3.5.2 Implementation of Industrial Standard Testing

(1) Aggregate Number of Applicants and Licensees

The total number of certifications granted under industrial standards as of February, 1987 is shown in Table 3.5.2-1. Agricultural products (tapioca pellets and other tapioca products) account for more than 70% of the total for both the number of applicants and the number of licensees, reflecting the actual conditions of the Thai industry.

When the number of applicable standards and types of certified industrial products are looked at a considerable number of applicants and licensees are found in every field, showing the conspicuous adoption of the certification system.

Table 3.5.2-2 shows aggregates of compulsory certifications issued in terms of number of applicants and number of licensees. The percentage of compulsory certification is about 30% of the total number of applicants and the total number of licensees except for agricultural products, and about 50% in those fields where compulsory certification items are included. This indicates that the arbitary certification system also has had some effect.

Table 3.5.2-1 Number of Certification Applicants and Licensees

1987. 2. 17

No.	Field	No. of product standards published	No. of product standards implemented		Number of products certified		Number of Applicants	Number of Licensees
			Number	Percentage	Number	Percentage		
1.	Chemical	64	28	43.75	23	35.94	101	85
2.	Mechanical Engineering	68	31	45.59	15	22.06	74	39
3.	Agricultural Products	36	11	30.56	8	22.22	3,202	1,599
4.	Plastic and Plastic Products	27	7	25.93	2	7.41	9	2
5.	Electric	46	28	60.87	20	43.48	142	97
6.	Consumer Products	59	32	54.24	20	33.90	94	54
7.	Basic Standards	0	0	0.00	0	0.00	0	0
8.	Pulp and Paper	18	8	44.44	8	44.44	17	12
9.	Metallurgical	55	31	56.36	22	40.00	143	104
10.	Civil Engineering	43	23	53.49	14	32.56	177	105
11.	Arthitecture	33	20	60.61	15	45.45	151	86
12.	Textiles	23	1	4.35	1	4.35	2	1
13.	Non-metal products	37	19	51.35	7	18.92	126	50
14.	Food	68	32	47.06	23	33.82	127	103
15.	Electronics and Tele-communications	5	1	20.00	1	20.00	5	5
	Total	582	272	46.74	179	30.76	4,370	2,350

Note: Excluding Methodological and basic standards

Source: TISI

Table 3.5.2-2 Actual Data of Compulsory Certification Applicants and Licensees

As of February 1987

Compulsory Certification Items	Applicants		Licensees	
1. Chemical	48	(101)	45	(85)
Carbon dioxide (medical use)	3		3	
Laundry detergent powder	11		10	
Nitrous oxide for medical purposes	3		2	
Oxygen for medical use	31		30	
2. Mechanical Engineering	25	(74)	20	(39)
Automotive safety glasses:				
1) Laminated safety glasses	5		3	
2) Tempered safety glasses	5		5	
3) Zone tempered	5		5	
Liquified petroleum gas cylinder	5		4	
Liquified petroleum gas cylinder for internal combustion engines	3		3	
Protective helmets for road users	2		0	
3. Agricultural Products	3,178	(3,202)	1,588	(1,599)
Hard tapioca pellets	94		66	
Tapioca products	3,084		1,522	
4. Plastic and Plastic Products	-		-	
5. Electric	66	(142)	54	(97)
Ballast for fluorescent lamps	23		23	
Electric irons	8		0	
Incandescent lamps	1		0	
PVC-insulated aluminium cables	9		9	

Table 3.5.2-2 Continued

Compulsory Certification Items	Applicants		Licensees	
PVC-insulated cables and flexible cords	23		22	
Starters for fluorescent lamps	2		0	
6. Consumer Products	35	(94)	27	(54)
Mosquito coils and sticks	16		14	
Plastic containers for sterile pharmaceutical products	3		3	
Polyvinyl chloride pipes for drinking water services	8		4	
Safety matches	8		6	
7. Basic standards	-		-	
8. Pulp and Paper	-		-	
9. Metallurgical	75	(143)	70	(104)
Steel bars for reinforced concrete				
1) Deformed bars	13		11	
2) Re-rolled round bars	46		43	
3) Round bars	16		16	
10. Civil Engineering and Construction Materials	-		-	
11. Architecture	-		-	
12. Textiles	-		-	

Table 3.5.2-2 Continued

Compulsory Certification Items	Applicants		Licensees	
13. Non-metal products	51	(126)	48	(58)
Automotive nitrocellulose lacquer thinner	16		14	
Lacquer thinner	35		34	
14. Food	18		18	
Canned pineapple	18		18	
15. Electronics and Telecommunications	-		-	

Note: Figures in parentheses represent the sum of compulsory and voluntary certifications.

