C for mechanical calibration and 23°C ± 2°C for electrical calibration.

4) Shop Floor Instruments

All the measuring instruments used on the shop floor are annually calibrated in-house using the above-mentioned standards. The measuring instruments owned by Sankyo are listed in Table 6-14.

5) Requests to the SIRIM Measurement Centre

- It is hoped that the calibration of Gauss meters with an accuracy of ±1% will be provided.

- It is hoped that the calibration of the characteristics of standard audio tapes to test audio head characteristics will be provided.

- The company requires the calibration of the magnetic force of small motors and wishes to know details of the relevant service provided by the SIRIM Measurement Centre.

- It is hoped than an on-site calibration service will be provided for pin gauges and oscilloscopes. The time currently required for calibration and calibration charge level are reasonable.

6.3.5 Automobile Industry

In the case of the automobile industry, the survey team visited Proton, a domestic manufacturer of passenger cars.

(1) Perusahaan Otomobil Nasional Berhad (PROTON)

1) Company Outline

Proton (Perusahaan Otomobil Nasional Berhad) was established in 1983 under the technical guidance of Mitsubishi Motors Corporation, Japan, to materialise the national automobile production initiative in Malaysia. Proton is capable of producing 120,000 small passenger cars a year and operates 2 shifts. Some 20,000 cars are annually exported and Britain is the largest market.

2) Management System for Measurement Standard

The in-house traceability is well established.

3) Standards

Nine types of standards, including the compound gauge, are calibrated by the SIRIM Measurement Centre while 4 types of standards, including the 12V battery tester, are calibrated by Airod. In addition, 4 types of standards, including the coordinate measuring machine (3-dimensional measuring tester), are calibrated by their respective manufacturers. Most of the standards are calibrated annually although some are calibrated quarterly. All the technical staffs assigned to the calibration room have undergone calibration training at the CIAST.

4) Shop Floor Instruments

In principle, the measuring instruments used on the shop floor are calibrated in-house but some are calibrated by the SIRIM Measurement Centre and Airod. While most of the instruments are calibrated annually, some are calibrated quarterly. The standards and measuring instruments owned by Proton are listed in Table 6-15.

5) Requests to the SIRIM Measurement Centre

Prior to the visit, it was expected that the company would have many requests because of its extensive use of measuring instruments and testers in the production, testing and inspection of cars. However, no concrete request was made.

6.3.6 Glass Industry

In the case of the glass industry, the survey team visited Malaysian Sheet Glass Bhd. (MSG) which manufactures sheet glass.

(1) Malaysian Sheet Galss Berhad (MSG)

1) Company Outline

MSG was established in 1971 as a local joint venture with Nippon Sheet Glass. It has some 1,200 employees and manufactures sheet glass, laminated glass and float glass, etc. While the supply priority is given to the domestic demand, some 40% of the production volume is exported to Singapore, Hong Kong and Japan, etc.

MSG has already been awarded the MS mark and JIS mark in addition to its registered status under the ISO 9002 which it acquired in 1988.

2) Management System for Measurement Standard

Although no traceability chart is available, the traceability system for individual instruments is well established.

3) Standards

Twelve types of standards, including block gauges and standard weights, are calibrated by the SIRIM Measurement Centre while the haze standard plate is calibrated by its Japanese manufacturer. All the standards are annually calibrated. The standards owned by MSG are listed in Table 6-16.

4) Shop Floor Instruments

A total of 86 measuring instruments are used on the shop floor and all of them are, in principle, calibrated in-house every 6 months by calibration technical staffs in accordance with the relevant calibration manuals.

5) Requests to the SIRIM Measurement Centre

MSG made the following concrete requests for the SIRIM Measurement Centre.

- The calibration of haze standard plates is hoped for.

- The calibration of viscometers and flowmeters (30 litres/min) is hoped for.

- The calibration certificate is currently sent one to 2 months following the return of the instrument which is returned as soon as calibration has been completed. As the actual use of a calibrated instrument depends on the entries on the calibration certificate, it is hoped that certificate will be returned along with the instrument concerned. It is also hoped that the calibration certificates will be written in English as well as Malay.

- It is hoped that training courses on calibration technologies/techniques will be arranged.

6.3.7 Other Industries

In addition to the companies described so far, the survey team visited Federal Package, a manufacturer of corrugated cardboard boxes, etc., SME, a manufacturer of weaponry, including automatic rifles, and Sime Inax, a manufacturer of toilet fixtures.

(1) Federal Package Sdn. Bhd. (Federal)

1) Company Outline

Federal was established in 1972 in Penang as a member of the Muda Holding Group. It manufactures corrugated cardboard boxes and paper bags for shop use, etc. Federal's turnover in fiscal 1988 totalled approximately 19.56 million M$.

2) Management System for Measurement Standard

While there is no company-wide traceability system, individual measuring instruments are properly controlled. Because of the company's important trade link with Sony, Federal undergoes an annual audit by Sony. The contents of this audit are similar to those required by the ISO 9000.

3) Standards

All the company's standards are annually calibrated by the SIRIM Measurement Centre. The calibration room has a controlled temperature of 20°C ± 2°C.

4) Shop Floor Instruments

All the measuring instruments used on the shop floor are calibrated in-house once or twice a year.

5) Requests to the SIRIM Measurement Centre

- The calibration of chromaticity meters is hoped for.

- The calibration of pH meters is hoped for.

- The calibration of load cell is requested with accuracy of 0.002.

- The SIRIM Measurement Centre's calibration charges appear rather high although they may be justified by the international credibility of the calibration results provided by the SIRIM Measurement Centre.

(2) SME Technologies Sdn. Bhd. (SME)

1) Company Outline

SME is a member of the SME Group and enjoys an exclusive licence to manufacture weaponry in Malaysia. The company manufactures rifles, aerospace equipment and other precision equipment. The company acquired registered status under the ISO 9002 in 1991.

2) Management System for Measurement Standard

The in-house traceability system, with calibration at the SIRIM Measurement Centre given the highest grade, is well established as the company is required to enforce particularly strict precision control as a manufacturer of weapons.

3) Standards

The Grade 1 gauge blocks, micrometer and thermohygrometer are calibrated by the SIRIM Measurement Centre while the coordinate measuring machine is calibrated based on the British Standard (BS). The oven is calibrated by Pyrometro while the profile projector and height micrometer are calibrated by Mitutoyo and Nusantra respectively. The calibration frequency is every 6 months.

4) Shop Floor Instruments

More than 2,000 measuring instruments are used on the shop floor are all of these instruments are calibrated in-house. The calibration frequency varies from once a month to once every 6 months depending on the instrument type.

5) Requests to the SIRIM Measurement Centre

SME believes that the calibration performance of the SIRIM Measurement Centre is totally reliable. Therefore, it did not make any special request and only the following comments.

- The calibration accuracy satisfies SME's requirements.

- The time required to complete calibration work is too long.

- The calibration charges are too low.

- The clean room specifications adopted by the SIRIM Measurement Centre are inadequate.

(3) Sime Inax Sdn. Bhd. (Inax)

1) Company Outline

Inax was established in 1984 as a joint venture between Sime Darby, a local manufacturer, and Inax, Japan. It mainly manufactures toilet fixtures and exports some 30% of its products to Japan. Inax has already applied for registered status under the ISO 9002 and the examination is expected to take place in October, 1993.

2) Management System for Measurement Standard

While the in-house traceability system is not clearly established, a management system for individual measuring instruments is operated.

3) Standards

Six types of standards are calibrated by the SIRIM Measurement Centre in addition to 12 types by Mecomb and 5 types by Pyrometro. The calibration frequency is either annually or every 6 months depending on the type of standard.

4) Shop Floor Instruments

Apart from the length gauge, the pressure gauge and all temperature-related instruments except thermocouples are calibrated in-house in accordance with the relevant calibration manuals. The thermocouples inside the tunnel furnace are calibrated by Pyrometro while others are calibrated on-site by Mecomb. The calibration frequency of the instruments used on the shop floor is either annually or every 6 months. The measuring instruments owned by Inax are listed in Table 6-17.

5) Requests to the SIRIM Measurement Centre

- The calibration of Rheo meters (220 kg/cm^2) used to determine the characteristics of clayey samples is hoped for.

- The calibration of colour meters is hoped for.

- Calibration at the SIRIM Measurement Centre requires a long period of time. This should be shortened to one or 2 weeks. The calibration accuracy satisfies the requirements of Inax and the calibration charges are believed to be lower than others.

6.4 Concrete Requests to SIRIM Measurement Centre

Total 46 requests for expansion of calibration services were made during our survey. The followings are those requests by laboratory.

1) Length laboratory

- Calibration on square master more than 300mm
- Absolute calibration on gauge blocks
- Calibration of flatness on surface tables
- Calibration of level on load cell with accuracy of 2/1000
- Establishment of clean room with cleanness less than 5000

2) Mass laboratory

none

3) Volume/flow laboratory

none

4) Force/pressure laboratory

- Calibration of vacuum meter (-30mmHg or lower)
- Calibration of vacuum meter
- Calibration of RHEO meter
- Calibration of manometer
- Calibration of hardness meter

5) Temperature laboratory

- Calibration of thermocouple
- Calibration of TG meter
- Calibration of anemometer

6) Electrical laboratory

- Upgrading of calibration accuracy to 0.025% in HF (500KHz - 300 MHz)
- Calibration in HF upto 200 MHz
- Calibration of high voltage upto 10kV
- Calibration of AM/FM signal generator
- Calibration of distortion meter
- Calibration of TRK off-set meter
- Calibration of jitter meter
- Calibration of high voltage (50kV AD/DC)
- Calibration in HF upto 100MHz
- Calibration of modulated frequency
- Examination of EMC
- Calibration in HF (4.3GHz)

7) Others

- Establishment of big test chamber for 3 dimensional measurement on plastic molding products.
- Calibration of densio meter
- Calibration of pH meter
- Impact strength testing
- Calibration of vibration meter
- Calibration of vibration tester
- Calibration of gauss meter
- Calibration of color meter

Table 6-1 List of Company Survey Results

Company						Calibration of Standards			Calibration of Measuring Instruments			Requests for SIRIM Measurement Centre			
Industry	No.	ISO 9000 Status	Management System	Availability of Traceability Chart	Availability of List of Standards	Calibrated by	Frequency (times/year)	Remarks	Calibrated by	Frequency (times/year)	Remarks	No. of Requests and Accuracy Level	Calibration Time Length	Calibration Charge Level	Remarks
Electrical	1	-	○	○	○	SIRIM: 90% In-House: 10%	1	High frequency calibration conducted by parent company	-	-	Provides calibration service for clients	2	To be shortened to 2 weeks or less	Low	Wants an express calibration service
	2	-	○	○	○	SIRIM: 10 types of standards	1	16 types of standards cannot be calibrated by SIRIM	In-house	1	Twice yearly calibration of instruments related to safety	7	To be shortened to 2 weeks or less	-	Calibration charge system is unclear
	3	9002 Planned	○	○	○	Mainly SIRIM but also SISIR	1-2	Wishes to know environmental conditions required of a calibration room	SIRIM In-house	1-2	List of instruments available	None	Slow	Low	Wants an on-site calibration service; metrological terminology is not uniform
	4	-	○	○	○	SIRIM: 5 types SAMM Accredited Lab: 6 types Manufacturers: 4 types	1	Calibration cost: RM 11,882	In-house	1	List of instruments available	None	-	Half of others	Wants an express calibration service
	5	-	○	×	○	SIRIM: 10 types SISIR Manufacturers	2	Owns 36 types of standards	In-house	2	List of instruments available	None	Long	Reasonable	Wants an on-site calibration service and an express calibration service
	6	9002 Planned	○	○	○	SIRIM: 3 types Manufacturers: 13 types	1	Repair and calibration conducted by manufacturers	In-house	2	List of instruments available	5	To be shortened to around 2 weeks	-	
	7	-	○	×	○	SIRIM: SISIR Parent Company	1-2		SAMM Accredited Lab Manufacturers In-house	1	Half of the 500 instruments calibrated on-site	3	To be shortened to 2 weeks or less	Half or one-third of others	Wants a training course on calibration technologies/techniques, and a certificate in English
	8	In Preparation	○	○	○	SIRIM: 19 types SISIR Parent Company	1	Has a manual to deal with instruments out of calibration	In-house	2	Calibration engineers trained by parent company	2	-	-	Wants measures to prevent electromagnetic interference
Semi-conductor	1	9002 Planned	○	○	○	SIRIM: 5 types Manufacturers: 8 types	1	Owns 13 types of standards	In-house	2	Calibration manuals available	2	To be shortened to 2 weeks or less	Reasonable	Wants a training course on calibration technologies/techniques
	2	9002 Acquired	○	○	-	Parent Company Manufacturers SISIR	1	No calibration request made to SIRIM	In-house	1 or more	-	1	To be shortened to 10 days or less	-	Wants simultaneous return of calibrated instrument and calibration certificate
	3	In Preparation	○	×	-	SIRIM: 2 types Parent Company: 2 types	1		In-house Manufacturers	2	9 calibration engineers	5	To be shortened to 3 weeks or less	-	Wants simultaneous return of calibrated instrument and calibration certificate
	4	9002 Planned	○	○	○	SIRIM: Parent Company Manufacturers	1	Owns 8 types of standards	In-house Manufacturers	1	Calibration engineers trained by parent company	3	To be shortened to 10 days or less	-	Wants a training course on calibration technologies/techniques, certificates in English and simultaneous return of instrument and certificate
Chemical	1	-	○	×	○	SIRIM:	1	Little interest in measurement control	In-house Manufacturers	1	-	None	None	-	
	2	9002 Planned	○	×	○	SIRIM: 11 types Calibration Lab In-House	1	Owns 13 types of standards	In-house	2	-	1	To be shortened to around 2 weeks	Reasonable	
	3	In Preparation	○	×	-	-	-	No standards	Manufacturers	1-2	Few instruments in use	2	-	-	Hopes to be awarded SIRIM Mark
Machine	1	In Preparation	○	○	○	SIRIM: 13 types	1		-	-	Provides calibration service for clients	5	Long	Low	Preparing to acquire SAMM accreditation
	2	9002 Under Assessment	○	○	-	SIRIM Manufacturers	1		In-house	1	List of instruments available	2	-	-	
Automobile	1	-	○	○	○	SIRIM: 9 types SAMM Accredited Lab: 4 types Manufacturers: 4 types	1	Quarterly calibration of some standards	In-house SIRIM SAMM Accredited Lab	1	Quarterly calibration of some instruments List of instruments available	None	-	-	
Glass	1	9002 Acquired	○	×	○	SIRIM: 12 types Overseas: 1 type	1	Calibration cost: RM 3,605	In-house	2	List of instruments available; 4 calibration engineers	3	To be shortened to around 2 weeks	-	Wants certificates in English, training course on calibration technologies/ techniques and simultaneous return of instrument and certificate
Others	1	-	○	×	-	SIRIM	1		In-house	1-2	Annual audit of leading client	3	-	Reasonable	
	2	9002 Acquired	○	○	-	SIRIM SAMM Accredited Lab Manufacturers	2		In-house	2-12		1	Long	Low	
	3	9002 Under Assessment	○	×	-	SIRIM: 6 types SAMM Accredited Lab: 17 types	1-2		In-house SAMM Accredited Lab	1-2	Calibration cost: RM 30,000 - 40,000 List of instruments available	2	To be shortened to 2 weeks or less	Low	

Refer to the main text for the actual contents of the requests.

Table 6-2 Questionnaire (Check List)

FACTORY VISIT FOR CALIBRATION SERVICES

1. About the Calibration Services:
   - i) Measurement Control System : Traceability Chart
     Standards equipment →
     Measuring/Testing Equipment
   - ii) Standards Equipment : Quantities (Length, Mass, Force & Pressure, Temperature Electrical, etc)
     List of Equipment : (Name, Model, Range, Accuracy)
   - iii) Calibration for Standards Equipment :
     - a) Where : SIRIM, Foreign Country (SISIR, etc), Mother Company, Others (SAMM Lab. etc)
     - b) How many : ( ) Times/Year and Reason
       Present Situation and Future Plan
     - c) Accuracy
   - iv) Calibration for Measuring/Testing Equipment :
     - a) Where : SIRIM, Foreign Country (SISIR, etc), Mother Company, Others (SAMM Lab. etc)
     - b) How many : ( ) Times/Year and Reason
       Present Situation and Future Plan
     - c) How to : Testing Items, Number of Testing Points
       List of Equipment : (Name, Model, Range, Accuracy)

2. About the Requests/Needs for SIRIM:
   - i) Expansion of Quantities
   - ii) Upgrading of Accuracy
   - iii) Delivery-term for Calibration Services (Expected period)
   - iv) Fee of Calibration (Expected Fee)

3. About the Problems and Countermeasures

4. Observation of your Calibration Laboratory (if possible)

Table 6-3 List of Major Equipment List Owned by JVC

EQUIPMENT NAME	Q'TY	NOTE
RC Oscillator	2	
PROG. RC Oscillator	2	
Frequency Counter	1	
2ch. Oscllator	1	
Oscilloscope	2	
Distortion Meter	2	
Digital Multimeter	1	Can not be calibrated by SIRIM
Noise Meter	2	
AM/FM SSG	4	Can not be calibrated by SIRIM
AM SSG	1	
Dig. Oscillator	1	
Flutter Analyzer	1	
Freq. Counter	3	
Pattern Generator	1	Can not be calibrated by SIRIM
TRK Offset Meter	1	Can not be calibrated by SIRIM
Audio Tester	1	
Attenuator	1	
2ch. AC Voltmeter	1	
2ch. Oscilloscope	1	
Voltage Comparator	1	
LCR Meter	1	Can not be calibrated by SIRIM
Pen Recorder	1	
AC Voltmeter	4	
Stereo Scope	5	
Wow Flutter Meter	4	Can not be calibrated by SIRIM
Digimar Scope	1	Can not be calibrated by SIRIM
Jitter Meter	1	Can not be calibrated by SIRIM
2ch. Wow Flutter	1	
Wide Band W/Flutter	1	Can not be calibrated by SIRIM
Universal Counter	1	
Digital Meter	1	
DC Current Meter	3	
AC Current Meter	4	
Watt Meter	1	
Insulation Tester	2	
W/I Auto Tester	1	
H.V. Voltmeter	1	
Prog. Oscillator	1	
DC Millivolt Meter	1	Can not be calibrated by SIRIM
2ch. Auto Dist. Meter	1	Can not be calibrated by SIRIM
2ch. AC Voltmeter	1	
FET Analyzer	1	