Source: TISI

(2) Number of Industrial Standard Testings in the Past 3 Years

The number of testings under industrial standards in the past 3 years (1984 - 1986) showed an annual increase of some 20%, as shown in Table 3.5.2-3, with about 5,000 tests being conducted a year.

There are 49 designated testing laboratories but less than half of them actually conducted testing in the past 3 years. Even in the case of those which did some testing, their tests were limited to certain areas, most tests were conducted by 4 testing laboratories, i.e. DSS, TISTR, DHW and DMR, with DSS playing a leading role. The number of tests conducted by these 4 laboratories in each field is shown in Table 3.5.2-4. The DSS has the highest ratio of testing in every field of standards, particularly in 1986 when the DSS's share amounted to more than 40% of the total.

The TISTR also covers practically every field of standards, ranking second to the DSS in the number of tests conducted. According to data for the past 3 years, the TISTR showed a similar performance to that of the DSS except for chemical analyses of chemicals and agricultural products in which the DSS is superior to the TISTR. It may be thus considered that the DSS and TISTR are practically supporting the industrial standard testing system.

In 1986, the DHW (Department of Highway) carried out 825 tests, next to the number of tests conducted by the TISTR. However, 683 tests were for reinforced concrete drain pipes, indicating that the arbitrary certification system was functioning effectively for products to be procured for public works.

Table 3.5.2-3 Status of Implementation of Industrial Standard Testing (Number of test samples)

Test lab. \ No. of tests \ Year	1986			1985			1984		
	Total	Percent-age	Compul-sory	Total	Percent-age	Compul-sory	Total	Percent-age	Compul-sory
D S S	2,010	40.5	1,089	1,370	33.1	738	913	26.2	373
T I S T R	842	17.0	356	1,178	28.4	778	783	22.5	529
D H W	826	16.6	0	283	6.8	0	241	6.9	11
D M R	358	7.2	285	428	10.3	372	195	5.6	145
P E A	189	3.8	175	134	3.2	110	161	4.6	97
C C U	181	3.7	120	62	1.5	59	25	0.7	19
M E A	151	3.0	113	232	5.6	163	228	6.5	155
D M S	90	1.8	58	159	3.8	149	51	1.5	40
F E C U	77	1.6	58	95	2.3	67	74	2.1	52
D O A	77	1.6	77	0	0	0	40	1.1	40
N S D	52	1.1	52	14	0.3	14	0	0	0
F O D	52	1.1	0	6	0.1	0	0	0	0
R F D	23	0.5	0	10	0.2	0	12	0.3	0
D I P	11	0.2	0	12	0.3	0	7	0.2	0
T T O	9	0.2	0	11	0.3	0	5	0.1	0
H T W	4	0.1	0	0	0	0	0	0	0
F S C U	0	0	0	143	3.5	143	715	20.5	715
P A T	0	0	0	3	0.1	0	0	0	0
B A T	0	0	0	1	0	0	0	0	0
F R P D	0	0	0	0	0	0	21	0.6	21
R I	0	0	0	0	0	0	8	0.2	0
T T M	0	0	0	0	0	0	8	0.2	0
Total	4,952	100	2,383	4,141	100	2,593	3,487	100	2,197

Note: For abbreviations, refer to Table 3.5.2-13, Designated Testing Laboratories.

Source: TISI

Table 3.5.2-4 Data on Testing Laboratories Classified by Fields on TIS Standards (Number of test samples)

Field \ Test lab. / Year	DSS			TISTR			DHW			DMR		
	1986	1985	1984	1986	1985	1984	1986	1985	1984	1986	1985	1984
1. Chemical	259	193	97	9	11	11	13	9	18	-	-	-
2. Mechanical engineering	126	127	126	140	94	125	-	-	-	50	47	40
3. Agricultural products	197	140	45	36	86	86	-	-	-	-	-	-
4. Plastic and Plastic products	37	11	6	-	-	-	-	-	-	-	-	-
5. Electrical engineering	118	99	55	140	85	118	-	-	-	-	-	-
6. Consumer products	187	229	174	69	113	96	-	-	-	4	-	3
7. Pulp and paper	19	12	12	19	11	14	-	-	-	-	-	-
8. Metallurgy	456	111	67	166	552	222	-	-	11	304	381	152
9. Civil engineering and construction materials	107	44	63	32	21	32	791	241	208	-	-	-
10. Architectural	112	35	24	150	94	57	-	-	-	-	-	-
11. Textiles	-	-	4	-	-	-	-	-	-	-	-	-
12. Non-metal products	66	101	12	81	111	22	22	33	4	-	-	-
13. Food	326	268	228	-	-	-	-	-	-	-	-	-
Total	2010	1370	913	842	1178	783	826	283	241	358	428	195

Source:: TISI

The number of applications shows a steady increases for the chemical, electrical, metallic, civil engineering, construction, non-metallic products and food fields (agricultural products excluded), as shown in Table 3.5.2-5.

Table 3.5.2-5 Trend of Applications for Industrial Standard Testing Classified by Industrial Fields and Testing Laboratories

Industrial field	1984 (%)		1985 (%)		1986 (%)	
Chemical	126	(3.6)	222	(5.4)	335	(6.8)
Mechanical	335	(9.6)	273	(6.6)	354	(7.1)
Agricultural products	867	(24.9)	369	(8.9)	233	(4.7)
Plastics	8	(0.2)	12	(0.3)	47	(0.9)
Electric	572	(16.4)	639	(15.4)	673	(13.6)
Consumer products	388	(11.1)	444	(10.7)	424	(8.6)
Pulp/paper	26	(0.7)	23	(0.6)	38	(0.8)
Metallic	472	(13.5)	1,089	(26.3)	1.051	(21.2)
Civil engineering	310	(8.9)	306	(7.4)	934	(18.9)
Construction	93	(2.7)	139	(3.4)	285	(5.8)
Textile	6	(0.2)	2	(0.0)	0	
Non-metallic	38	(1.1)	350	(8.5)	248	(5.0)
Food	228	(6.5)	269	(6.5)	328	(6.6)
Electronics/ communications	18	(0.5)	4	(0.1)	2	(0.0)
Total	3,487	(100.0)	4,141	(100.0)	4,952	(100.0)

Data on compulsory and non-compulsory tests and the number of applicable standards are tabulated in Table 3.5.2-6. This Table shows that the number of tests for compulsory standards (28 standards) per year is approximately 2,000. Although the number of tests for agricultural products (tapioca products) dropped from 844 in 1984 to 202 in 1986, it simply means that most domestic factories subject to approval had been already approved by then. Other industrial fields show considerable increases every year.

The number of tests for non-compulsory standards also increased steadily every year, as did the number of such standards.

Table 3.5.2-6 Number of Tests Classified by Industrial Fields and Number of Applicable Standards

Industrial field	1984		1985		1986	
	Compulsory	Non-compulsory	Compulsory	Non-compulsory	Compulsory	Non-compulsory
Chemical	53 (2)	73 (14)	121 (4)	101 (20)	155 (3)	180 (14)
Mechanical	194 (6)	141 (10)	161 (6)	112 (15)	205 (6)	149 (16)
Agricultural products	844 (2)	23 (3)	335 (2)	34 (4)	202 (2)	31 (6)
Plastics		8 (3)		12 (4)		47 (7)
Electric	422 (5)	150 (15)	444 (3)	195 (18)	496 (6)	177 (20)
Consumer products	295 (3)	93 (18)	341 (4)	103 (13)	331 (4)	93 (15)
Pulp/paper		26 (7)		23 (4)		38 (5)
Metallic	323 (3)	149 (17)	922 (3)	167 (17)	763 (3)	288 (17)
Civil engineering		310 (12)		306 (11)		934 (14)
Construction		93 (10)		139 (13)		285 (15)
Textile		6 (2)		2 (2)		
Non-metallic		38 (5)	193 (2)	157 (8)	130 (2)	118 (12)
Food	66 (1)	162 (17)	76 (1)	193 (18)	101 (1)	227 (26)
Electronics		18 (1)		4 (1)		2 (1)
Total	2,197 (22)	1,290(134)	2,593 (25)	1,548(148)	2,383 (27)	2,569(168)

Note: Figure in ( ) shows the number of applicable standards.