Table 6-4 List of Major Standards and Equipment Owned By INNOPOWER

Class	Standard Instrument	Calibration Period
1	AC Current/Voltage Generator	1 year
	Thermo-Recorder	1 year
	Multimeter	1 year
	Multimeter	1 year
	STD Weight Block	1 year
	Gauge Block	1 year
	Resistance 100 MΩ	1 year
	HV Digital Meter	1 year
Class	**Sub-Standard Instrument**	**Calibration Period**
2	Resistance Box	6 months
Class	**Critical Instrument**	**Calibration Period**
3	Withstanding Voltage Tester	6 months
	Resistance Box	6 months
	Insulation Tester	6 months
	Digital Meter	1 year
	Resistance 100 MΩ	1 year
	Wheatstone Bridge	1 year
Class	**Non-Critical Instrument**	**Calibration Period**
4	Analog Volt/mVolt/A/mA Meter	1 year
	Withstanding Voltage Tester	1 year
	Temperature Controller	1 year
	Multimeter	1 year
	Super Mega Ohm Tester	1 year
	Oven	1 year
	Thermo Recorder	1 year
	Resistance Box	1 year
	Load Resistor	1 year
	Dig. AC Meter	1 year
	Graph Plate	1 year
	Push Pull Scale	1 year
	Micrometer	1 year
	Caliper	1 year
	Digital Thermometer	1 year
	Height Gauge	1 year
	Tension Gauge	1 year
	Humidity Thermometer	1 year
	AVM	1 year
	Digital Panel Meter	1 year

Table 6-5 List of Standards Owned by CRYSTAL

Standard Name	Q'ty	Calibrated By
Measuring Receiver	1	Maker in Singapore
Sensor Module	1	Maker in US
Audio Analyzer	1	Maker in Malaysia
Multimeter	1	Maker in Malaysia
Oscilloscope	1	SIRIM Penang
Power Supply Tester	1	SIRIM Penang
Wow Flutter Calibrator	1	SIRIM Penang
Q-Meter	1	SIRIM Penang
Variable Attenuator	1	SEEL in Singapore
Digital Multimeter	1	SIRIM Penang
Universal Bevel Protector	1	NUSANTARA in KL
Digimatic Height Gauge	1	NUSANTARA in KL
Dial Test Indicator	1	NUSANTARA in KL
Granite Surface Plate	1	NUSANTARA in KL
Digital Torque Meter	1	Maker in Malaysia
Digital Tension Gauge	1	SEEL in Singapore

Table 6-6 List of Equipment Owned by CRYSTAL

Standard Name	Q'ty
AC Voltmeter	5
Digital Multimeter	1
Multimeter	4
Frequency Counter	2
RDS Counter	1
Distortion Meter	1
Audio Generator	3
FM/AM Signal Generator	2
AM Signal Generator	1
ARI Signal Generator	1
Stereo Modulator	3
Pulse Noise Generator	2
IF Genescope	1
IF Sweepscope	1
Oscilloscope	2
DC Power Supply	7
Standard Amplifier	1
Antenna Dummy Box	1
BTL Dummy Box	1
Wow & Flutter Meter	2
BTL Adaptor	1
PLL Controller	1
Attenuator	1
Power Supply Tester	1
Audio Analyzer	1
Measuring Receiver	1
Sensor Module	1
Wow & Flutter Calibrator	1
Q Meter	1
LCR Meter	1

Table 6-7 List of Standards Owned by SHARP

Standard Name	Specification	Q'ty
1. PRIMARY STANDARD		
Integrated Digital Multimeter	0.0005%	1
High Voltage Meter	0-2 kV, 0.1%	1
Cut-off Current	0-10 A, 0.1%	1
2. SECONDARY STANDARD		
Standard Resistors	0.1,1,10k,1MΩ, 0.005%	4
Wheatstone Bridge	0.1-100 MΩ, 0.01%	1
Decade Resistance Box	0-111.1110 MΩ, 0.01%	1
Decade Resistance Box	0-111.110 MΩ, 0.05%	1
DC Shunt	0.005%	1
DC Voltage STD Shunt	1000 mV-1000 V, 0.005%	1
DC Current STD Shunt	100 mA-30 A, 0.01%	1
Deviation Unit	0.5 %-3 %, 0.01%	1
Current Transformer	0.5 A-100 A, 0.01%	1
AC Voltage/Current STD Unit	20 A/3, 0.05%	1
Multifunction Synthesizer	0.08%	1
Digital Power Meter	3-600 V,0.1-30 A, 0.1 %	1
Digital Power Meter	0-300 V, 0-30 A, 0-300 W	1

Table 6-8 List of Equipment Owned by SHARP

Equipment Name	Specification	Q'ty
Insulation Tester	0-200MΩ, 0.5%	
Digital Multimeter	200mV-200V,200mA-10A,	
	200-20M Ω, 0.5%	
DC Volt-Ammeter	1mA-10A,3mA-30A,	
	50mV-100V, 0.5%	
AC Voltmeter	0.15V,0-300V, 0.5%	
AC Ammeter	0.25A,0-25A, 0.5%	
AC Volt-Ammeter	0.15-3A,7.5-30A,30-750V	
AC 1Ph Wattmeter	0-120W, 0.5%	

Table 6-9 List of Major Equipment Owned by SONY

(Those which are calibrated by SIRIM)

Equipment Name	Q'ty	Calibrated Frequency
Oscilloscope	1	1 year
Digital Wattmeter	1	1 year
High Volt Digital Meter	1	1 year
Sweep Generator	1	1 year
Sweep Oscillator	1	1 year
Stop Watch	2	1 year
Steel Ruler	3	1 year
Push Pull gauge	5	1 year
Electronic Counter	1	1 year
Gauge Block Set	1	1 year
AC Millivoltmeter	1	1 year

Table 6-10 List of Equipment Owned by MELCOM

Standard Name	Specification	Q'ty	Calibration
1. MECHANICAL			
Gauge Block	0.5-200 mm	2	SIRIM
Optical Parallel	12.00-12.37 mm	2	
Optical Flat	45 mm	2	
Caliper Checker	10-300 mm	1	SIRIM
Calibration Checker	0-25 mm	1	SIRIM
Pin Gauge	3.4-5.6 mm dia.	2	
Ring Gauge	10-4 5mm dia.	1	
Granite Table	3 μm flatness	2	
Height master	310 mm	1	SIRIM
Standard Weight	1 g-20 kg	2	SIRIM
Torque Driver Tester	0-100 kgf	1	JAPAN
Pressure gauge Tester	50 kgf/cm	1	
Digital Weight Machine	5000 g	1	
2. Electrical			
Standard Ammeter	20/50/100/200 mA	1	
Standard Voltmeter	150/300 V	1	
Potential Transformer	3300/2200/440/220 V	1	
Decade Resistance Box	111.110 MΩ	2	SIRIM
AC Voltage/Current STD	1 mV-1200 V, 1 mA-60 A	2	SIRIM
Power Meter	12 kW	1	SIRIM
Digital Multimeter	6 1/2 digit	2	SIRIM
Fluke Calibrator	1100 V, 2 A, 100 MΩ	1	SIRIM
Digital Power Factor Meter	1-10 A, 240, 480 V	1	
RC oscillator	15 Hz-109.9 kHz	1	SIRIM
Phase Shifter	0-360	1	SIRIM
Oscilloscope Calibration STD		1	SIRIM
DC Calibration STD		1	SIRIM
Portable Calibrator		1	
Digital Thermometer	6 1/2 digit	1	SIRIM

Table 6-11 List of Standards Owned by HITACHI

Standard Name	Q'ty	Calibrated By
Calibrator	1	SIRIM
DC Voltage Current STD/voltage Unit	1	
Digital Thermometer	1	
Universal Counter	1	
Decade Resistor	3	SIRIM
Time Maker Generator	2	
Calibration Generator	2	
Oscilloscope	1	
Psychrometer	1	SIRIM

Table 6-12   Specification of Standards Owned by TOSHIBA

Equipment	Range	Accuracy	Traceable
DC Voltage	0-1200 V	±0.005%	Supplier
DC Current	0-36 A	±0.005%	Supplier
AC Voltage	0-1200 V	±0.008%	Supplier
AC Current	0-60 A	±0.008%	Supplier
Resistance	0-111 MΩ	±0.005%	Supplier
Frequency	10 Hz-3 GHz	±0.001%	Supplier
Weight	1 mg-10 kg	class F1	SIRIM
Length (Gauge Block)	1.001-100 mm	Grade 0	SIRIM
Temperature	-80℃-+1500℃		SIRIM

Table 6-13 List of Standards Owned by USRA

Equipment Name	Range	Accuracy	Calibration
Digimatic Micrometer	0-25 mm	1 μm	SIRIM
Digimatic Vernier Caliper	0-150 mm	0.01 mm	SIRIM
Vernier Caliper	0-300 mm	0.02 mm	SIRIM
Vernier Caliper	0-150 mm	0.02 mm	SIRIM
Vernier Caliper	0-150 mm	0.05 mm	SIRIM
Vernier Caliper	0-150 mm	0.02 mm	SIRIM
Micrometer	0-25 mm	1 μm	SIRIM
Height Gauge	0-300 mm	0.01 mm	SIRIM
Electronic Platform Scale	0-3 kg		EMEC
Vernier Caliper	0-1000 mm	0.05 mm	SIRIM
Radius Gauge	0.5-13 mm		
Granite Surface Table	36"x36"x4"		
Vernier Caliper	0-600 mm	0.02 mm	SIRIM
Vernier Caliper	0-600 mm	0.02 mm	SIRIM

Table 6-14 List of Standards Owned by SANKYO

Standard Name	Q'ty	Calibration Period
Microscope	1	12 months
Dial Gauge (0.01-10mm)	1	12 months
Dial Gauge (0.01-10mm)	1	12 months
Dial Gauge (0.01-3mm)	1	12 months
Dial Gauge (0.01-10mm)	1	12 months
Micrometer	1	12 months
Digimatic Caliper	1	12 months
Balancing (2000g)	1	12 months
Balancing (2000g)	1	12 months

Table 6-15 List of Equipment Owned by PROTON

Equipment Name	Q'ty	Calibration
12V Battery Tester	1	AIROD
3-Dimensional Measuring Tester	1	Instrument Maker
3 Function Type Gauge	2	AIROD
AC/DC Volt Amp. Tester	1	Instrument Maker
Accelerometer	9	Instrument Maker
Air Micrometer	5	Instrument Maker
Ammeter	10	
Aneroid Barometer	4	AIROD
Belt Tension Gauge	5	
Block Gauge Set	7	
Brake Force Tester	4	
Brinell Hardness Tester	1	
Calibration Exiter	1	
Cam Angle Tacho Tester	6	
Camber Level Meter	2	
Charge Amplifier	2	
Chassis Dynamometer	1	
Compound Gauge	1	SIRIM
Compression Gauge	4	
Conductivity Meter	1	
Control Meas. Instrument	1	
Cylindrical Square	2	
Dial Comparator	4	
Dial Gauge Tester	3	
Derth Micro Checker	1	
Digital Engine Analyzer	2	
Digital Engine Tachometer	1	
Digital Multimeter	3	
Digital Pressure Gauge	1	SIRIM
Digital Thermometer	4	
Digital Weight Balance	4	
Drum Tester	1	
Dynamic Alignment Tester	1	
ECI Checker	1	
Elcometer	1	
Electronic Balance	1	
Engine Dynamometer	2	
Engine Leak Tester	1	
Engine Tachometer	2	
Exhaust Analyzer	2	
Force Appliance Gauge	1	
Frequency Voltage Converter	1	AIROD
Fuel Flow Pulse Detector	2	Instrument Maker
Fuel Flow Meter	7	Instrument Maker
Fuel Flow Sensor	2	Instrument Maker
Fuel Flow Tranducer	3	Instrument Maker
Fuel SG Meter	1	
Gasoline Engine Tachometer	5	
Gear Oven	1	
Gloss Meter	1	
GO & NOT GO Gauge	28	
Granite Surface Plate	12	

Table 6-15 List of Equipment Owned by PROTON (Cont'd)

Equipment Name	Q'ty	Calibration
Hand Digital Tachometer	2	
Hand Held Radar Gun	1	
Handy Master Scanner	2	
Hardness Tester	1	
Headlight Tester	2	
Height Master	2	
HI-Q-Qualimetric	3	
Humidity/Temp. Sensor	1	
Hunter Opt. 4 Wheel Alignment	1	
Impact Hammer	2	
Intake Vacuum Gauge	1	SIRIM
Intergation Sound Level Meter	1	
K/J Thermometer	3	SIRIM
Layout Machine	2	
LCR Meter	2	
Main Body Inspection Machine	1	
Manometer	4	
Manostar	2	
Measuring Amplifier	1	
Measuring Cylinder	3	SIRIM
Mega Ohm Tester	1	
Micro Hardness Tester	1	
Milliammeter	1	
Multitester	3	
Non-Contact Sppedmeter	4	
Nut Runner	1	
Oil Temperature Gauge	3	SIRIM
Oscilloscope	1	
Ozone Weathering Meter	1	
Permascope Thickness Meter	1	
Pin Gauge Set	6	
Piston Gauge	1	
Plug Gauge	3	
Pocket Digital Thermometer	1	
Portable Hybrid Recorder	4	
Precision Balancer	1	
Pressure Gauge	9	SIRIM
Profile Projector	1	
Psychrometer	6	
Pull Push Gauge	25	
Regulated DC Power Supply	1	
Ring Gauge	54	
Riser Block	1	
Rockwell Hardness Tester	1	
Roundness Tester	1	
RPM Meter	1	
S&M Color Computer	1	
Surface Roughness Tester	1	
Safety Oven	1	
Salt Spray Test Machine	1	
Side Slip Tester	1	
Sound Intensity Analyzer	2	

Table 6-15 List of Equipment Owned by PROTON (Cont'd)

Equipment Name	Q'ty	Calibration
Sound Level Calibrator	2	
Sound Level Meter	10	
Speed Meter	2	
Sprit Level	1	
Spotron Force Gauge	17	
STD Fade Meter	1	
STD Sunshine Weather Meter	1	
STD Weight Set	6	
Stop Watch	7	
Stroboscope	1	
Surface Texture	1	
Temp. Controller & Thermocouple	14	SIRIM
Temp. Controller Water Bath	1	
Theodolite	5	
Thermometer	4	
Timing Belt Tension Gauge	2	
Timing Light	6	
Torque Checker	9	
Tracking Filter	1	
TSK Roncom	1	
Turning Angle Tester	1	
Tyre Balancing Machine	3	
Tyre Pressure Gauge	1	
Ultrasonic Thickness Tester	1	
Uniformity Matching Machine	1	
Universal Counter	2	
Universal Testing Machine	1	
V-Belt Tension Gauge	2	
Vacuum Pump Gauge	1	
Vapour Lock Indicator	1	
Vibration Meter	2	
Vickers Hardness Tester	2	
Volt Meter	1	
Water Temperature Gauge	1	SIRIM
Weighbridge	3	
Weld Tester	3	
Wheel Aligner	1	
pH Meter	1	

Table 6-16 List of Standards Owned by MSG

Equipment Name	Specification	Calibration	
		Frequency	Organization
Block Gauge	1.25-20 mm	1 year	SIRIM
Standard Weight	1-500 g	1 year	SIRIM
Standard Scale	1 m	1 year	SIRIM
Standard Measuring Tape	2 m, 5 m	1 year	SIRIM
Digital Temperature Controller		1 year	SIRIM
Resistance Box		1 year	SIRIM
Digital Timer		1 year	SIRIM
DC Volt Generator		1 year	SIRIM
DC Voltage Current Standard		1 year	SIRIM
Standard Weight	1 mg-10 kg	1 year	SIRIM
Standard Weight	20 kg	1 year	SIRIM
Thickness Gauge	0.01-0.16 mm	1 year	SIRIM
Haze Standard Plate		1 year	JAPAN

Table 6-17 List of Equipment Owned by INAX

Equipment Name	Specification	Accuracy	Q'ty	Calibration Frequency
1. Raw Material Section				
Scale	25-1500 kg	±0.5	8	6 months
Air Pressure Regulator	10 kgf/cm²	±0.5	6	12 months
2. Mould Section				
Scale	60-300 kg	±0.2	2	6 months
Thermometer	40℃	±2.0	1	12 months
Temperature Controller	100 ℃	±5 ℃	1	12 months
Thermocouple	100 ℃	±5 ℃	1	12 months
Vacuum Gauge	30 cmHg	±0.2	2	6 months
3. Casting Section				
Humidity Controller		±5%	1	12 months
Air Pressure Regulator	10 kgf/cm²	±0.52	62	12 months
Thermocouple	100 ℃	±5 ℃	14	12 months
Temp./Humidity Recorder		±5%	3	12 months
4. White Body Dryer Section				
Temperature Controller	100 ℃	±5 ℃	8	12 months
Humidity Controller	100 ℃	±5 ℃	1	12 months
Oven Temp. Controller		±5 ℃	1	12 months
Temp. Controller		±5 ℃	1	12 months
5. Grazing Section				
Scale	30 kg	±0.3	4	6 months
Air Pressure Regulator	10 kgf/cm²	±0.5	18	12 months
6. Firing Section				
Temperature Controller	1800℃	±10.0	32	12 months
7. Final Inspection Section				
Air Pressure Regulator	10 kgf/cm²	±0.5	7	12 months
Water Pressure Regulator	4 kgf/cm²	±0.2	1	12 months
8. Laboratory				
Viscometer	500 000 cP	±100	3	6 months
Pressure Gauge		±0.1%	1	12 months
pH Meter	12 pH	±0.5	1	12 months
Hardness Meter	5 mm	±0.1	2	6 months
Temperature Recorder	1200-1600 ℃	±10.0	2	12 months
Electric Oven	150-200 ℃	±2.0	2	12 months
Thermal Expansion	1200℃	±1.0	1	12 months
Scale	2 kg-10 kg	±1.0	3	6 months
Vibra Scale	1200 kg	±0.5	2	6 months

Fig. 6-1 Traceability Chart (1) (YOKOGAWA)

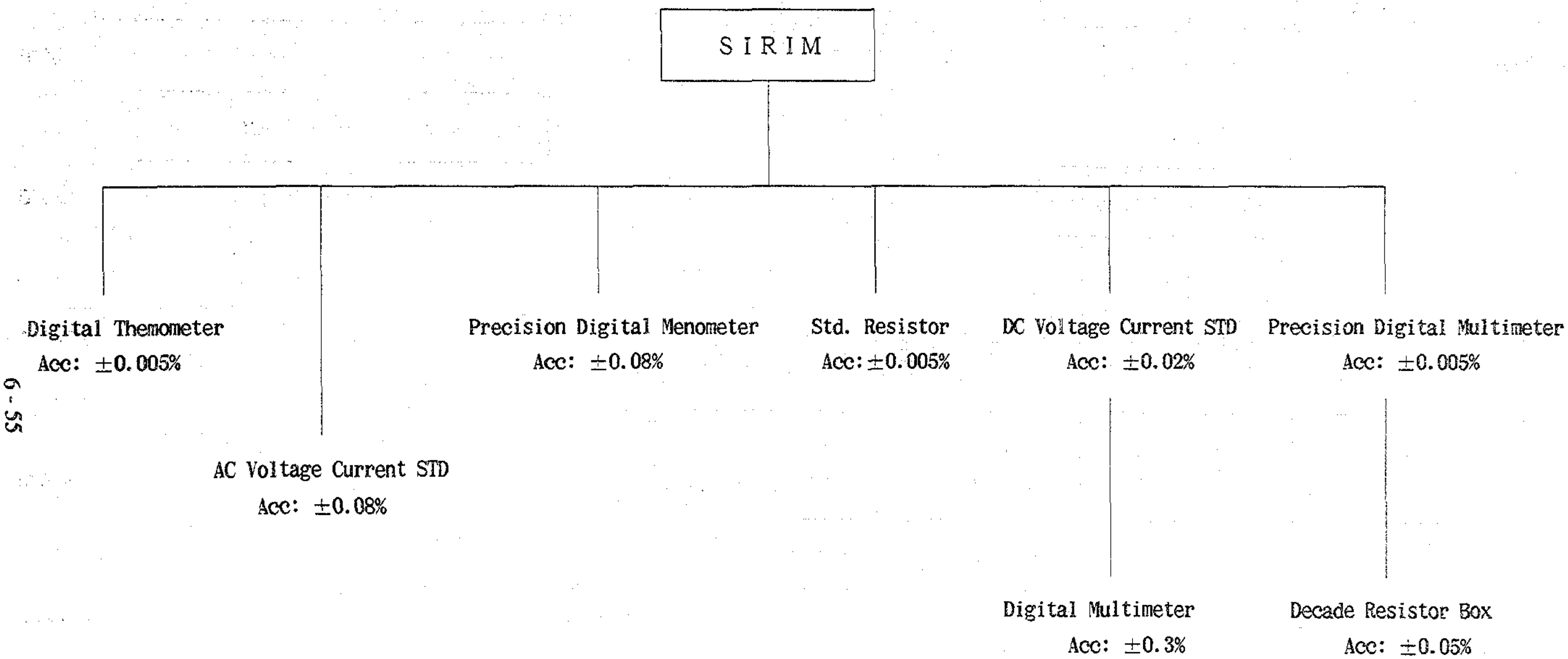


Fig. 6-2 Traceability Chart (2) (YOKOGAWA)