Source: TISI

Table 3.5.2-7 Data on TIS Mark (Cumulative)

	Up to 1984	Up to 1985	Up to 1986
Number of enterprises applying	3,756	4,062	4,386
Number of enterprises approved	2,071	2,232	2,352
Number of approvals	4,255	4,531	4,774

Source: TISI

However, the number of approved enterprises in 1986 accounted for only some 3% of the total number of registered factories shown in Table 3.5.1-2 despite some annual increases seen in Table 3.5.2-7, showing a slow adaptation of the TIS mark system. The number of approvals per enterprise under the TIS mark system is only 2 or so, indicating the low availability of products above the level required by industrial standards.

(3) Suggested and Actual Lengths of Testing

The data concerning suggested lengths of testing for 19 compulsory standards and 19 voluntary standards indicated by the TISI, actual length of testing experienced at testing laboratories, the maximum length, mean length and the relative ratio between them are shown for each product category in Table 3.5.2-8. The "length of testing" referred to here means the total length of time required for the testing, including the time for the TISI to initiate the procedure to request the test of a testing laboratory, waiting time at the laboratory, testing time, time required to prepare the test result document after the testing, etc. out of this TISI certification procedure as mentioned in 3.4.1 (1).

Table 3.5.2-8 Suggested Length and Actual Length of Testing

TIS No.	Category	Product	Suggested length	Actual max. length	Ratio	Actual mean length	Mean ratio	
11	Electric	PVC insulated cables and flexible cords	30	300	10.0	193	6.4	*
17	Consumer products	Polyvinyl chloride pipes for drinking water services	60	102	1.7	87	1.5	*
20	Metallic	Steel bars for reinforced concrete (round)	15	99	6.6	46	3.0	*
23	Electrical	Ballast fluorescent lamps	20	186	9.3	106	5.3	*
24	Metallic	Steel bars for reinforced concrete (deformed)	15	71	4.7	39	2.6	*
27	Mechanical	Gas cylinders	94	253	2.7	53	0.56	*
30	Chemical	Nitrous oxide for medical purpose	30	66	2.2	66	2.2	*
78	Chemical	Laundry detergent powder	42	52	1.2	52	1.2	*
196	Mechanical	Automotive safety glasses (laminated)	28	261	9.3	261	9.3	*
211	Metallic	Steel bars for reinforced concrete (re-rolled)	15	141	9.4	38	2.5	*
293	Electrical	PVC insulated aluminium cables	30	288	9.6	189	6.3	*
309	Consumer products	Mosquito coils and sticks	30	39	1.3	34	1.1	*
366	Electrical	Electric irons	90	58	0.64	58	0.64	*
369	Mechanical	Safety helmets for road user	30	127	4.2	127	4.2	*
496	Non-metallic	Lacquer thinner	20	34	1.7	30	1.5	*
520	Non-metallic	Automotive nitrocellulose lacquer thinner	30	39	1.3	29	0.97	*
531	Consumer products	Plastic containers for sterile pharmaceutical products	35	79	2.3	66	1.9	*
539	Chemical	Carbon dioxide for medical use	30	35	1.2	35	1.2	*
540	Chemical	Oxygen for medical use	30	85	2.8	85	2.8	*
7	Electrical	Battery containers	45	84	1.9	84	1.9	
49	Metallic	Arc welding electrodes	45	42	0.93	36	0.8	

TIS No.	Category	Product	Suggested length	Actual max. length	Ratio	Actual mean length	Mean ratio
64	Electrical	Copper conductors	25	177	7.1	177	7.1
86	Electrical	Aluminium conductors	35	232	6.6	165	4.7
92	Electrical	Table-type fans	30	141	4.7	112	3.7
93	Mechanical	Leaf springs	94				
118	Electrical	Automotive low voltage cables	29	89	3.1	89	3.1
146	Mechanical	V-belts	7	60	8.6	60	8.6
226	Electrical	Polyester enamelled copper wires	22	53	2.4	53	2.4
236	Electrical	Fluorescent lamps	96	165	1.7	165	1.7
248	Metallic	Corrugated sheets	50	91	1.8	91	1.8
254	Mechanical	Bicycle frames	28	72	2.6	72	2.6
276	Metallic	Steel pipes	45	135	3.0	108	2.4
279	Electrical	Insulators	15	68	4.5	40	2.7
291	Mechanical	Hexagon bolts	45	175	3.9	175	3.9
300	Mechanical	Track pins	25	456	18.2	456	18.2
325	Metallic	Aluminium foil	14	59	4.2	49	3.5
343	Metallic	Water taps	90	38	0.42	23	0.26
476	Pulp	Stencil paper	65	77	1.2	77	1.2

Note 1: Data on testing time for TIS No. 93 are not provided by test laboratories.

Note 2: * indicates a compulsory standard.

Note 3: Actual maximum length for TIS 366 and TIS 343 was only for some certain test items and the length required for all test items is 110 and 90 days respectively.

Source: TISI

As shown in the Table, most tests exceed their suggested testing lengths, and those with actual maximum lengths exceeding their expected lengths by 3 times or more are 8 out of 12 electrical standards, 5 out of 8 metallic standards, and 5 out of 7 mechanical standards. Other standards - consumer products, pulp/paper, chemical and non-metallic standards - have no case where the actual testing length exceeds 3 times or more of the suggested length.

Those with testing lengths exceeding 90 days are shown in Tables 3.5.2-9 and 3.5.2-10. Based on the data from testing laboratories in those tables, they are divided into each testing laboratory and category of product, respectively.

Table 3.5.2-9 Cases Where Testing Lengths Exceed 90 Days (Classified by Testing Laboratory)

Test lab.	No. of applicable standards	Those exceeding 90 days	Percentage of those exceeding 90 days (%)
DSS	150	27	18
TISTR	75	31	41.3
MEA	11	8	72.7
FSCU	1	0	0
FECU	7	3	42.9
DHW	13	3	23.1
PEA	9	1	11.1
DMR	24	0	0
FRPD	1	0	0
DMS	8	1	12.5
CCU	11	3	27.3
DOA	1	0	0
DIP	2	1	50
RI	3	1	33.3
RFD	2	2	100
NSD	2	0	0
FOD	1	0	0
TTO	2	0	0
TTM	1	0	0
PAT	1	0	0
Total	324	81	25.0

Table 3.5.2-10 Cases Where Testing Lengths Exceed 90 Days (Classified by Product Category)

Category	No. of applicable standards	Those exceeding 90 days	Percentage of those exceeding 90 days (%)
Chemical	28	2	7.1
Mechanical	33	13	39.4
Agricultural products	12	0	0
Plastics	5	2	40
Electrical	43	21	48.8
Consumer products	41	15	36.6
Pulp/paper	9	3	33.3
Metallic	63	9	14.3
Civil engineering	22	2	9.1
Construction	19	3	15.8
Textile	2	1	50
Non-metallic	19	9	47.4
Food	27	0	0
Electronics	2	1	50
Total	324	81	25.0

The study on testing lengths of 67 cases relating to compulsory standards showed that those exceeding 90 days were 15 cases, 22.4% of the total.

Accordingly, with regard to industrial standard testing, it can be said that 1 in every 4 tests exceeds 90 days regardless of it being related to a compulsory or non-compulsory standard. In terms of classification by product category, significant delays are found in mechanical, electrical, consumer and non-metallic products. Among testing laboratories with relatively large amount of testing, the

TISTR and the MEA (The Metropolitan Electricity Authority) show significant delays.

Data obtained by the study on cases with test lengths shorter than 30 days are shown in Table 3.5.2-11 and 3.5.2-12.