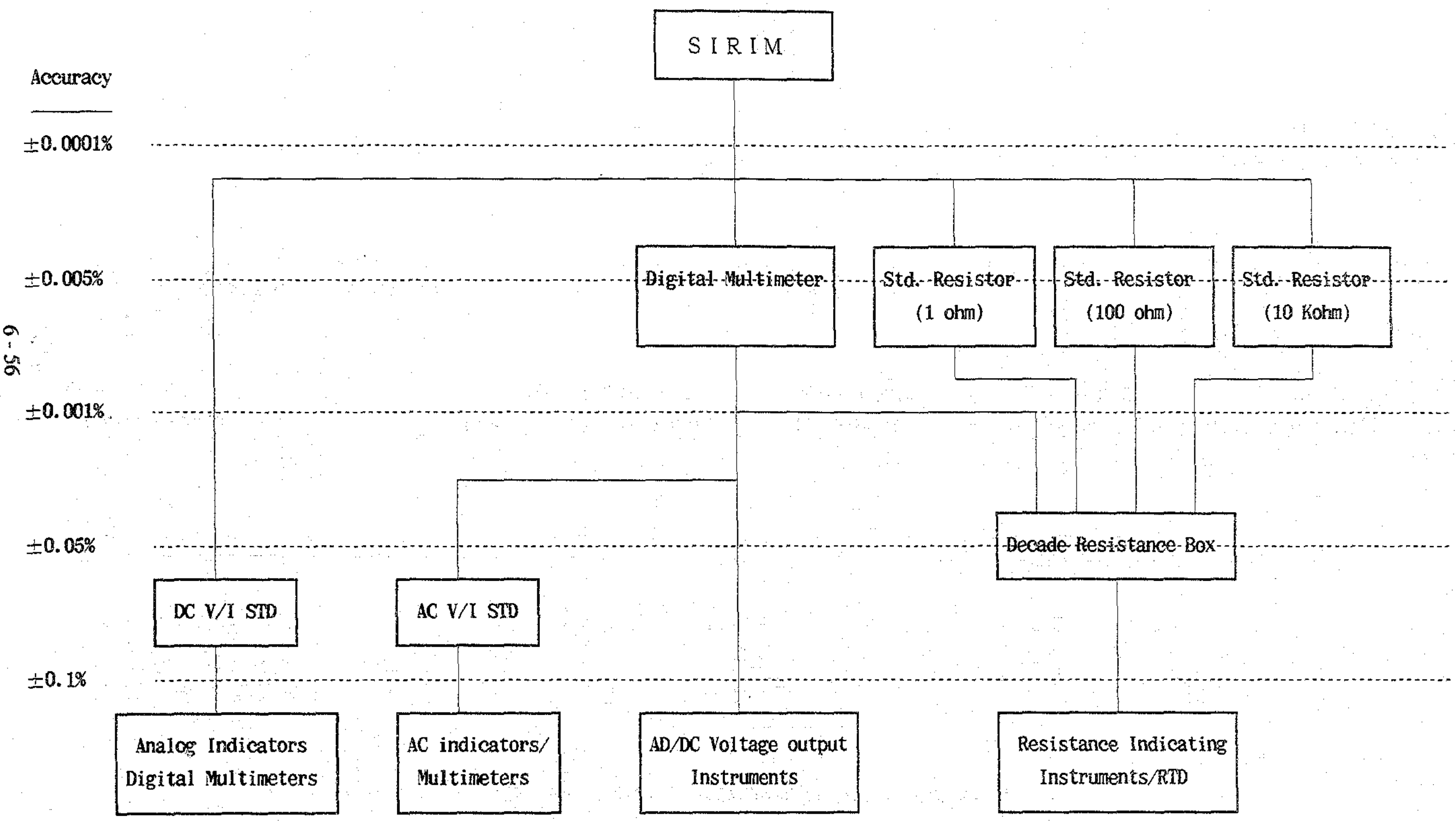


Fig. 6-3 Traceability Chart (1) (J V C) - Mechanical

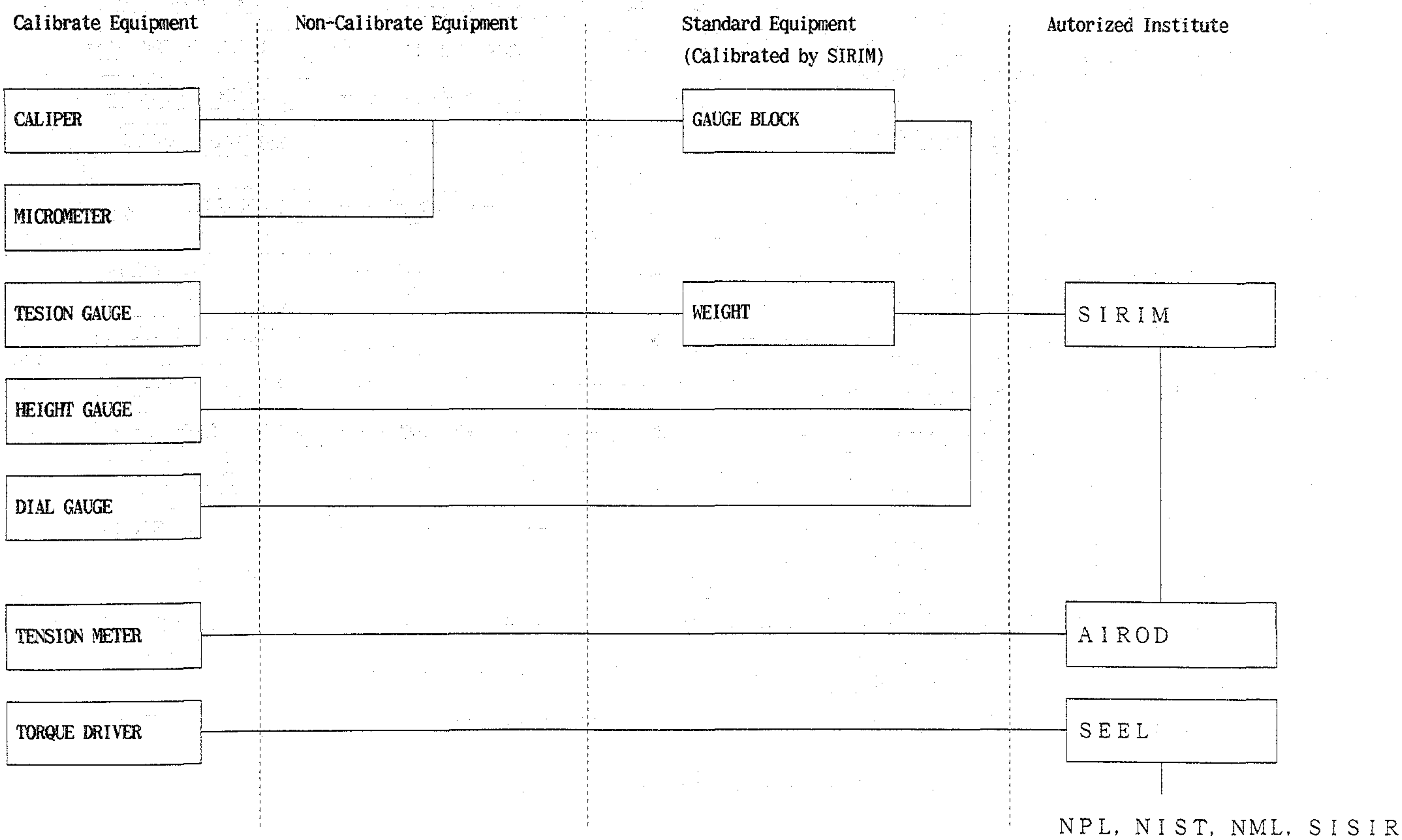


Fig. 6-4 Traceability Chart (1) (J V C) - Electrical

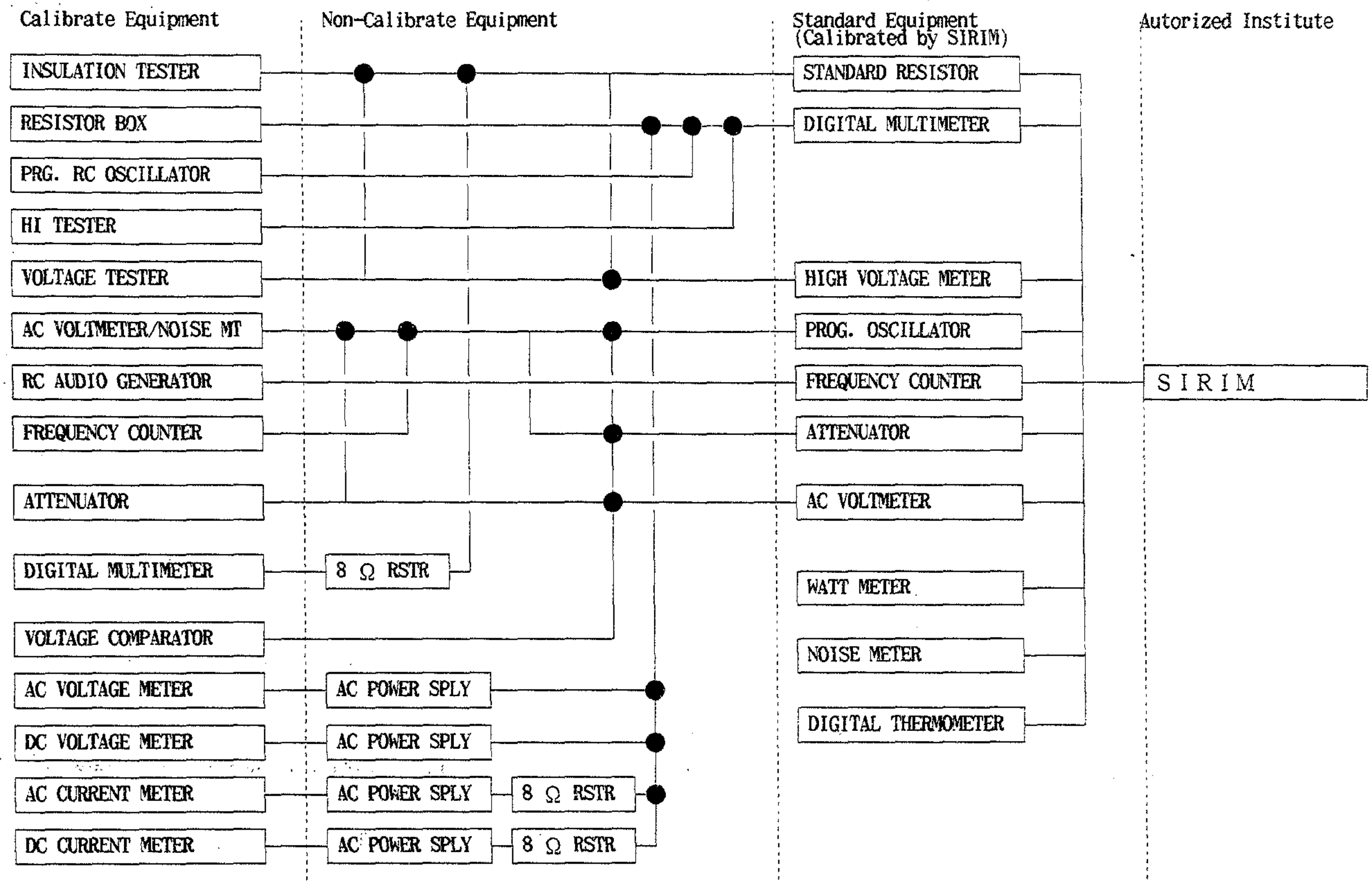


Fig.6-5(a) Traceability Chart (INNOPOWER) - Mechanical

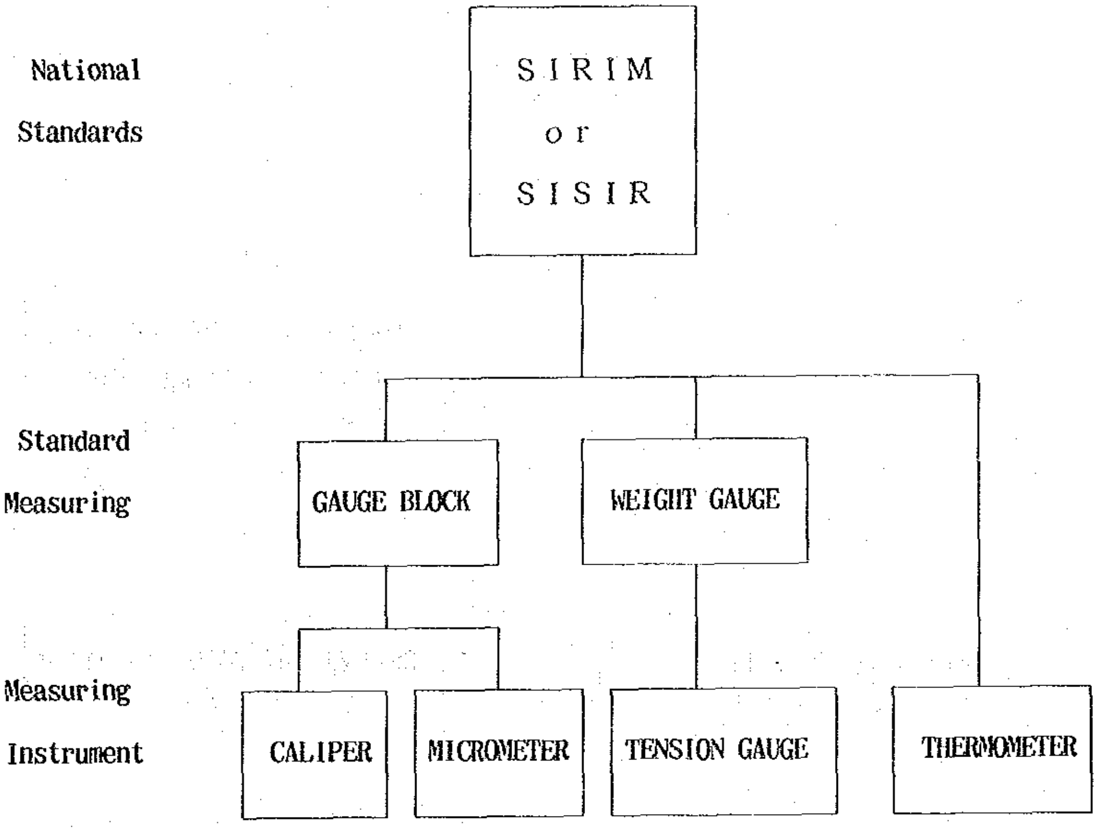


Fig.6-5(b) Traceability Chart (INNOPOWER) - AC Current

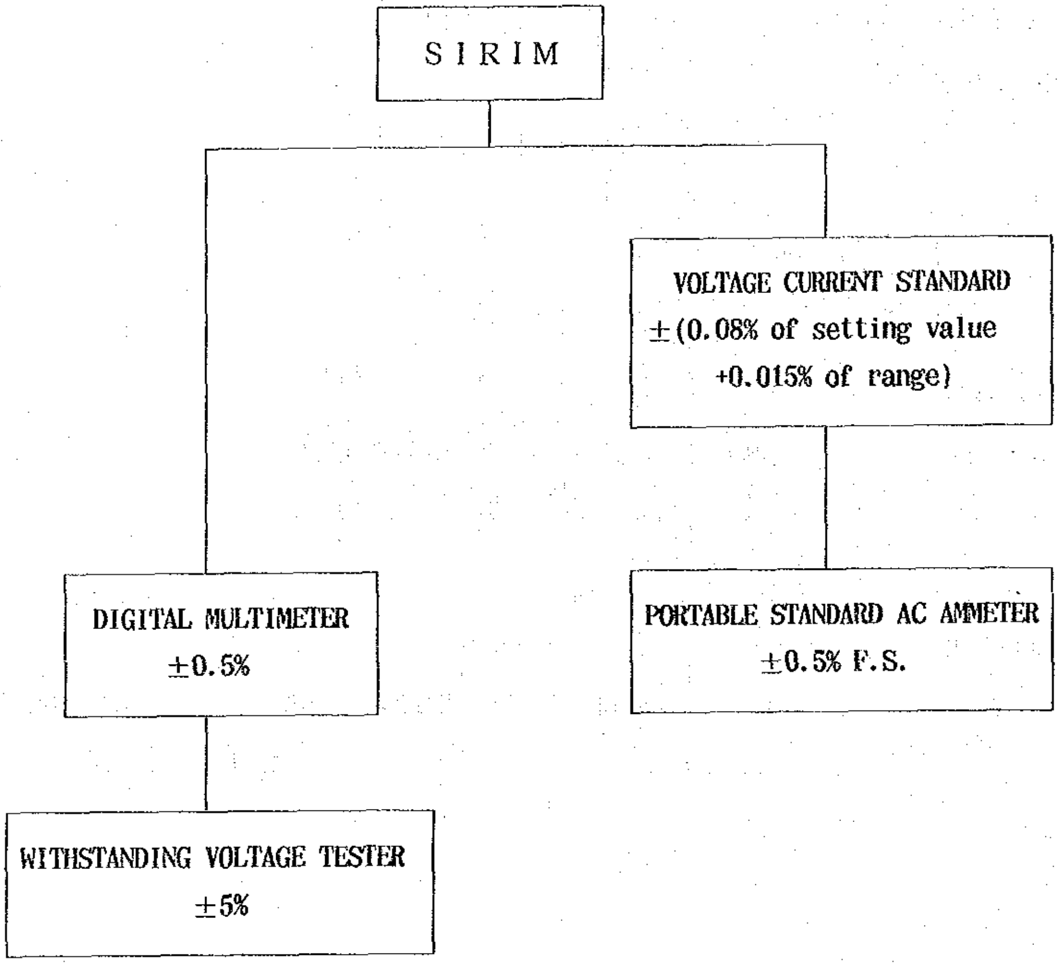


Fig.6-5(c) Traceability Chart (I N N O P O W E R) - AC Voltage

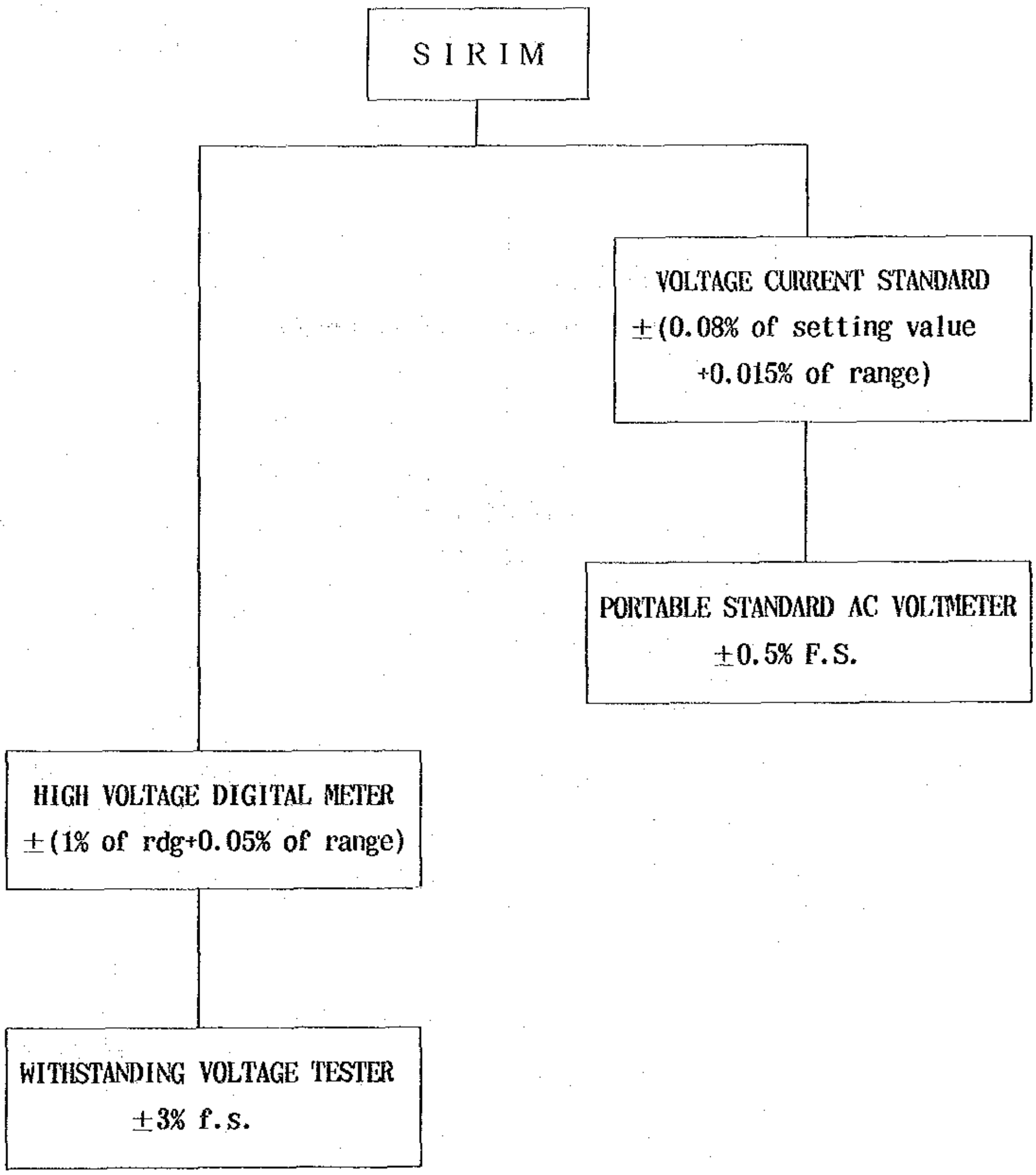


Fig. 6-5(d) Traceability Chart (INNOPOWER) - DC Voltage

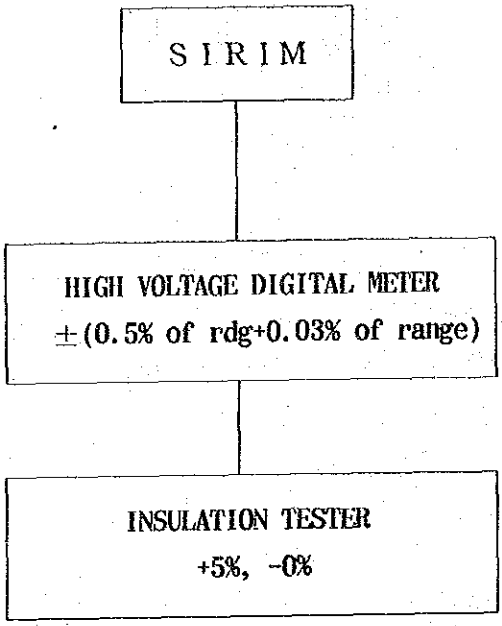


Fig.6-5(d) Traceability Chart (INNOPOWER) - Resistance

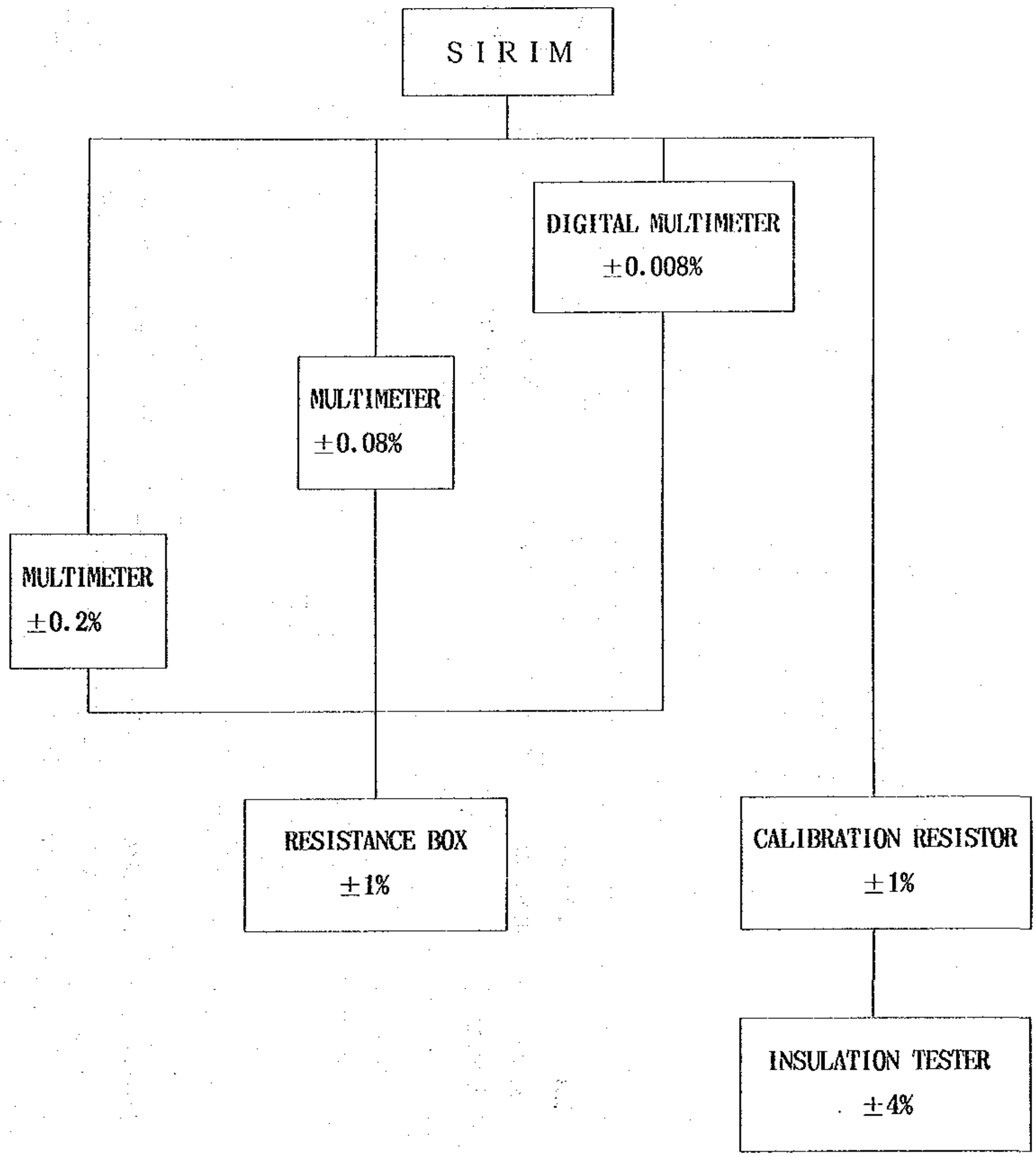


Fig.6-6 Traceability Chart (CRYSTAL)