Table 3.5.2-11 Cases of Testing Lengths Shorter than 30 Days
(Classified by Testing Laboratory)

Test lab.	No. of applicable *standards*	Test length less *than 30 days*	Percentage of those *less than 30 days (%)*
DSS	150	30	20
TISTR	75	12	16
MEA	11	1	9.1
FSCU	1	1	100
FECU	7	0	0
DHW	13	1	7.7
PEA	9	6	66.7
DMR	24	22	91.7
FRPD	1	0	0
DMS	8	0	0
CCU	11	3	27.3
DOA	1	0	0
DIP	2	1	50
RI	3	0	0
RFD	2	0	0
NSD	2	2	100
FOD	1	0	0
TTO	2	1	50
TTM	1	1	100
PAT	1	1	100
Total	324	82	25.3

Table 3.5.2-12 Cases of Testing Lengths Shorter than 30 days (Classified by Product Category)

Category	No. of applicable standards	Shorter than 30 days	Percentage of those with testing lengths shorter than 30 days (%)
Chemical	28	9	22.1
Mechanical	33	10	30.3
Agricultural products	12	5	41.7
Plastics	5	1	20
Electrical	43	7	16.3
Consumer products	41	11	26.8
Pulp/paper	9	4	44.4
Metallic	63	23	36.5
Civil engineering	22	1	4.5
Construction	19	4	21.1
Textile	2	0	0
Non-metallic	19	4	21.1
Food	27	2	7.4
Electronics	2	1	50
Total	324	82	25.3

In terms of product category, those with relatively short testing lengths of less than 30 days are mechanical, agricultural and metallic products. As a testing laboratory, the DMR completed some 25% of all the tests in less than 30 days.

Tests to determine product conformity with the relevant standards are generally completed in about 30 days in Japan and North America. In comparison, the testing length in Thailand is fairly long. When the actual testing length far exceeds the suggested testing length, com-

companies are forced to revise their production schedules or business deals, causing difficulties. The effect of testing delays on compulsory certification items is particular severe as their legal production is impossible without certification.

It is difficult to make a general statement on testing duration since it depends on different requirements of individual standards and capabilities of testing laboratories. However, it is desirable to complete a test within the period suggested by the TISI and to feed back test results of products.

3.5.2.3 Designated Testing Laboratories

(1) Designation of Testing Laboratories

The TISI, the juridical body of the Industrial Standardization Act, has all power in execution of testing/inspection (and verification) specified by the Act. However, it designates other national organizations, national testing laboratories and other public bodies as authorized testing laboratories to entrust necessary testing pursuant to Article 5 of the Industrial Standardization Act in view of the inadequate testing facilities of its own.

The TISI has designated the 49 testing laboratories listed in Table 3.5.2-13, but the accreditation is not based on the General Requirements (Draft), as the draft has not been implemented yet.

Table 3.5.2-13 Designated Testing Laboratories

I. Government Bodies

1.	**Ministry of Agriculture and Cooperatives**	
1.1	Department of Agriculture	DOA
1.2	Department of Livestock Development	DLD
1.3	Land Development Department	LDD
1.4	The Royal Forestry Department	RFD
1.5	The Royal Irrigation Department	RI
2.	**Ministry of Commerce**	
2.1	Department of Commercial Registration (Fuel Oil Division)	FOD
3.	**Ministry of Communications**	
3.1	The Department of Highways	DHW
4.	**Ministry of Defence**	
4.1	Aeronautical Engineering	AE
4.2	Chemical Department	ACD
4.3	Naval Dockyard Department	NDD
4.4	Naval Science Department	NSD
4.5	Quartermaster General's Department	QGD
5.	**Ministry of Education**	
5.1	The Institute of Technology and Vocational Education (Thewet Campus)	
5.2	The Institute of Technology and Vocational Education (Uthen Thawai Campus)	UTW
6.	**Ministry of Finance**	
6.1	The Excise Department	TED