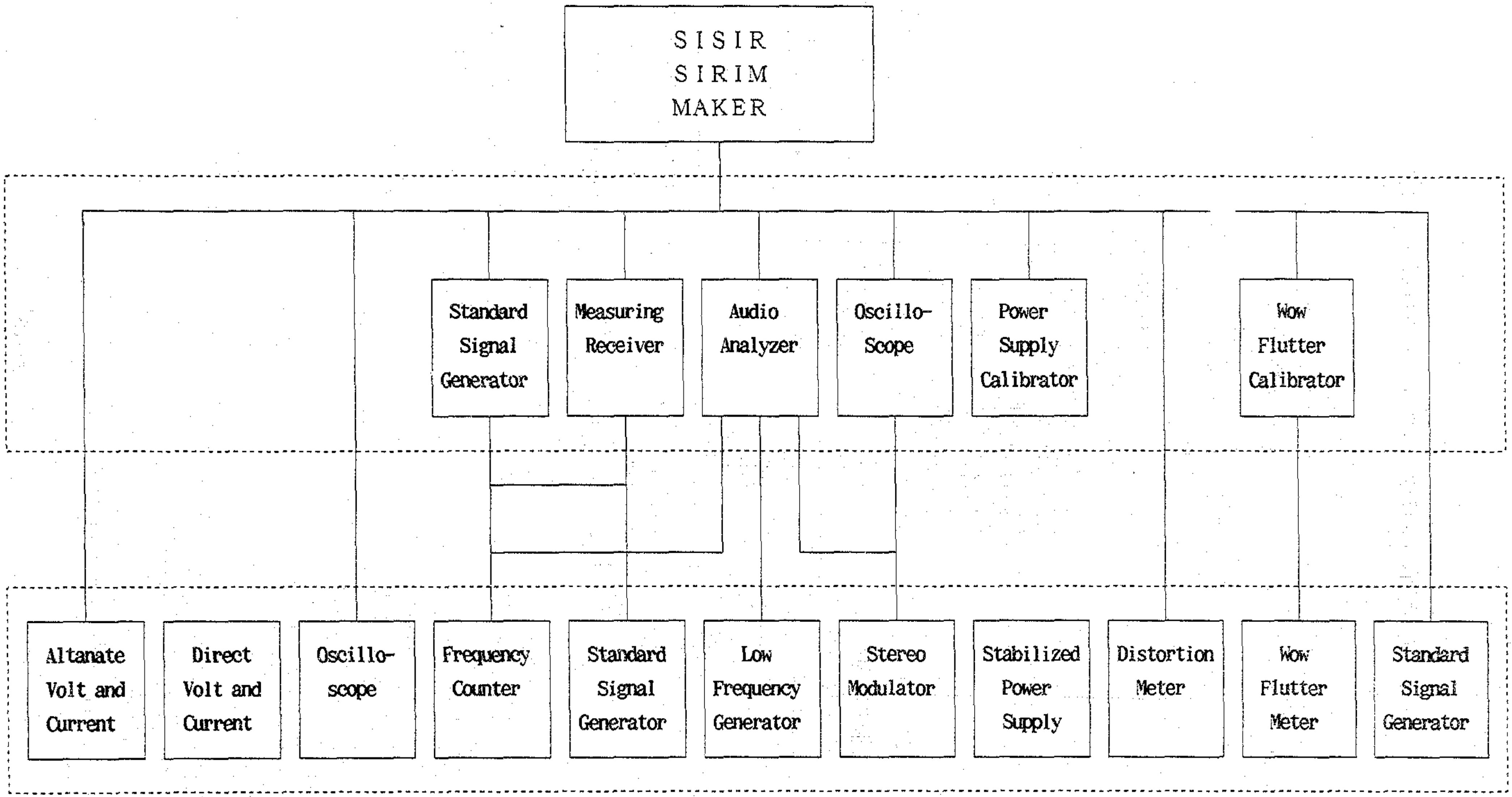


Fig.6-7(a) Traceability Chart (SHARP) - Resistance

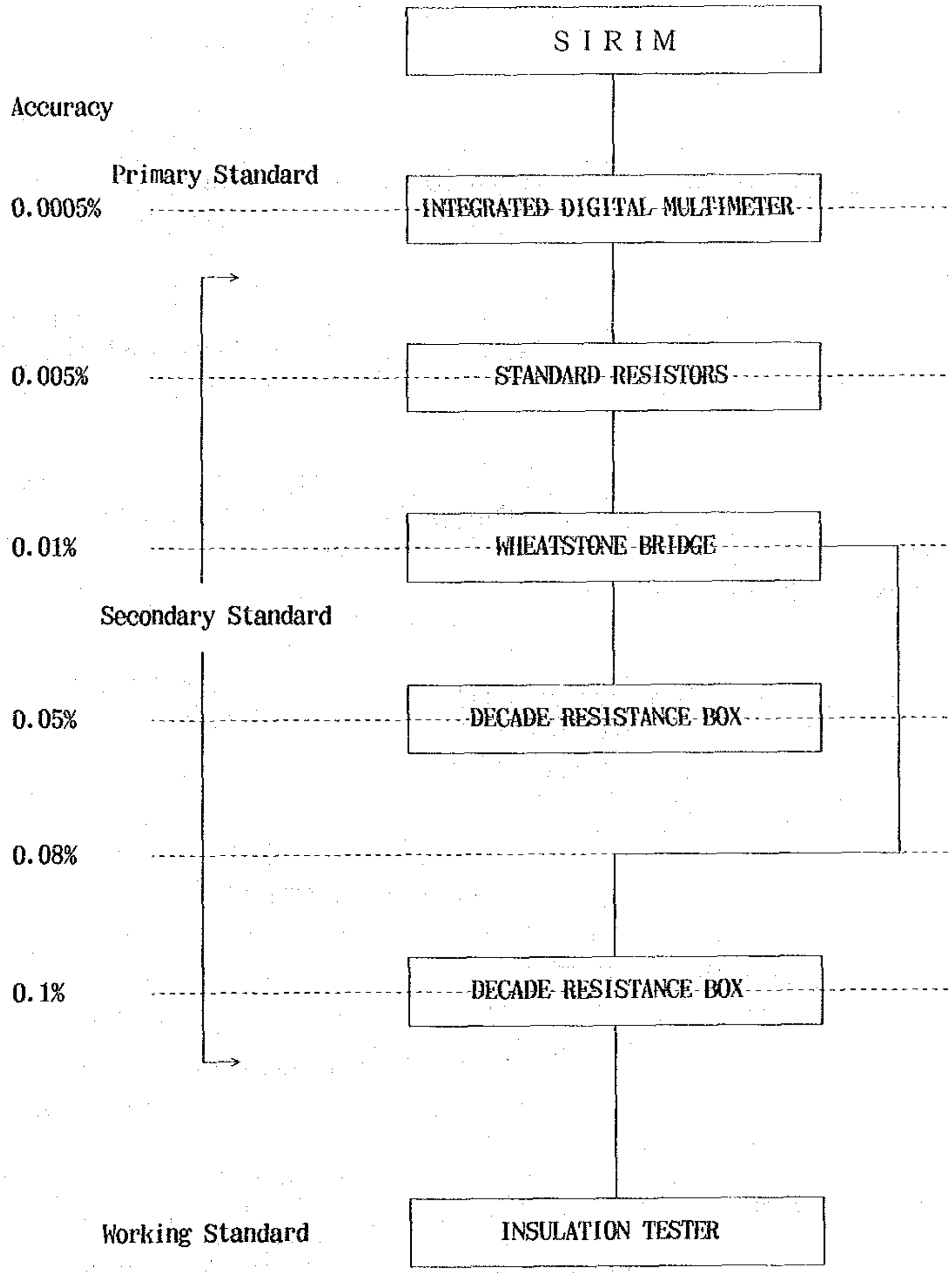


Fig.6-7(b) Traceability Chart (SHARP) - DC Voltage and Current

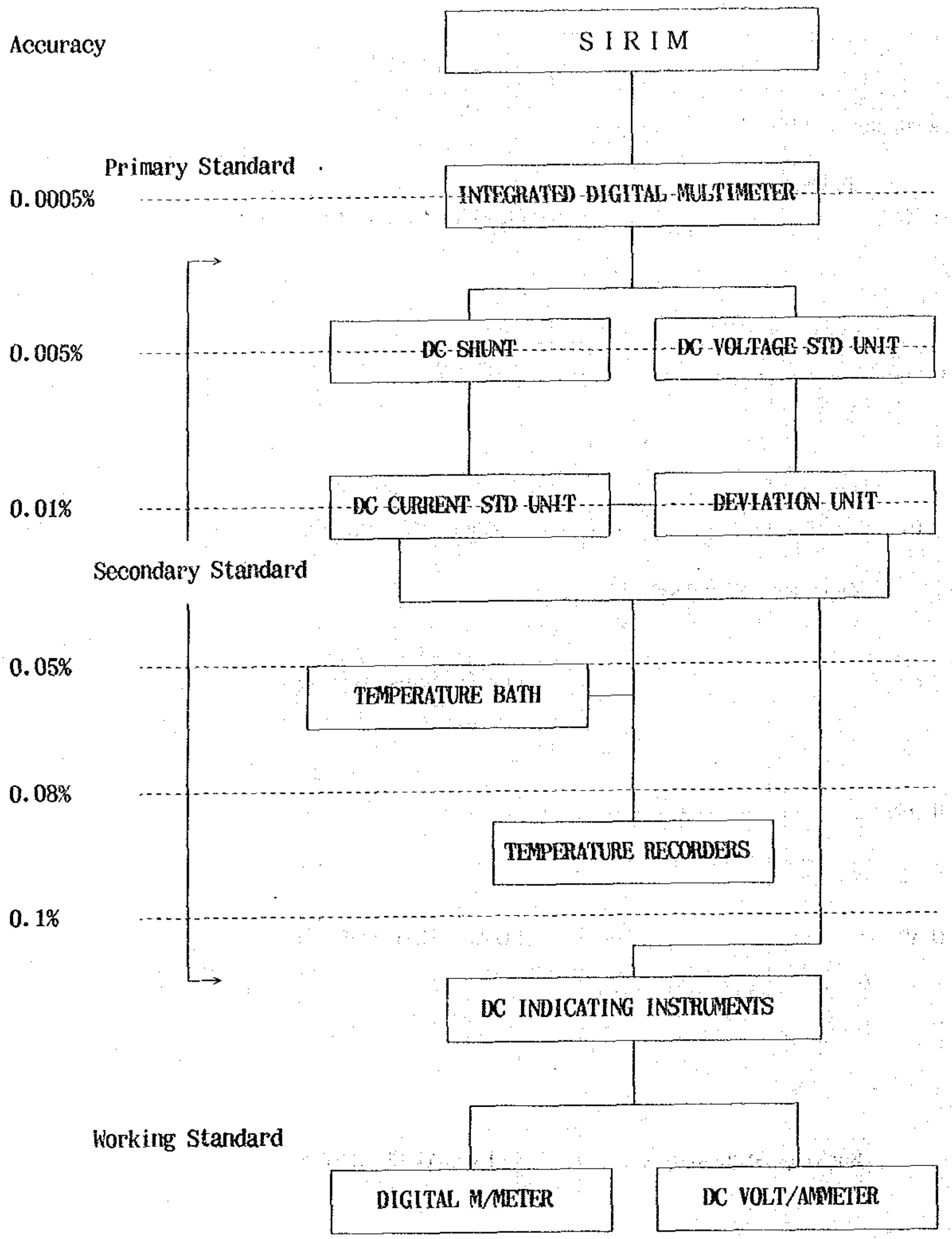


Fig.6-7(c) Traceability Chart (SHARP) - AC Voltage, Current and Power

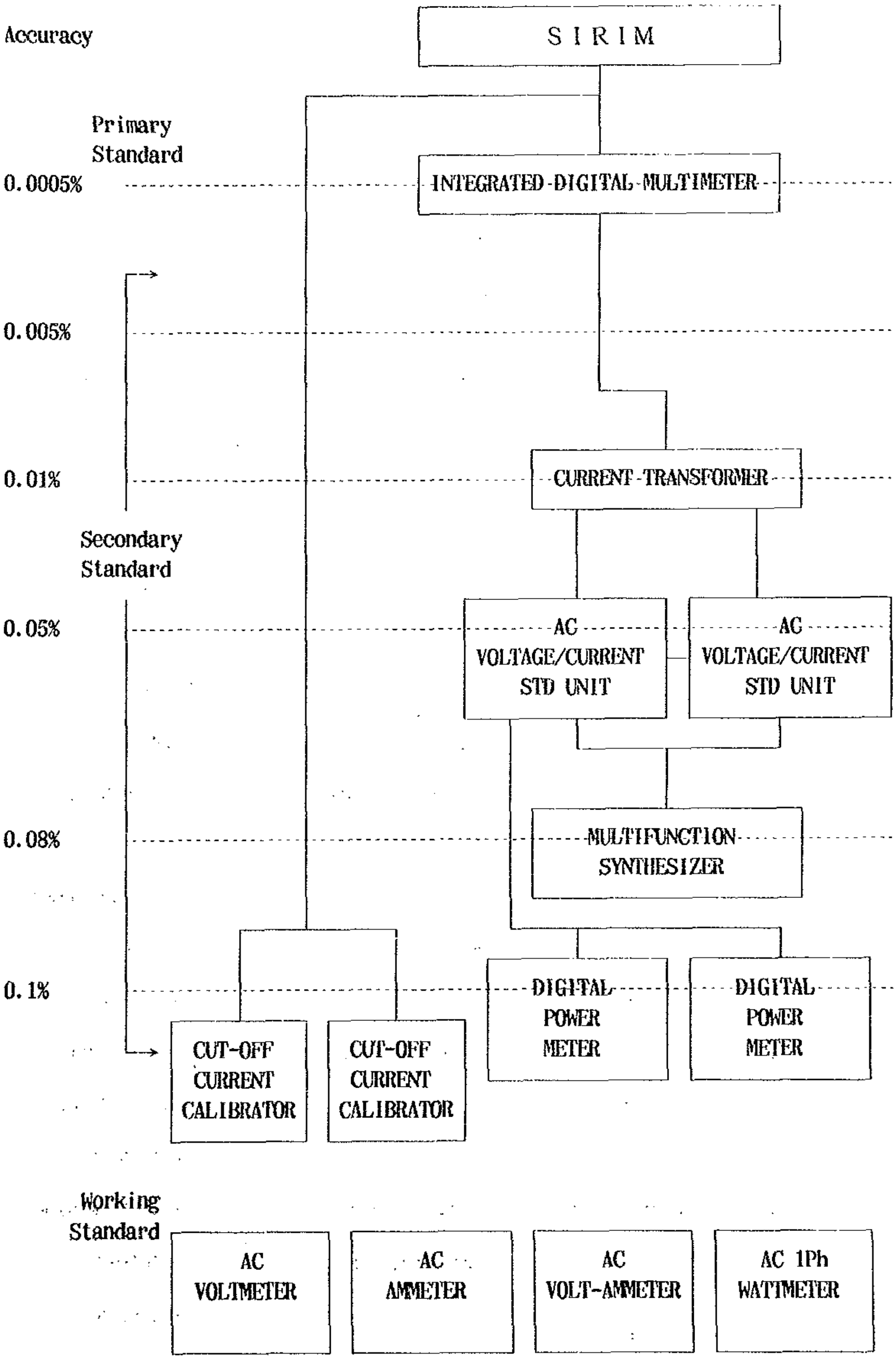
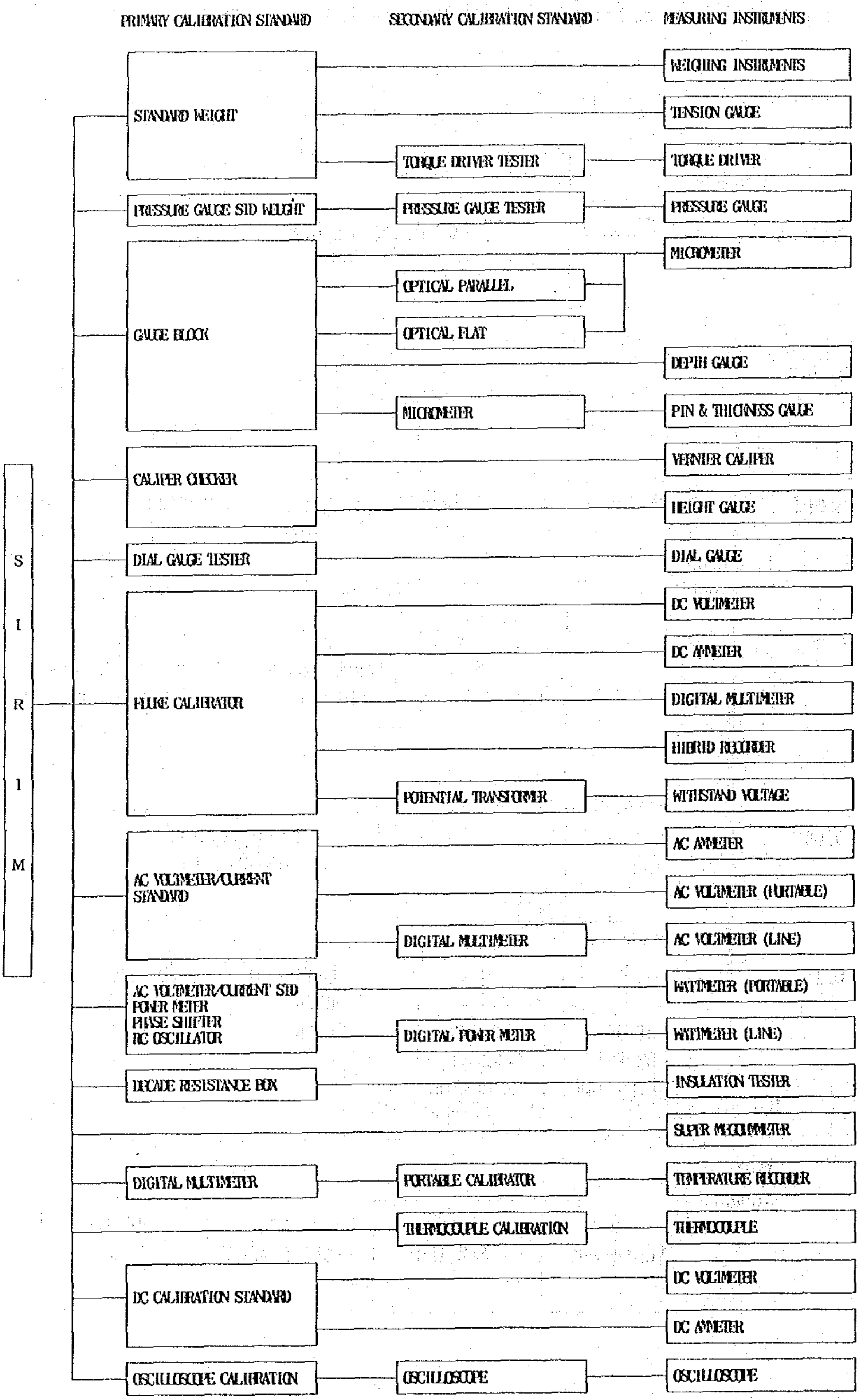


Fig. 6-8 Traceability Chart (MELCOM)



CHAPTER 7

PROPOSAL FOR UPGRADING SIRIM MEASUREMENT CENTRE

7. PROPOSAL FOR UPGRADING SIRIM MEASUREMENT CENTRE

This Study is intended to investigate the social role which a national metrology system should play today from a versatile standpoint and to propose a upgrading plan of the SIRIM Measurement Centre, the core of the national metrology system, in as concrete forms as possible. To bring our proposal into practice, it is necessary to make sufficient discussions with the parties concerned in Malaysia about the basic principles. For this purpose, we have submitted a progress report at the final stage of our field survey, and in this progress report we showed the basic concepts of the upgrading plan and asked Malaysian counterparts to state opinions about corrections and demands.

Such opinions and demands have been reflected upon the practical and executable details of the upgrading plan described in this chapter. However, the conditions for achieving the upgrading plan include many indefinite matters. Thus, it is necessary to review and revise the details described in this chapter according to further progress of the circumstances.

7.1 Establishment of National Metrology Committee

7.1.1 Aim of this proposal

Many countries adopt engineering and technical regulations based on the laws in order to secure people' safe lives and to maintain the economical order properly. Many of such regulations require unified engineering and technical specifications concerning metrology and measurement for their enforcement. As described in Chapter 3 "Measurement System and Technical Regulation," our study proved that several sections and departments take charge of establishing and enforcing most of the engineering and technical regulations independently in Malaysia but do not make efforts to examine the standards and technologies of metrology from a versatile standpoint or to establish unified metrological and technical standards or rules. They adopt the regulations of the law of weights and measures to measuring and weighing for transactions and certifications, which have a direct relation with peoples' lives. However, that law is applicable to a limited range only, and accordingly it does not provide a unified basis of the measuring technology necessary for a wide variety of administrative actions.

In addition, the specifications, accuracy and other requirements of the measuring instruments necessary for enforcing various legal regulations are not specified, and such instruments do not have required performances in many cases. The characteristics and reading accuracies of the measuring instruments should be certified through the calibration done by the national organization of metrology, SIRIM or other organizations accredited by SIRIM. However, SIRIM is not ready for or capable of fulfilling all requirements. As a result, the legal regulations are not so effective in many cases.

To solve these problems, it is necessary to grasp the specifications and quantity of necessary measuring instruments in the stage of planning and enforcing new regulations and to make the engineering details of the regulations into practical forms. For this purpose, it is necessary to establish liaison committees about measurement in the sections and departments concerned and to make versatile examinations about smooth enforcement of further regulations. Thus, we propose that a national liaison conference should be established for this purpose. (We call it temporarily the National Metrology Committee.)

The National Metrology Committee makes it possible to specify the targets of new regulations. The sections and departments participating in the Committee will be able to grasp the current conditions of SIRIM and other measurement organizations. If there is a great inconsistency between the actual condition and the target, temporary measures can be taken for more practical and efficient actions.

7.1.2 Purpose, structure, and activity of the National Metrology Committee

The purpose, structure, and activity of the National Metrology Committee are summed up as shown below.

1) Purpose

1. Harmonizing the engineering and technical matters of the legal regulations planned by the sections and departments concerned

2. Enhancing engineering cooperation between the sections and departments concerned in order to establish a unified metrology system

3. Clarifying the metrology characteristics necessary for enforcing legal regulations (such as specifications, accuracies, ranges, and so forth of measuring equipment) and adjusting these requirements to the calibration and measurement capability

4. Making every effort to unify the certificates of the measuring and weighing instruments and standards as far as possible in order to eliminate duplicate inspections or certifications

5. Preparing a plan of a unified measurement law covering a wide range of metrology and measurement

2) Structure of National Metrology Committee

The National Metrology Committee consists of representatives of the sections and departments in charge of legal regulations and representatives of SIRIM, the custodian of metrology. It is managed by SIRIM. The applicable sections and departments in charge of legal regulations include the Measures and Weights Dept, Environment Dept, Transport Dept, Electricity and Gas Supply Dept, and Chemistry Dept, etc. Many other sections and departments concerned should take part in the conference.

Great importance is attached to the international harmonization about engineering regulations. Thus, it is recommended that the committee members should include specialists of international standardization.

Fig. 7-1 shows the organization of the committee.

3) Activity of National Metrology Committee

The major activity of the National Metrology Committee is to investigate the details and enforcement procedures of the legal regulations concerning measurement from a technological standpoint and to propose effective procedures based on agreement of the committee members. In examination, the committee will grasp the levels of applicable technologies, take account of enforcing procedures to achieve the target step by step, and avoid estrangement between the political target and target of enforcement. It may ask corrective opinions about regulations which are difficult from a technical standpoint from the sections and departments concerned. The sections and departments take charge of such regulations and should be responsible for enforcement. Thus, this committee, a horizontal organization of the sections and departments, will not have any authority of judging validity or invalidity of the regulations themselves.