7. Ministry of Industry

7.1 Department of Industrial Promotion — DIP

7.2 Department of Mineral Resources — DMR

7.3 Office of the Can and Sugar Board — OCSB

8. Ministry of Interior

8.1 Public Works Department — PWD

9. Ministry of Public Health

9.1 Department of Medical Sciences — DMS

10. Ministry of Science, Technology and Energy

10.1 Department of Science Service — DSS

10.2 Office of Atomic Energy for Peace — OAEP

10.3 Office of the National Environment Board — ONEB

10.4 The National Energy Administration — NEA

11. Ministry of University Affairs

11.1 Chulalongkork University

(1) Faculty of Dentistry — DCU

(2) Faculty of Engineering — FECU

(3) Faculty of Science — FSCU

(4) The Scientific and Technological Research Equipment Centre — CCU

11.2 Kasetsart University

(1) Faculty of Agriculture — FAKU

(2) Faculty of Engineering — FEKU

(3) Faculty of Forestry — FFKU

(4) Institute of Food Research and Product Development — FRPD

(5) Kasetsart University Research and Development Institute (Agriculture Machinery Centre) — CKU

11.3 King Mongkut's Institute of Technology (North Bangkok Campus)

(1) Faculty of Engineering — FEKNU

11.4 King Mongkut's Institute of Technology (Thonburi Campus)

(1) Faculty of Engineering — FEKTU

11.5 Mashidol University

(1) Faculty of Science — FSMU

11.6 Prince of Songkhla University

(1) Faculty of Engineering — FEPU

II. Private Sector

1. The Badminton Association of Thailand — BAT

III. State Enterprises

1. Ministry of Communications

1.1 The Telephone Organization of Thailand — TOT

2. Ministry of Defense

2.1 The Preserved Food Organization — PFO

2.2 The Tanning Organization — TTO

3. Ministry of Finance

3.1 Thailand Tobacco Monopoly — TTM

4. Ministry of Industry

4.1 Petroleum Authority of Thailand — PAT

5. Ministry of Interior

5.1	The Metropolitan Electricity Authority	MEA
5.2	The Metropolitan Water Works Authority	MWA
5.3	The Provincial Electricity Authority	PEA

6. Ministry of Public Health

6.1	The Government Pharmaceutical Organization	GPO

7. Ministry of Science, Technology and Energy

7.1	Thailand Institute of Scientific and Technological Research	TISTR

8. Office of the Prime Minister

8.1	The Electrical Generation Authority of Thailand	EGAT

(a) TISTR

The TISTR was founded in 1963 as a public corporation pursuant to the Thailand Institute of Scientific and Technological Research Act under the jurisdiction of the Ministry of Science, Technology and Energy with the purpose of promoting development of science and technology.

Functions

Major functions of the TISTR are as follows.

- to conduct research and to provide scientific and technological services to state agencies and private enterprises for economic and social development of the country;
- to conduct scientific and technological research in order to promote the utilization of natural resources, in turn, to improve the economic condition, environment, health and welfare of the people;

- to improve productivity in accordance with the Government policies by propagating the results of scientific and technological research to benefit Thai agriculture, industry and commerce;
- to train scientific and technological researchers;
- to provide testing and measuring services and other scientific and technological services.

The TISTR has the power and duty to carry out the following activities in order to materialize the functions specified above.

- to sell, construct, procure, accept transfer, hire, let, buy or sell on hire-purchase, exchange, have ownership, processory right or real right, and dispose of movable or inmovable properties within and outside Thailand as well as accept property granted or donated to it;
- to accept remuneration for research and fees for services within the power and duty of the Institute as well as to conclude agreements on conditions relating to such remuneration and fees;
- to establish, operate and improve the agencies for scientific and technological research;
- to co-operate with other agencies, whether they are state agencies or private agencies, with respect to the activities relating to scientific and technological research and utilization of the research results;
- to provide for and maintain the national physical standards for the purpose of measuring various quantities and qualities;
- to collect and propagate scientific and technological information;
- to publish scientific and technological documents as well as processes in or relating to science and technology and other documents relating to the work of the Institute;
- to borrow, lend with sureties or invest; provided that it is for scientific and technological research only;

- Each borrowing, lending or investing, if being in excess of five million Baht, shall require prior approval of the Council of Ministers;
- to co-operate with other countries, organizations, or other foreign agencies in scientific and technological activities;
- to provide for and grant scholarships and scientific and technological research fellowships.