7.1.3 Measurement law

One of the major purposes of the National Metrology Conference is to draft the measurement law. This section describes the details.

The measurement law to be considered for Malaysia should cover the details of the weights and measures law currently in use and should provide the concept of measurement and metrology as the basis of various legal regulations. It belongs to the general laws. In other words, it is regarded as one of the most important legal regulations concerning measurement and metrology. Various regulations will be enforced in close contact with the measurement law. Thus, the activities of the National Metrology Committee proposed in this paper will be covered by the measurement law in the future.

OIML's international document No. 1 "Law of Metrology" and Measurement Law of Japan are appended for reference.

7.2 Expansion Plan for SIRIM Measurement Centre Activities

At present, the SIRIM Measurement Centre has two major functions. One is to maintain and control the Malaysian national standards of metrology (i.e., to research and develop the standards). The other is to provide calibration services (i.e., to supply the standards). These two functions cover quite different business operations, though they should be complementary to each other and be fulfilled in close cooperation. The former is mainly related to scientific researches and technological developments, while the latter provides engineering services such as calibration of measuring instruments and standards all the time. Accordingly, there are differences in the forms and operations of the organizations, education and training of the staff, communication with external organizations, and methods of optimum. Thus, this paper refers to the part of SIRIM concerning the former as the National Metrology Laboratory (NML) and the part concerning the latter as the National Calibration Laboratory (NCL), and proposes the expansion plans for them. These proposals do not mean that these laboratories should have separate organizations. It is intended to make their operations independent.

With the rapid advance of industrial technology in Malaysia, it is urgent to establish the metrological standards and measurement technologies which are the basis of industrial technology. For this purpose, it is necessary to improve the range and quality of

NML's operations remarkably. Judging from the characteristics of operations, the NML may be located in any area of Malaysia. However, its location and building facilities should be suitable to an organization which represents the nation and takes charge of international operations. On the other hand, the NCL should desirably be located in a place near the industrial areas to which it mainly provides the calibration services. It should have several facilities, including branch offices. As described in Chapter 2 "Present Status and Future Outlook of Industrial Development in Malaysia," the NCL should have offices in Kuala Lumpur, Penang, and Johol Baharu at least, judging from the current distribution of industrial areas.

It is important to locate the NML in a place which will be permanently the national center of science and technology and have potential for development. Thus, it should be examined comprehensively with regard for the basic principles of the science and technology policy. This report examines only the necessary conditions of the location without regard to actual places and describes the engineering issues, which should be taken into account when determining the location.

7.2.1 National Metrology Laboratory (NML)

7.2.1.1 Outline of expansion plan

Prior to explaining the details of the NML expansion plan, this section describes the outline of the plan.

1) Aim of the NML

The aim of the NML is to maintain and control the national standards recognized internationally as the Malaysian national metrology organization and to provide them to the calibration organizations.

1. The NML should maintain, control, research, develop and desseminate the national standards and measurement technology.

2. The NML as a representative metrology organization of Malaysia should join international comparison of metrological standard to examine the technological level and to acquire international reputation and recognition.

3. The NML should desseminate measurement standard and measurement technology the NCL and other organizations with necessary standards.

4. The NML should provide training.

As for the measures which the NML nearly undertakes, the NML provides calibration services for a while in order to avoid duplicate investment to the NML and NCL and for efficient utilization of the facilities as described below.

2) Quantities to be dealt with

Judging from expected industrial progress, etc. in the decade from now and the demands of the industry we surveyed this time, we recommend that the quantities which the NML handles and their best accuracies be as shown below.

1. Length : 0.5 ppm (2 ppm)
2. Mass : 0.5 ppm (0.002mg)
3. Volume and flow : 0.1% (0.5%)
4. Force and pressure : 0.01% (0.025%)
5. Temperature : 0.001°C (0.01°C)
6. Electrical
   a) Direct current and low-frequency : 1 ppm (10 ppm)
   b) High-frequency : 1%
   c) Time and frequency : 10^{-13} (10^{-11})
   d) Magnetic : 0.01%
   e) Photometry : 1.0%
   f) Acoustic : 0.1% (0.1 dB)
   g) Vibration : 0.5%

Note: Values in parentheses show the best accuracy at present.

The NML should carry out researches and development concerning these quantities in order to maintain the national standards at the required accuracies. The target of the engineering level which the NML should aim at should be such that it will be highly appraised by other nations' organizations when it is compared with the international standards. Thus, the NML does not always need to establish the national standards based on the International System of Units (SI) by itself. It may take over internationally certified standards from other nations' organizations as necessity requires.

The Chemistry Dept should take charge of the chemical standard reference materials, since it is examining independently the method of unified management and domestic distribution of the standard reference material now. The NML, therefore, will not take charge of such operations for a while. The electromagnetic wave strength is not included in this expansion plan, since calibration technology in the electromagnetic wave strength is not established now.

3) Building

When drafting the plan, we determined the necessary area of the laboratory for each quantity, and added the areas of the common-use facilities such as the conference room, office room, warehouse and lavatories; traffic facilities such as entrances, corridors, and elevators; and ancillary facilities such as the machine room, monitor room and duct spaces to find the necessary total floor area. We examined metrological laboratories in overseas countries and decided that the ratios of the sum of the common-use and traffic facilities and other facilities should be 0.5 and 0.5, respectively, provided the total required area is 1.0.

We recommend that 6 meter × 8 meter modules be used to construct a building with consideration of the Measurement Centre currently in use and for easy operation. Each laboratory consists of two modules, in principle. A wider laboratory should have an area which is an integral multiple of the module area. Laboratories related each other should be placed closely. The recommended building height should be 4 to 4.5 meters as we take account of piping and wiring works and layout of the experimental instruments and equipment. The floor should have the average load resistance of 500 kg/m^2 or so. A two-storied building is adopted for the reason of economical use of the land, though a one-storied building is ideal since instruments and equipment should be subject to as few vertical vibrations as possible.

The floor area of each laboratory in this facility is described below. The floor area of the laboratories is approx. 2400 m^2 and the total floor area of the NML is approx. 5000 m^2.

In general, a metrology laboratory requires a land area of around 10 times to its floor area of its building considering necessary area for utilities like parking lot, internal power station, etc. and for a future expansion. Accordingly, in case that NML is established independently around 5 ha land area will be necessary, on the other hand when NML is established within or near SIRIM complex around

2 ha land area will be necessary because present facilities of SIRIM are utilized effectively.

The following shows the general requirements to be taken into account when designing the laboratory building:

1. Air conditioning facility

   a) The ratings of the temperature and humidity should comply with the international and domestic standards, in principle.

   b) The temperature and humidity in the whole building should be controlled to 27°C ±5°C and 65% ±20% in compliance with the Malaysian Standards.

   c) The temperature and humidity in each laboratory should be determined according to the quantity which the laboratory handles in compliance with the international standard concerning the laboratory conditions (ISO554-1976). If some special conditions are required, they should be determined in compliance with the international standards.

   d) The circulation rate and ventilation rate of the room air should be determined according to experiences in equivalent laboratories.

2. Vibration and noise insulation

   a) Vibration insulation

   The NML should be located in a location free from vibrations transmitted from the ground, since it carries out precision experiments in a quiet environment. To keep out harmful vibrations from outside, a building is recomended to be 500 m or more apart from the nearest trunk road. At least, it must be 200 m or more linearly apart from the nearest trunk road. A laboratory for precision experiments and measurements must be 50 m or more apart from a service road on the site. Vibrations produced in other facilities (i.e., produced from the machine room and equipment used in other laboratories) must be reduced in the vibration source facilities to prevent them from being transmitted. In particular, laboratories which must not be exposed to vibration must be located on the ground floor. Precision instruments should be placed on independent bases as necessity requires.

b) Noise insulation

In order to remove noises and aerial vibrations transmitted from outside, it is necessary to examine proper countermeasures against noises when selecting the building site. In general, the best possible means is to locate the building apart from the noise source. The target noise level must be 50 dB or less. If necessary, the building itself should be noise-insulated.

3. Water feeding and draining

The water feeding and draining facilities must have much more capacities than the normal standard. It is recommended to supply cooling water to equipment and instruments from an exclusive water feeding system (neutral water) free from chlorine, foreign matters, etc. in order to prevent corrosion or contamination. Drain water which may contain harmful contents must be treated by centralized drain disposal facilities. The rain water draining system should desirably have a capacity of handling a heavy rain which may possibly occur once per 100 years.

4. Laboratory facilities

a) Grounding

Each laboratory must have grounding lines of sufficient performances. In particular, electricity-related laboratories must have independent grounding lines, whose grounding resistance must desirably be less than 1 ohm.

b) Dust-proof structure

Laboratories handling the length, mass, etc. must be clean rooms of class 10000 or so. They should be so designed, when designing the building, that higher-level clean rooms or clean benches may be installed if necessary.

c) Hume hood

Laboratories which may produce inflammable or harmful gases must be provided with fume hood and exclusive ducts in order to exhaust such gases to outside, make them harmless or the like.

d) Shielded rooms

Laboratories which will be exposed to reduced external electromagnetic waves must be shielded rooms.

5. Supporting Facilities

a) Fire prevention

Fire retarding walls and fire retarding doors must be provided in each necessary area. Each laboratory must be provided with a fire alarm and an initial fire extinguishing facilities. It is recommended to provide the common-use areas with sprinklers. Laboratories, etc. which must be free from water must be provided with inactive gas fire extinguishing facilities.

b) Power failure and water failure

Even if there is a slim possibility of power failure or water failure, emergency power supplies and water reservoirs must be provided, taking account of the specialty of NML's operations.

c) Centralized control of facilities

A centralized monitor system and monitor center must be provided in order to monitor the conditions of the power supply systems, air conditioning systems, and other facilities running continuously for 24 hours.

d) Control of going in and out

Each necessary area must have an automatic locking door and ID card system for grasping and controlling going in and out.

e) Instrumentation

Instrumentation activity must be provided for maintenance and repair of facilities and equipment in NML. Several technical staffs must be allocated for this activity.

f) Workshop

Workshop must be provided for preparation of sample for R&D activities in each laboratory and simple repair of equipment.

6. Others

Some laboratories may have the special features shown below, which must be taken into consideration at the stage of building design.

a) Special room height (ceiling height) and special load resistance of the floor

b) Cranes, hoists and other transportation facilities

c) Foundations and experiment bases independent from the floor pits and building structures

Taking account of metrology laboratories in overseas countries, we decided that these laboratories should be arranged like an island in the center of the building in order to avoid direct sunlight and should be enclosed by technical staff offices, conference room, library, and so forth. Some laboratories are located in a separate building since they produce vibrations or heavy objects are handled in them or they require special structures.

Fig. 7-2 shows the NML layout based on this plan. Table 7-1 shows the conditions of the laboratories, equipment and facility expenses, etc. The layout of each laboratory is described in the following section.

The construction cost of these buildings is approx. one billion yen as we refer to the costs of equivalent facilities in Japan.

4) Equipment plan

The equipment plan is described in details in the following section according to the laboratories. The basic principle of making the equipment plan is as shown below.

a) The target accuracies of the national standards should be specified in classes, and equipment and instruments suitable to these classes should be selected.

b) Equipment and instruments should be systematized for promoting common use. In order to establish a systematic standards, it is necessary to combine a number of equipment and instruments systematically. Thus, the equipment and instruments must have well-balanced performances and specifications and output data must be used commonly to process and control data in a centralized manner.

c) The equipment layout plan must be made according to the modules suitable to the laboratories. Sufficient work spaces must be secured. The equipment, racks, etc. should not cover 30% or more of each laboratory area, in principle.

The following shows the equipment plan and its cost of each laboratory decided in the above-shown principle. (The values shown below indicate the purchase costs in Japan. Note that they are shown for reference only.) The total costs amount to approx. 1.577 billion yen.

Length standards laboratory	Approx. 287 million yen
Mass standards laboratory	Approx. 150 million yen
Volume and flow standards laboratory	Approx. 220 million yen
Force and pressure standards laboratory	Approx. 320 million yen
Temperature standards laboratory	Approx. 110 million yen
Electrical standards laboratory	Approx. 520 million yen
DC voltage	(Approx. 30 million yen)
Resistance	(Approx. 40 million yen)
LC	(Approx. 50 million yen)
AC voltage	(Approx. 35 million yen)
Electric power and energy	(Approx. 50 million yen)
High voltage	(Approx. 30 million yen)
Time and frequency	(Approx. 25 million yen)
High-frequency and microwaves	(Approx. 80 million yen)
Acoustics and vibrations	(Approx. 60 million yen)
Photometry	(Approx. 100 million yen)
Magnetic	(Approx. 20 million yen)
Total	Approx. 1607 million yen

Note: Figures in parentheses mean breakdown of those of "Electrical standards laboratory".

5) Conditions of location

We hear that the NML will possibly be located in any of the following four places.

a) Kulim Hi-Tech Park
b) Technology Park, Kuala Lumpur
c) Near the Sepang New Airport which will be constructed in the future
d) On the current SIRIM site or adjacent to it

We examined the sites shown above (except for the Sepang New Airport which is not expected so much) and collected data. Table 7-2 compares the characteristics of these locations from an engineering standpoint with consideration of the above-shown conditions.

As described below, the NML will require more than 100 employees at least in the future. Thus, we should take account of the employment problem as one of the important factors when deciding the NML site. Most of the employees of the current SIRIM Measurement Centre may move to the new NML. Thus, we should take account of the intentions and wishes of these employees carefully.

6) Management plan

Maintenance, researches and development of the metrological standards are quite public. It takes a huge amount of money to manage these activities. It is difficult to show in a concrete form how much costs are returned. It is also difficult to obtain profits since this operation has less direct beneficiaries. However, it is clear that the results of the laboratories are widely fed back to the people of the nation and serve as great bases of industry and economy. Therefore, many nations established metrology laboratories for maintaining the metrological standards and normally manage them using national budgets.

We made the expansion plan on the assumption that the Government will manage the NML using the national budget in Malaysia.

7) Staffing plan

We estimated the necessary number of technical staffs of each laboratory and determined the employee plan up to the year of 2000. Details of the necessary numbers of technical staffs of the laboratories are described in the following section. The table below shows the total number of technical staffs only. The first year is 1994.

	1994	1995	1996	1997	1998	1999	2000
Length standards laboratory	3	4	5	5	5	6	6
Mass standards laboratory	3	4	5	5	5	6	6
Volume and flow standards laboratory	3	3	4	6	7	9	10
Force and pressure standards laboratory	3	3	4	5	5	6	6
Temperature standards laboratory	4	4	4	5	5	6	6
Electrical standards laboratory	21	23	25	26	26	28	28
DC voltage / Resistance	(3)	(3)	(4)	(4)	(4)	(5)	(5)
LC / AC voltage	(3)	(3)	(4)	(4)	(4)	(5)	(5)
Electric power and energy / High voltage	(3)	(3)	(3)	(3)	(3)	(3)	(3)
Time and frequency	(1)	(1)	(1)	(1)	(1)	(1)	(1)
High-frequency and microwaves	(3)	(3)	(3)	(4)	(4)	(4)	(4)
Acoustics and vibrations	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Photometry	(4)	(4)	(4)	(4)	(4)	(4)	(4)
Magnetic	(2)	(4)	(4)	(4)	(4)	(4)	(4)
Total	37	41	47	52	53	61	62

Note: Numbers of technical staffs in parentheses mean those of "Electrical standards laboratory" in each parameter.

In general, a metrology R/D organization requires staffs of general affairs, financial affairs, planning, etc. and employees for miscellaneous jobs. Some laboratories require office workers for calibration services. Provided the same number of employees as the technical staffs are required, the whole NML will require approx. 80 employees at the beginning and approx. 130 employees in the year 2000.

Likewise, the NML requires a number of technical staffs. Even though the technical staffs of the current SIRIM Measurement Centre will move to the NML, the NCL described in section 7.2.2 below also requires a number of technical staffs. It is urgent to secure technical staffs. As described in Chapter 5 above, the SIRIM Measurement Centre is short in technical staffs even at present, and insufficient experiences lead to low calibration capability. Thus, we must say with special emphasis that it is urgent to secure experienced technical staffs and improve their engineering capabilities through proper training prior to the start of this plan.

8) Training plan

The NML handles the Malaysian national standards and aims to be an organization recognized internationally. Therefore, the NML should have higher technical levels than the current levels, including those of quantities which the NML will handle newly. In principle, NML's technical staffs should be trained in overseas metrology laboratories for all quantities. As for the quantities which the SIRIM Measurement Centre handles now, the technical staffs should be mainly trained in the SIRIM Measurement Centre.

Training in overseas organizations should begin with operation of the equipment and instruments to be purchased. It may take 3 to 6 months, including theoretical education.

9) Implementation plan

This plan will begin with construction of the NML buildings and requires a total budget of approx. 2600 million yen (reference cost) for constructing the buildings and purchasing equipment. The Malaysian Government will require a period of preparing and handling the budget. We made the implementation plan as shown below on the assumption that this plan may be started in 1994.

1. Preparing the building construction plan and equipment plan
2. Employing technical staffs and carrying out preliminary training in the SIRIM Measurement Centre
3. Constructing the buildings
4. Purchasing and installing equipment
5. Implementing engineering training
6. Starting NML's research and development

Fig. 7-3 shows the flow of these works.

10) To be a membership of the Meter Convention

In relation with NML being internationally recognized metrology laboratory, it is highly recommendable that Malaysia will be a membership of the Meter Convention.

International comparison of measurement standards joined by each member country is one of the activities under the Meter Convention. As NML is planned to be a national metrology laboratory, when Malaysia be a member of the Meter Convention it is important and essential for NML to join international comparison with the purpose of this proposal.

7.2.1.2 NML expansion plan of each laboratory

A. Length standards laboratory

The length standards laboratory shall take charge of research and development of the field of length measurement. Specific calibration methods will be developed and accuracies will be improved and such improved technologies will be handed over to the NCL when appropriate. Till then, the length standards laboratory shall provide precision calibration services as well.

1) Facilities and equipment plan

The length laboratory of the SIRIM Measurement Centre calibrates the gauge blocks with comparison method only at present, while the most important target of the length standards laboratory is to possess facilities capable of absolute measurement of length based on the light wavelength and to make efforts to improve the technical abilities to the extent that it will participate in the international comparison.

The length standards laboratory shall conduct absolute calibration of the class 00 gauge blocks. When technical staffs master the calibration skills, such skill should be transferred to the NCL.

The facilities and equipment plan of this laboratory is made so that it has the traceability system shown in Fig. 7-4. Judging from the current demands for calibration, the priority is given as shown below.

1. Gauge blocks
2. Long scales
3. Standards of angle
4. Other standards of length

Table 7-3 shows equipment and instruments to be acquired for the length standards laboratory. Some of them are possessed by the length laboratory of the SIRIM Measurement Centre at present. They will be transferred to the NCL described later. The length standards laboratory is going to have newly purchased equipment and instruments.

2) Laboratory conditions

The length standards laboratory will have some rooms, which are assigned according to the types of research. In compliance with the international standards, the following conditions should be taken into consideration:

1. Room for conducting absolute measurements (light wave interference measurements)
   - It should consist of a module at least.
   - The temperature and humidity should be 20°C ±0.5°C and 50% or less, respectively.

2. Room for conducting other research
   - It should consist of two modules at least.
   - The temperature and humidity should be 20°C ±0.5°C and 60% or less, respectively.

Each room should be conditioned to the necessary degree of cleanliness (class 10000 at least) with filters and electric dust collector. Since the set temperature is lower than that of other laboratory rooms, each room should have an entrance room to prevent air from moving.

3) Layout in laboratory

Since the 20 meters long bench of the laser length measuring machine for long scale calibration cannot be housed in the unit, a necessary space should be secured by providing a special partition wall between the unit and the adjacent room.

The room spaces should be assigned to the following three laboratory operations, taking account of the convenience of using the facilities and equipment.

1. Laser interferometer
2. Absolute calibration of gauge blocks
3. Other measurements

Fig. 7-5 shows the general layout of the large-sized equipment. There should be a space sufficient to place the gauge blocks and other objects of measurement for temperature conditioning before measurement.

4) Staffing plan

Research and development in this laboratory are conducted by three full-time technical staffs at starting of NML. The technical staffs of the length laboratory of the Measurement Centre must be moved to this laboratory, since it is difficult to employ experienced technical staffs from outside. A further employment plan is as shown below according to expansion of the research subjects. The table below assumes that the first year is 1994.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	1	2	2	2	2	2	2
Assistant R/O	1	1	2	2	2	3	3
Technician	1	1	1	1	1	1	1
Total	3	4	5	5	5	6	6

5) Training and education plan

There is no staff experienced in absolute calibration of the gauge blocks in the SIRIM Measurement Centre. It is necessary to cultivate experienced technical staffs through education and training. Such training will be conducted in an metrology organization in an overseas country which can teach the absolute calibration technique. Needs for precision calibration will increase in the future. Therefore, education and training on the basic technique such as flaw removal and adjustment before calibration should be conducted for the technical staffs, including the calibration staff.

6) Approximate costs of equipment

The approximate costs of purchasing equipment according to the facilities and equipment plan shown above are 287 million yen. They are classified into the following:

1. Block gauges : 180 million yen
2. Scales : 15 million yen
3. Standards of angle : 7 million yen
4. Other standards of length : 85 million yen

B. Mass standards laboratory

The mass standards laboratory in the NML will conduct research and development work of mass. The most important subject of this laboratory is to maintain and control the standards which are to be traceable to the international standards.

1) Facilities and equipment plan

The mass laboratory of the SIRIM Measurement Centre has an independent measuring room for maintaining and controlling the standards of mass and necessary minimum standards and measuring instruments. However, it should have more instruments and equipment for further system establishment and improved accuracy.

The following shows the major subjects of research and development of the mass standards laboratory in the NML:

1. Maintaining and controlling the national standards (i.e., prototype or equivalent)
2. Calibrating the class E1 weights based upon the national standards
3. Calibrating the class E2 weights used by the NCL
4. Actions upon request of calibrating the class E1 weights from third parties

Table 7-4 shows the equipment necessary for ranking the classes E1 and E2 weights. Above all, the precision balance for ranking the class E1 weights in comparison with the national standards is large in size. Such precision balances are manufactured and adjusted by a small number of manufacturers, which are highly reputed internationally.

Some balances and weights currently possessed by the mass laboratory of the SIRIM Measurement Centre may be utilized to transfer the class E2 weights based on the class E1 weights. However, they will be transferred to the mass calibration laboratory in the NCL, since its facilities need to be expanded. With these equipment and instruments, the traceability system of mass is as shown in Fig. 7-6.

2) Laboratory conditions

The mass standards laboratory should have several rooms according to the types of research and accuracy. The following conditions must be taken into consideration in compliance with the international standards:

1. Precision balance room for maintaining and controlling the national standards

   - Room must consist of a module at least.
   - The temperature and humidity should be 23°C ±0.5°C and 60% ±5%, respectively.
   - Room to be free from vibrations transmitted from outside must have balance bases with rigid and stable foundations.

2. Precision balance room

   - Room for housing the precision calibration equipment must have two modules at least.
   - The temperature and humidity must be 23°C ±0.5°C and 60% ±5%, respectively.
   - Room to be free from vibrations transmitted from outside must have balance bases with rigid and stable foundations.

3) Layout plan in laboratory

The 1 kg precision balance for calibrating the national standards must be operated remotely to keep out influences of the measurer's body heat. Thus, it requires partation with the standard storage room.

Each room for other research subjects requires a space of two modules, since it uses a number of mass comparators, precision balances, etc. according to the mass ranges. Every balance should be installed on an insulated balance base. Fig. 7-7 shows the approximate layout plan of the rooms, which are roughly divided into two areas.

4) Staffing plan

Research and development in this laboratory are conducted by three full-time technical staffs at starting of NML. The major operation of this laboratory is to maintain and control the national standards and to calibrate the primary and secondary standards. We assume that the standards are calibrated every 5 to 7 years. Calibration work does not require many personnel. However, it requires secure maintenance and transmission of the technique and skills. The further staffing plan, taking account of international comparison of the standards and the increase of requests for high precision calibration, is as shown below. The table blow assumes that the first year is 1994.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	1	2	'2	2	2	2	2
Assistant R/O	1	1	2	2	2	3	3
Technician	1	1	1	1	1	1	1
Total	3	4	5	5	5	6	6

5) Education and training plan

The precision balances for handling the national standards are purchased newly. Acquisition of operation skills is necessary to make full use of them. Therefore, prior to shipment of the balances, the technical staffs must be trained practically for approx. a month in the balance manufacturer or so in order to acquire the skills of operating the instruments. Then, the skills of maintaining and controlling the national standards must be acquired. Engineering training should be conducted in the NML as necessity requires.

6) Approximate costs of equipment

The approximate costs of purchasing the set of standard weights, precision balances, etc. seem to be 150 million yen.

C. Volume/flow standards laboratory

The volume/flow standards laboratory should aim to establish the traceability of the volume and flow of gaseous bodies. The volume and flow laboratory in the SIRIM Measurement Centre established the traceability of low-pressure gas for calibrating the home-use gas meters. However, it did not calibrate many meters because its demands were not big. The instruments and equipment for measuring gas flow supplied during previous cooperation do not include the basic verification system for the mass standards (kilograms), and accordingly they haven't been calibrated since then. Natural gas deposits and production are great in Malaysia. Thus, it is urgent to establish the traceability and the method and facilities of calibrating industrial-use high-pressure gas meters.

1) Facility and equipment plan

The major target of the volume/flow standards laboratory is to establish the basic gas flow verification system. This system consists of a bell prover, standard tank, volumetric meter (rotator type) and piping as shown in Figs. 7-8 and 7-9. It uses oil of low viscosity and low volatility as a medium, measures the amount of oil discharged from an air-tight standard tank, and makes use of the principle that the same amount of gas flows into the tank to calibrate the volume and flow of the gas. The physical properties of the medium should be determined in order to secure high accuracy. This system is used to rank the bell prover, volumetric meter, wet type gas meter and so forth. Larger bell provers and gas meters are calibrated using the calibrated instruments.

The volume/flow standards laboratory may have to take charge of calibration of the standard meters, which are the standard of transmission to the NCL. The basic verification system is large in size and requires a remarkable installation space. Thus, it is sufficient if the basic verification system is installed in the NML. It need not be installed in the NCL. The laboratory operation range for research of the standards of volume and flow should include calibration of flow meters for high-pressure gas up to 8 atm. Natural gas should be able to be used as a medium for calibrating high-pressure gas meters. These calibration facilities require large area and high pressure gas is dangerous, therefore, laboratory location other than NML will be considered.

The traceability of the volume and flow of liquid has already been established. It is necessary to purchase additional equipment concerning weights and measures. The primary standards for liquid possessed by the volume and flow laboratory of the SIRIM Measurement Centre will be moved to the volume/flow standards laboratory, and the standards for inspection will be calibrated by the NML.

The volume/flow standards laboratory should establish, maintain and control the standards of viscosity, which has not been examined. The standard solution for calibrating viscometers ranked with the standard capillary viscometer or the like will be supplied to the NCL. The NCL should establish the system of calibrating various types of viscometers using the standard solution.

Table 7-5 shows a list of equipment and instruments necessary for these works. Fig. 7-10 shows the hierarchical system of the volume.

2) Laboratory conditions

The volume/flow standards laboratory uses some tall equipment and heavy objects. Therefore, it is not located in the NML building.

The room where the basic verification system is to be installed must be provided with an air conditioner for stable temperature control. The temperature should desirably be controlled to 20°C ±0.5°C. However, it may be a little higher, provided it is stable. The gas calibration room must have a space of four modules at least and should be controlled to 23°C ±1.0°C, 60% or less.

The liquid calibration room must also have a space of four modules at least and must be controlled to 23°C ±2.0°C, 60% or less.

These rooms should be equipped with cranes on their ceilings since heavy objects are carried frequently.

3) Layout plan in laboratory

The gas calibration facilities including the basic verification system should be installed in a room for convenience in carrying out various types of research and operations. The liquid calibration facilities should be installed in a room separately from the gas calibration facilities. Fig. 7-11 shows the equipment layouts in these rooms.

4) Staffing plan

Research and development in this laboratory are conducted by three full-time technical staffs at starting of NML. It seems difficult to newly employ technical staffs in this field. Thus, the technical staffs of the Measurement Centre should be moved to the laboratory to establish the new research system through cooperation with the SIRIM Measurement Centre.

In the future, research officers will be assigned in the fields of flow, volume and viscosity. In this laboratory, some technical staffs cooperate in each operation. Thus, it is necessary to establish the cooperative system of the sections concerned. The following shows the staffing plan for this laboratory. This plan assumes that the first year is 1994.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	1	1	1	2	2	3	3
Assistant R/O	1	1	2	3	4	5	6
Technician	1	1	1	1	1	1	1
Total	3	3	4	6	7	9	10

5) Education and training plan

At present, one technical staff takes charge of research and development in the volume and flow laboratory in the SIRIM Measurement Centre. However, the members of the calibration section have long-term experiences and sufficient knowledge about the new calibration system. Additional education and training are needed for these members as necessity requires. Newly employed staff must be educated and trained in the laboratory under the leadership of the above-shown members.

6) Approximate costs of equipment

The approximate costs of purchasing the basic verification system are 220 million yen.

D. Force and pressure standards laboratory

The force and pressure laboratory in SIRIM Measurement Centre which involves research and development section does not possess the facilities for maintaining and controling standards at present. Accordingly, major work of the force and pressure standards laboratory of NML is to maintain and control the national standards of force and pressure.

1) Facilities and equipment plan

Facilities and equipment plan of the force and pressure standards laboratory must be planned separately by force and pressure respectively.

1. Standards of force

This laboratory must be equipped with the standards of force according to the required measurement ranges and accuracies in order to calibrate the standard force meters and load cells to be used by the NCL. In addition, needs for calibrating the hardness and torque standards are increasing.

Thus, necessary facilities should be prepared. The hardness and torque standards should be calibrated based on the research of this laboratory, and the calibration work will be handed over to the NCL in the future. Table 7-6 shows the necessary equipments and instruments of the following fields.

a) Standards of force
b) Standards of hardness
c) Standards of torque

The standard force machine must provide the measurement ranges which are applicable to both the actual load type and hydraulic type. Combination of the volumes and accuracies should be properly selected in order to cover a wide range of standards with few equipment and instruments.

Fig. 7-12 shows the traceability system of the standards of force.

2. Standards of pressure

This laboratory must be equipped with a standard pressure gauge for maintenance and control of the national standards of pressure in the normal pressure ranges. It should mainly use the standard system of pascal, the SI derived unit of pressure, in principle. However, it must also have the precision pressure gauges for the weight kilogram and PSI systems, since there are still great needs for calibration in these systems. Table 7-7 shows a list of necessary equipment and instruments. The following shows the order of priority to be attached to the equipment and instruments.

a) Dead weight standard pressure gauges
b) Mercury column manometers
c) Barometer calibrators
d) McLoad gauges for calibrating vacuum gauges

Fig. 7-13 shows the traceability system of the standards of pressure.

2) Laboratory conditions

The force standard room of the force and pressure standards laboratory requires a space of three modules, while the pressure standard room requires a space of two modules. These rooms must be controlled to 23°C ±2.0°C, 60% or less and special partation within the laboratory shall be provided for the dead weight force machine. The dead weight force standard machine must be installed on the dug ground.

3) Layout plan in laboratory

In the force standard room, the standard force machine and multi-purpose calibrator cover the most space and are heavy. Thus, great care must be used for installation and maintenance works. The standard hardness meter, standard torque meter and other instruments must be placed on experiment tables.

The pressure standard room must be separated from the force standard room since the former uses different equipment and instruments from those used by the latter. It need not be located adjacent to the latter.

Fig. 7-14 shows the equipment layout plans of these laboratories.

4) Staffing plan

Research and development in this laboratory are conducted by three full-time technical staffs at starting of NML. These research fields are expected to expand in the future. Their employment plan is as shown below. This plan assumes that the first year is 1994.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	1	1	2	2	2	2	2
Assistant R/O	1	1	1	2	2	3	3
Technician	1	1	1	1	1	1	1
Total	3	3	4	5	5	6	6

5) Education and training plan

Since they are short in specialist technical staffs, education and training for newly employed technical staffs are inevitable and should be planned early. They may have to be educated and trained in an overseas organization since there are many newly adopted equipment and instruments.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 320 million yen. The following shows the approximate amounts of each field.

1. Standards of force

   a) Standards of force : 210 million yen
   b) Standards of hardness : 12 million yen
   c) Standards of torque : 12 million yen

2. Standards for pressure

   a) Dead weight standard pressure gauges : 31 million yen
   b) Mercury column manometers : 42 million yen
   c) Barometer calibrators : 5.5 million yen
   d) McLoad gauges for calibrating vacuum gauges : 7.5 million yen

E. Temperature standards laboratory

At present, the temperature laboratory of the SIRIM Measurement Centre offers calibration services using the standard thermometers calibrated by an overseas metrology organization. The temperature standards laboratory of the NML is to have fixed point apparatus to realize the international temperature scales (ITS-90) in the necessary temperature ranges and to establish a system of maintenance and control of the primary temperature standards. It is to calibrate periodically the standard thermometers, etc. used by the NCL for calibration services and to take part in the international standard comparison to confirm international traceability.

The NCL temperature calibration laboratory must have various standard thermometers, thermostatic baths and furnaces for comparison, and a small number of fixed point apparatus necessary to check variance of the calibrated standard thermometers, since it offers calibration services for general users using the temperature standards supplied by the temperature standards laboratory of the NML.

The NML is to calibrate extra-high thermometers and thermometers and temperature standards for special use.

1) Facilities and equipment plan

Instruments for determining the major fixed points of the international temperature scales (ITS-90) and instruments for calibrating the primary thermometers are the main instruments to be prepared. Judging from the current needs for calibration in Malaysia, the temperature range for the primary standards is -190°C to 1550°C. The NML should have the fixed point temperature measuring instruments shown below.

1.	Triple points of argon	(-189.3442°C)
2.	Triple points of mercury	(-38.8334°C)
3.	Triple points of water	(0.01°C)
4.	Triple points of gallium	(29.7646°C)
5.	Triple points of indium	(156.5985°C)
6.	Freezing point of tin	(231.928°C)
7.	Freezing point of zinc	(419.527°C)
8.	Freezing point of aluminum	(660.323°C)
9.	Freezing point of silver	(961.78°C)
10.	Melting point of palladium	(1552°C by wire method)

Note: The instruments of calibrating the triple points of water, freezing point of tin and freezing point of zinc currently in use at SIRIM Measurement Centre should be transferred to the NML.

To calibrate at these fixed points, thermostatic baths or electric furnaces capable of precision temperature control are required for each fixed point. Same electric furnaces can be used for fixed points 5, 6, 7 and 8. The melting point of palladium is used for calibration of thermocouples by "wire method". It need not be so accurate that it can be realized with a normal electric furnace for comparison. Table 7-8 shows a list of equipment and instruments required for this plan. Fig. 7-15 shows the traceability system of this laboratory with these equipment and instruments.

Considering probable demand from industry, equipment for calibrating precision radiation thermometers, such as fixed point black body furnaces, should be provided in the future.

2) Laboratory conditions

The temperature standards laboratory consists of three modules, since it uses some large-sized equipment. It has an additional room, in which electric precision measuring instruments are installed along the center wall.

The entire laboratory should be controlled to 27°C ±2°C, 60% ±5%, respectively. The electric measuring instrument room should be controlled to 23°C ±1°C, 55% ±5%.

The temperature standards laboratory must desirably be provided with an independent air conditioner, since it uses a number of heat generating equipment and instruments. It is difficult to maintain the temperature and humidity constant in the whole laboratory. Thus, precision instruments which must be thermally stable must be used in a separate room. An entrance as well as wiring and piping ducts should be provided between both rooms, which should allow smooth and easy movement and communication.

3) Layout plan in laboratory

Fig. 7-16 shows the layout plan of the large-sized equipment. The installation positions of the electric furnaces, thermostatic baths, etc. should be determined with consideration of the necessity of a water cooled jacket, inert gas purging and exhaust ducts, and other facilities related to the building structure.

4) Staffing plan

Research and development in this laboratory are conducted by four full-time technical staffs at starting of NML. This research is expected to expand in the future. Its staffing plan is as shown below. This plan assumes that the first year is 1994.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	2	2	2	2	2	2	2
Assistant R/O	1	1	1	2	2	2	2
Technician	1	1	1	1	1	2	2
Total	4	4	4	5	5	6	6

5) Education and training plan

In the field of temperature research, required knowledge and skills differ with the temperature ranges, fixed points, and types of thermometers. Sufficient education and training for as long as one year are required for each type of knowledge and skill. Temperature research may involve dangers. Thus, the technical staffs should desirably be educated and trained in overseas metrology organization having sufficient experiences in this research field.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 110 million yen. The following shows the approximate amounts of each field.

1.	Fixed temperature point cells (Fixed point substances, crucibles, etc.)	20 million yen
2.	Fixed point electric ovens or thermostatic ovens (3 sets according to the temperature ranges)	30 million yen
3.	Standard thermometers	10 million yen
4.	Other equipment and instruments (such as measuring instruments, controllers, etc.)	50 million yen

F. Electrical standards laboratory

As described in Chapter 5 above, the electric laboratory of the SIRIM Measurement Centre possesses quite high-level electric measure standards and measuring instruments and has established a system for offering highly precise calibration services to meet the needs in Malaysia at present. Thus, the NML expansion plan should include the issues concerning new fields which have not been covered by the current operation range and adoption and updating of the standards and measuring instruments for improved accuracy. Facilities and equipment suitable to the current industrial needs and tendency should be employed, in principle. As for new fields, the electrical standards laboratory should make efforts to establish the standard system and take direct actions for calibration demands from the industry.

It is necessary to secure a continuous research budget to maintain research and development in new fields, which should contain the following:

1. Expenses for transfering standards from overseas metrology organizations

2. Costs for purchasing the standards, measuring instruments and other facilities necessary for research

3. Expenses necessary for international information collection, including presentations of research results and participating in international conferences.

It is important for researchers and technical staffs not only to pursue desk research but to confirm the performances of equipment and instruments and to carry out measurements and experiments by themselves. The target of preparing facilities and equipment is to have the technical staffs and researchers gain experience and know-how, to accumulate and transmit these as engineering property, and to build up a system to popularize such technical experiences and know-hows in the industry.

The following describes the expansion plan of each electric parameter.

F1. DC voltage standards

1) Facilities and equipment plan

Judging from the principle of preparing the facilities suitable to the industrial needs, we do not consider that the Josephson's voltage standard system, which is being regarded as the international DC voltage standard, is the need of great urgency. Thus, it is not contained in our proposal. However, we consider that the Josephson's DC voltage standard is a system for monitoring the primary standards, since the instruments for constructing that system have been adopted in the electrical laboratory of the SIRIM Measurement Centre and the laboratory is preparing to establish the voltage standards based on that system. It is not appropriate to adopt that system to practical applications, since it requires huge costs for maintainance and control, and needs quite high-level and specialized know-how and technology to make use of it. On the other hand, however, it is important for a laboratory aiming to be an internationally recognized organization to possess such system.

A system for maintaining and controlling the DC voltage standards has been completed. It is necessary to take account of replenishment and replacement of the standards and measuring instruments in order to manage the section for maintaining and controlling the national standards and the calibration service section separately in the future. The transfer standards and primary standard currently in use will be satisfactory in both the accuracy (target accuracy: 1 ppm) and quantity. The instruments and equipment shown below are necessary to calibrate the working standards and improve the automatic calibration system used to maintain the primary standards.

1. Current comparison type potentiometers
2. Standard dividers having a 0.2 ppm order accuracy
3. Detector
4. Standard DC voltage generator having a several ppm order accuracy
5. Digital voltmeter
6. Voltage standards for transfer to the NCL: 2 sets

Fig. 7-17 shows the traceability system of these instruments and equipment. Table 7-9 shows a list of instruments and equipment.

2) Laboratory conditions

The electrical standards laboratory should take charge of the resistance standards shown below. It requires a space of two modules on the assumption that it will possess the Josephson's voltage standard system. The conditions of the electrical standards laboratory are shown below. These conditions also apply to the rooms for research of other parameters.

1. The temperature and humidity must be controlled to 23°C ±1°C and 55% ±10%, respectively.
2. Conditioned air must be blown out as evenly as possible from the ceiling. Air inlets must be provided in the lower parts of the four walls. The air amount must be suppressed for uniform temperature distribution.
3. The power source for measurement and that for general use must be separated and must not be brought close to each other. The power source for measuring instruments must have an insulating transformer on the power distribution board to eliminate disturbing noises.
4. An exclusive grounding line for the measuring instruments must be provided. Its grounding resistance must desirably be 1 ohm or less.
5. An emergency power supply system must be provided for uninterrupted operation of the voltage standards and air baths (for the standard cells) at least.

It is not included in this plan to provide the collection system of helium gas because it is not profitable to set the system, considering the consumption of the helium gas and the operation frequency of the Josephson's voltage standard system.

3) Layout plan in laboratory

Fig. 7-18 shows the equipment layout plan of this room.

4) Staffing plan

It is recommended that research technical staffs be divided into several groups and a responsibility sharing and cooperation system be established in order to transmit and share the engineering technologies. For example, it is recommended that each of the subjects shown below be researched by a 3- to 5-person group.

1. DC voltage and resistance standards
2. AC voltage and LC standards
3. Electric power, energy and high voltage
4. Time, frequency and high-frequency

Staffing plan for DC voltage and resistance standard is described in F2.

5) Education and training plan

The technical staffs shown above should be trained internally in the laboratory. They should be educated and trained in overseas metrology laboratories as necessity requires.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 30 million yen.

F2. Resistance standards

1) Facilities and equipment plan

At present, the Malaysian national standards are maintained in a system based on 1 ohm. Resistance ranges are expanded using resistance converters. The facilities and equipment currently in use seem to have sufficient accuracy to meet the current industry needs and the accuracy is not expected to be remarkably improved in the near future. Thus, this expansion plan aims to maintain the current condition and to prepare facilities and equipment capable of improving the accuracy in the future.

We should pay attention to the fact that the quantized Hall resistor system is used for international comparison of the resistance standards. Many countries tend to adopt the system based on 10 kΩ to maintain the national standards since this system provides the standard resistance of 10 kΩ. It is recommended that the standards be maintained based on 1 Ω for the time being, preparation be made for adopting the 10 kΩ basis system in the future, and matching of both systems be examined. Thus, we plan that a 10 kΩ basis system will be established newly. It will be necessary to establish the Quantized Hall Resistance System if NML would be located as international metrology laboratory in the future.

In addition, peripheral equipment and instruments should be prepared to complete the automatic resistance measuring system being made by the electrical laboratory in the SIRIM Measurement Centre and necessary measuring instruments should be added and newly adopted to cooperate with the NCL. Fig. 7-19 shows the traceability system. Table 7-10 shows a list of equipment and instruments.

2) Laboratory conditions

In addition to the conditions shown in 2), F1 above, the following conditions must be taken into account.

1. An oil feeding pipe for replacing oil must be provided close to the oil bath. An oil recovery equipment and oil storage room must be provided.
2. Conditioned air must be blown out as evenly as possible from the ceiling. Air inlets must be provided in the lower parts of the four walls. The air amount must be suppressed for uniform temperature distribution. An Armstrong type air conditioner is recommended.
3. An exclusive grounding line for the measuring instruments must be provided. Its grounding resistance must desirably be 1 ohm or less.
4. A great amount of paraffin is used. Thus, inactive gas fire extinguishing facilities must be provided.
5. Cooling water facilities must be provided.

3) Layout plan in laboratory

The facilities and equipment for the resistance standards must be installed in the room for research of DC voltage. Fig. 7-18 shows the layout plan.

4) Staffing plan

Research and development of the DC voltage and resistance standards are conducted by three full-time technical staffs at starting of NML. This research is expected to expand in the future. Its staffing plan is as shown below. This plan assumes that the first year is 1994. The staffing plans of other groups are described in the corresponding sections.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	2	2	3	3	3	3	3
Assistant R/O	1	1	1	1	1	2	2
Technician	0	0	0	0	0	0	0
Total	3	3	4	4	4	5	5

5) Education and training plan

As described in the DC voltage standards above, the technical staffs of the resistance standards should be trained in the laboratory, in principle. It may be necessary to educate and train them concerning the quantized Hall resistance standard system in overseas metrology laboratories.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 40 million yen.

F3. LC standards

1) Facilities and equipment plan

The standard capacitance system transmitted by an overseas metrology laboratory having established standards based on the cross capacitors by using the standard capacitors (10, 100, & 1000 pF, stability: ±20 ppm/year) should be adopted as the national standard system. Based on this system, low-order standards (10, 100 & 1000 pF) should be established using capacitance bridges. Range ratios should be determined to expand the capacitance ranges. The standard source frequency for measurement should be 1 kHz. If frequency expansion is needed, the laboratory should examine the frequency characteristics and determine the values.

Metrology laboratories in overseas countries also develop their own technologies and equipment to expand the ranges. It is difficult to transfer such technologies. Thus, the NML should establish its own system. As for low-frequency, large-capacity capacitors and low-frequency, high-voltage capacitors, the standard air capacitors and high-voltage capacitors should be used as the standards, and the ranges should be expanded using current comparators.

High-precision inductance measuring instruments are not available on the market, since there are little needs. For the time being, the standard inductors (1 μH to 1 H) should be used as the national standards, and low-order standards should be determined using LCR meters.

As for the AC resistances, metrology laboratories in overseas countries do not have established traceability systems at present. In particular, high-precision and high-frequency AC resistances are maintained and controlled through repeated trial and error. We find it hard to make a concrete proposal at present. For the time being, calibration tests should be made using LCR bridges. Technologies concerning high-precision and high-frequency AC resistances should be developed in the future. Fig. 7-20 shows such a traceability system. Table 7-11 shows a list of equipment and instruments.

2) Laboratory conditions

This laboratory requires a space of two modules, since it also takes charge of AC current shown below. The conditions of this laboratory are the same as described in 2), F1 above.

3) Layout plan in laboratory

Fig. 7-21 shows the equipment layout plan of this laboratory.

4) Staffing plan

Staffing plan for LC standards and AC voltage standards is described in F4.

5) Education and training plan

The technical staffs of the LC standards should be trained in the laboratory, in principle. It may be necessary to educate and train them in overseas metrology laboratories.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 50 million yen.

F4. AC voltage standards

1) Facilities and equipment plan

It requires a great amount of costs and technical difficulties to maintain the AC voltage standards to high precision over a wide range from low to high frequencies. Provision of the standards and measuring instruments is not enough for high-precision calibration. Thus, only several countries have established the AC voltage standard systems. The range of industyr needs is not so wide. Thus, we propose that the standards should be established step by step in the following procedures.

1. In the early stage, the low-frequency standards should be established. The target calibration accuracy should be 50 ppm at 1 kHz.
2. When the low-frequency standards are established, the standard frequency range should be expanded. The target calibration accuracy should be 50 ppm at 10 kHz.
3. Then, necessary research and development should be carried out in order to establish higher-precision, higher-frequency standards according to the needs of the industry.

AC-DC differential standards should be handed over from an overseas metrology laboratory having established AC-DC differential standards, and the voltage and frequency ranges should be expanded using AC voltage generators, DC voltage generators, AC-DC converters, etc. based on the supplied AC-DC differential standards.

At present, AC-DC thermal transfer standards and AC-DC thermal converter sets are possessed as the transfer standards in the electrical laboratory of SIRIM Measurement Centre. It is difficult to carry out comparison calibration using these instruments. New standards and measuring instruments are necessary. It is necessary to replace the AC voltage generators and DC voltage generators with highly stable instruments to improve the accuracy of the whole system, since these instruments are the sources of the comparison voltages.

The AC-DC differential standards should be used to supply standards to this laboratory of the NML. The AC standard voltage generators or precision DMM should be used to supply standards to other laboratories.

Fig. 7-22 shows the traceability system in this research field. Table 7-12 shows a list of equipment and instruments.

2) Laboratory conditions

In addition to the conditions shown in 2), F1 above, a shielded room is necessary in this laboratory.

3) Layout plan in laboratory

The facilities and equipment for the AC voltage standards must be installed in the room for research of the LC standards. Fig. 7-21 shows the layout plan.

4) Staffing plan

Research and development of the LC standards and AC voltage standards are conducted by three full-time technical staffs at starting of NML. This research is expected to expand in the future. Its staffing plan is as shown below. This plan assumes that the first year is 1994.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	2	2	3	3	3	3	3
Assistant R/O	1	1	1	1	1	2	2
Technician	0	0	0	0	0	0	0
Total	3	3	4	4	4	5	5

5) Education and training plan

The technical staffs should be trained in the overseas metrology laboratories as necessity requires.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 35 million yen.

F5. Electric power and energy standards

1) Facilities and equipment plan

Like the AC voltage standards, it is quite difficult from a facility-related and technical standpoint to establish high-precision electric power standards in a wide frequency range. In a country which begins to establish a standard system, it is recommended that it aims to establish the standards in the commercial frequency range of industrial needs and then make efforts to establish the high-frequency standards. The following shows our plan.

The standards should be supplied by an overseas metrology laboratory having established the electric power standards. The thermal converters used as the transfer standards should be used as NML's national standards. They should be maintained to the accuracy of ±100 ppm.

The NML should make the work standards using the standard electric power converters through comparison with the supplied standards and should maintain the accuracy of the single-phase electric power standards to ±200 ppm. It uses two high-precision calibrators to generate precision power necessary for maintaining the national standards and transfering to the work standards. Using a synthesizer as a phase converter, it controls the voltage and current phases at a resolution of 0.3' to generate precision electric power. It establishes the 3-phase electric power standards for works by adding the power of three standard electric power converters. In other words, the NML should make the standards of 3-phase electric power, phases, power factors, etc. based on the single-phase electric power standards.

It may take long time to establish the electric power standard system and make use of it in daily calibration works. Thus, this proposal assumes that this laboratory will supply the standard of this field for a while. Establishment of the high-frequency electric power standards is a future problem.

The purpose of establishing the energy standards is to establish the standards of watt-hour meters used for electric energy transactions. The single-phase and 3-phase energy standards should be supplied by an overseas metrology laboratory having established the energy standards. Based on these standards, the NML should establish a system of calibrating the standard watt-hour meters of electric power companies. The target accuracy should be ±200 ppm, which seems to be satisfactory traceability of watt-hour meters.

In addition to the above, the standard electric power may be multiplied by time. If the result of multiplication is equal to the result of the above-shown method, the multiplication method may be adopted. 3-phase, 4-wired standard watt-hour meters are necessary as the standards, and electric energy testing machines are necessary as the comparison and calibration machines. Calibration of transformers pertaining to the watt-hour meters is not contained in this paper, since there are few demands of electric power companies.

Fig. 7-23 shows the traceability system designed as described above. Table 7-13 shows a list of equipment and instruments.

2) Laboratory conditions

This laboratory requires a space of two modules. The conditions of this laboratory are the same as described in 2), F1 above.

3) Layout plan in laboratory

Fig. 7-24 shows the equipment layout plan of this laboratory.

4) Staffing plan

Research and development of the electric power standards and electric energy standards are conducted by three full-time technical staffs at starting of NML. This research may be able to be conducted by these technical staffs for the time being. This plan assumes that the first year is 1994.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	2	2	2	2	2	2	2
Assistant R/O	1	1	1	1	1	1	1
Technician	0	0	0	0	0	0	0
Total	3	3	3	3	3	3	3

5) Education and training plan

Before installing equipment and instruments, it is necessary to carry out training about maintenance and control of the standards. Then, technologies and skills should be transmitted in the laboratory.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 50 million yen.

F6. High voltage standards

1) Facilities and equipment plan

The field concerning the high voltage standards covers a wide engineering spheres. It requires huge expenses to establish a standard system covering all spheres. It is also quite difficult from a technical standpoint. It is important for a country standing at the start point to restrict the target to the current needs.

We researched the needs in this field and consider that the major subject is calibration of the transformers for the meters and withstand voltage testers. Thus, the standard system should be constructed for this purpose.

The calibration tests of the transformers for the meters and withstand voltage testers up to 100 kVAC and 100 kVDC are included in the standard AC and DC voltage system. This also applies to the current transformers. Therefore, 100 kVAC transformers for the standard meters and 100 kVDC standard potential dividers should be prepared and regarded as the national standards. For the time being, standards may be supplied by overseas metrology laboratories. In the future, this laboratory can calibrate the standard transformers by calibrating the elements of the DC potential dividers one by one using the standard capacitors. As for the current transformers, the laboratory should establish the standard system up to 1000 A using the current comparator type current transformer testing equipment to fulfill the needs for calibrating current transformers.

Fig. 7-25 shows the traceability system of the high voltage standards. Table 7-14 shows a list of equipment and instruments.

2) Laboratory conditions

This laboratory should be detached building and requires a space of 2 modules at least. In addition to the conditions shown in 2), F1 above, this laboratory requires testers with safety devices installed in a shielded room in order to eliminate electromagnetic influences upon other laboratories, since this laboratory produces high voltage. A control room must be provided, and it must have a structure which allows technical staffs to check the high voltage test conditions from outside.

3) Layout plan in laboratory

Fig. 7-26 shows the equipment layout plan.

4) Staffing plan

The full-time technical staffs of the electric power and electric energy standards should also take charge of the high voltage standards. The staffing plan is as described in 4), F5 above.

5) Education and training plan

This is a new field of research. Thus, the technical staffs should be educated and trained in overseas laboratories of weights and measures.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 30 million yen.

F7. Time and frequency standards

1) Facilities and equipment plan

At present, the SIRIM Measurement Centre possesses three cesium atomic standards of frequency and maintains the national standards of time and frequency by means of comparison of these standards and group control. The current standard accuracy (frequency stability) is controlled to 10^{-12} order.

The international standards of time and frequency are maintained to one class higher 10^{-13} order. To achieve such accuracy, it is necessary to have a receiver of an artificial satellite GPS system. This plan is made to establish 10^{-13} order standards. Fig. 7-27 shows the traceability system. Table 7-15 shows a list of facilities and equipment.

2) Laboratory conditions

This laboratory requires a space of 1 module. Its conditions are as shown in 2), F1 above.

The measuring instruments are to be installed on vertical racks. A receiver installation space must be provided on the roof.

3) Layout plan in laboratory

Fig. 7-28 shows the equipment layout plan.

4) Staffing plan

The research of the time and frequency should be taken charge of by one full-time technical staff.

5) Education and training plan

The technical staff should be educated and trained in the laboratory according to the subject of researches.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 25 million yen.

F8. High-frequency and microwave standards

1) Facilities and equipment plan

Since the field of high-frequency and microwaves is a new subject, this laboratory should take charge of calibration services in addition to research and development in order to fulfill industry needs. In the future, calibration services should be transferred to the NCL since demands for calibration will increase.

The laboratory should handle attenuation, RF voltage, RF power and electromagnetic noises.

1. The piston attenuator is used as the standard of calibrating attenuation. Attenuation in the range from 0 to 117 dBm is calibrated in the frequency range from 10 MHz to 18 GHz. With a set of an attenuation calibration system, calibration services in this range are enabled.

2. The micropotentiometer is used as the standard of calibrating RF voltage. RF voltage in the range from 10 μV to 10 V is calibrated in the frequency range up to 1 GHz.

3. The microcalorimeter is used as the standard of calibrating RF power. RF power is calibrated in the frequency range from 10 MHz to 40 GHz. For calibration, comparison with the standard power meter is used. The power meter calibration system is adopted.

4. The standard noise generator is used as the standard of calibrating electromagnetic noises. Electromagnetic noises are calibrated in the frequency range from 10 MHz to 26.5 GHz. The noise figure measurement system is adopted as the calibration equipment.

Fig. 7-29 shows the traceability system. Table 7-16 shows a list of facilities and equipment.

2) Laboratory conditions

Since the high-frequency and microwave standard equipment is not so influenced by the environmental conditions, it does not require the high-performance air conditioning facilities required for the DC standards. Nevertheless, a double door must be used for the entrance and other proper measures must be taken in order to avoid sharp change in the conditions.

The laboratory requires a space of three modules. It must be controlled 23°C ±2°C, 50% ±5%, respectively. Other conditions of this laboratory are as the same as shown in 2), F1 above.

3) Layout plan in laboratory

Fig. 7-30 shows the equipment layout plan. The tables for measurement should be arranged close to each other since the high-frequency and microwave standards handle measures closely related to each other. In addition, this laboratory must desirably be located close to the DC standards laboratory since the high-frequency and microwave standards are based on DC voltage.

4) Staffing plan

Researches and development of the high-frequency and microwave standards are conducted by three full-time technical staffs. It is urgent to bring up the major staff since there are no experienced technical staffs devoted to the high-frequency and microwave standards. More problems will be caused at higher frequencies. Experiences are the best to solve such problems. At the beginning, it is necessary to establish a system capable of fulfilling approx. 100 calibration demands per year. Then, the laboratory will be able to fulfill approx. 200 calibration demands per year if the skills of the technical staffs are improved and an additional technical staff is employed. Calibration works will be transferred to the NCL as operations increase.

	1994	1995	1996	1997	1998	1999	2000
Research Officer	1	1	1	2	2	2	2
Assistant R/O	2	2	2	2	2	2	2
Technician	0	0	0	0	0	0	0
Total	3	3	3	4	4	4	4

We estimated the number of demands for calibration services as shown below.

	1994	1995	1996	1997	1998	1999	2000
Requests (Estimation)	100	150	200	300	400	500	600

5) Education and training plan

Before installing facilities and equipment, it is necessary to carry out education and training on the technologies and skills in the calibration ranges (frequency ranges, level ranges and so forth). The high-frequency and microwave standards also handle the attenuation, RF voltage, RF power, etc. in relation. Thus, all full-time technical staffs should be educated simultaneously and gain knowledges of all measures concerned. Most overseas calibration organizations handle the high-frequency and microwave standards. It seems relatively easy to master necessary skills in such organizations.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 80 million yen. Details are as shown below:

1.	Attenuation	: Approx. 10 million yen
2.	RF voltage	: Approx. 25 million yen
3.	RF power	: Approx. 30 million yen
4.	Electromagnetic noises	: Approx. 15 million yen

F9. Acoustics and vibration standards

1) Facilities and equipment plan

At present, the acoustics calibration section of the SIRIM Measurement Centre has 1-inch microphones, 1/2-inch microphones and standard sound sources. Sound pressure levels are compared with the standard microphones to calibrate microphones. However, the standard microphones do not have satisfactory traceability, and the facilities should be improved and expanded.

Anechoic room is necessary for calibrating sound level meters. It is inevitable, in particular, to measure the self noises and directivity of sound level meters. Since a great amount of investment is required to build a dead room, this laboratory cannot help offering calibration services.

Fig. 7-31 shows the acoustic traceability system. Table 7-17 shows a list of equipment and instruments.

A vibrator and a piezoelectric type standard pickup are needed to calibrate vibrations. They are also needed for the calibration section. However, we assume that the NML will offer calibration services for the time being to avoid duplicate investment, since there are not so many needs for vibration calibration.

Fig. 7-32 shows the acoustic traceability system. Table 7-18 shows a list of equipment and instruments.

2) Laboratory conditions

The outer building of the anechoic room is made of reinforced concrete and the inner room of the anechoic room requires an effective space of 8 × 8 × 5m.

Thickness of the reinforced concrete is more than 30cm to reduce inner noise level and approximately 2 meters wedge-shape noise insulators made of glass wool are stuck all over the inner wall. The inner room shall be supported by vibration free rubber.

Thus, the outer dimension of the dead room are 12 × 12m.

Since it has such a special structure, it should be built as a separate building. Conditioned air must be blown out from the ceiling and air inlets must be provided in the lower parts of the room.

The connection box must be installed to pull in the microphone cables, signal cables and measuring cables.

Halogen lamps must be installed on the inner wall of the room for lighting.

In order to keep out vibrations transmitted from an air conditioner, the air conditioner must be installed on a foundation separate from the building foundation, and these foundations must be apart from each other.

The temperature and humidity must be controlled to 20°C ±2°C and 70% or less, respectively.

The vibrator used for vibration calibration must be as large in size as possible and must be installed on a sufficiently large foundation to reduce influences of vibrations. The foundation must be built separate from the building foundation.

The temperature and humidity must be controlled to 20°C ±2°C and 70% or less, respectively.

3) Layout plan in laboratory

A measuring room must be located close to the anechoic room. It should be 12 × 18 meters in dimensions. The vibration standard room must have a space of 1 module. Fig. 7-33 shows the acoustic and vibration equipment layout plan.

4) Staffing plan

Two full-time technical staffs seem to handle works sufficiently for the time being, since there will not be so many needs for calibration. Experienced technical staffs of the SIRIM Measurement Centre may be transferred to the new laboratory.

5) Education and training plan

It is an unfamiliar work to calibrate sound level meters in a free sound field in anechoic room. Thus, the technical staffs should be educated and trained in an overseas metrology organization.

6) Approximate costs of equipment

The approximate costs of purchasing the equipment and instruments for this laboratory are 10 million yen for the acoustic research section and 50 million yen for the vibration research section, amounting to approx. 60 million yen, which does not include the costs of constructing the anechoic room, since it is regarded as a part of the buildings.

F10. Photometry standards

The photometry standard research is an unfamiliar subject. The plan is intended to establish a system to fulfill the industrial needs, which seem to be little. The following shows our proposal on the calibration systems according to the amount of the standards to be supplied based on the traceability system shown in Fig. 7-34.

1. Calibration of light intensity

The light intensity should be calibrated using a light intensity standard lamp, and test piece lamps are calibrated through comparison.

The calibration system consists of a 6-meter photometer bench, regulated DC power supply unit for supplying specified voltage to lamps, V (λ) light receiver for detecting the difference in the light intensities of the standard lamp and test piece lamps, and DMM for measuring the output level.

2. Calibration of illumination meters

The light intensity standard lamp, illumination standard, etc. are used to calibrate illumination meters.

The light intensity standard lamp is turned on at a 0 meter position on the photometer bench, the light receiving sensor of an illumination meter on the