Organizational Structure

The organizational structure of the TISTR is as shown in Fig. 3.5.2-1. Tests entrusted under the Thai Industrial Standards or major foreign and international standards are carried out by the Testing and Standards Centre (TSC).

The organizational structure of the TSC is as shown in Fig. 3.5.2-2.

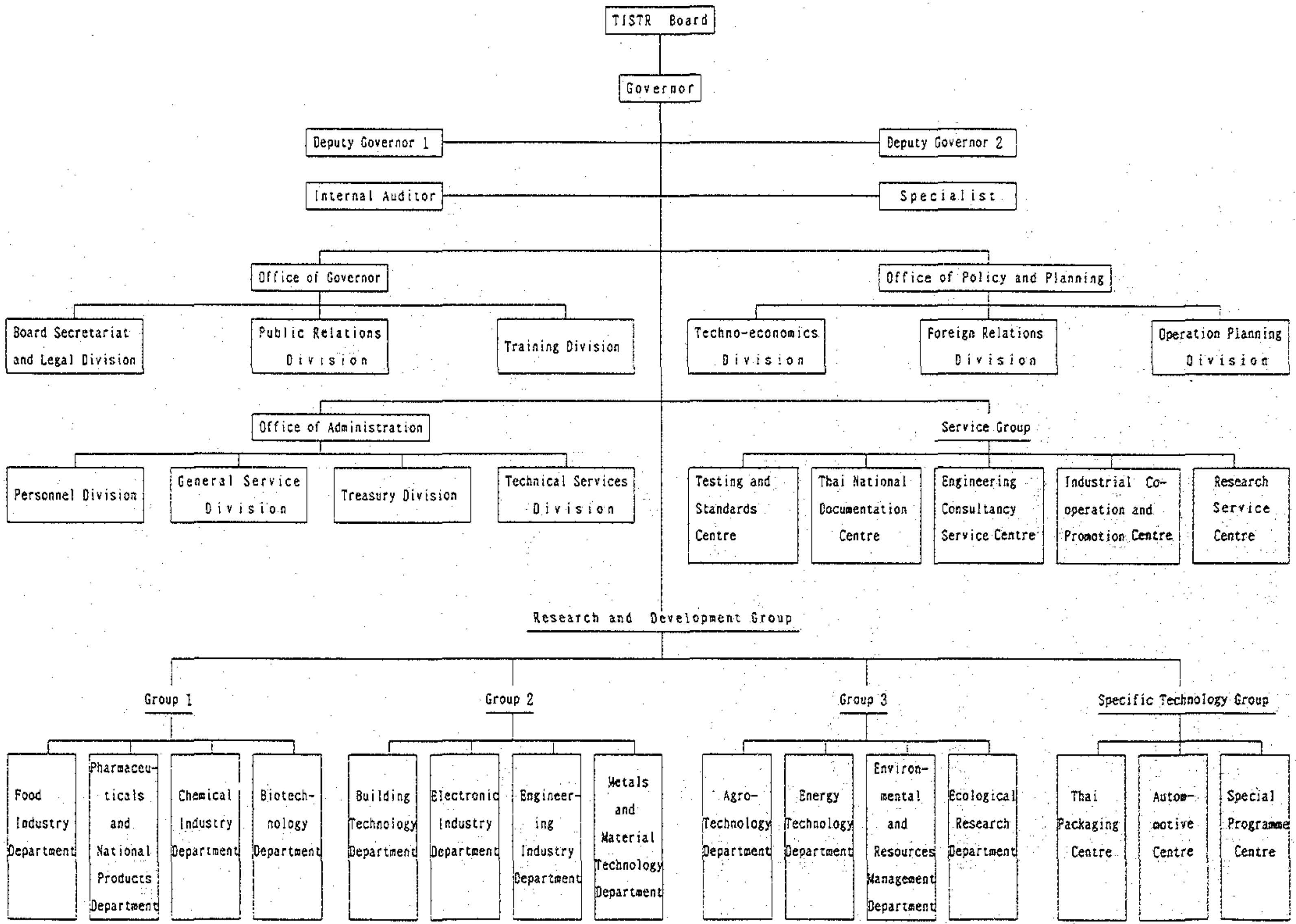
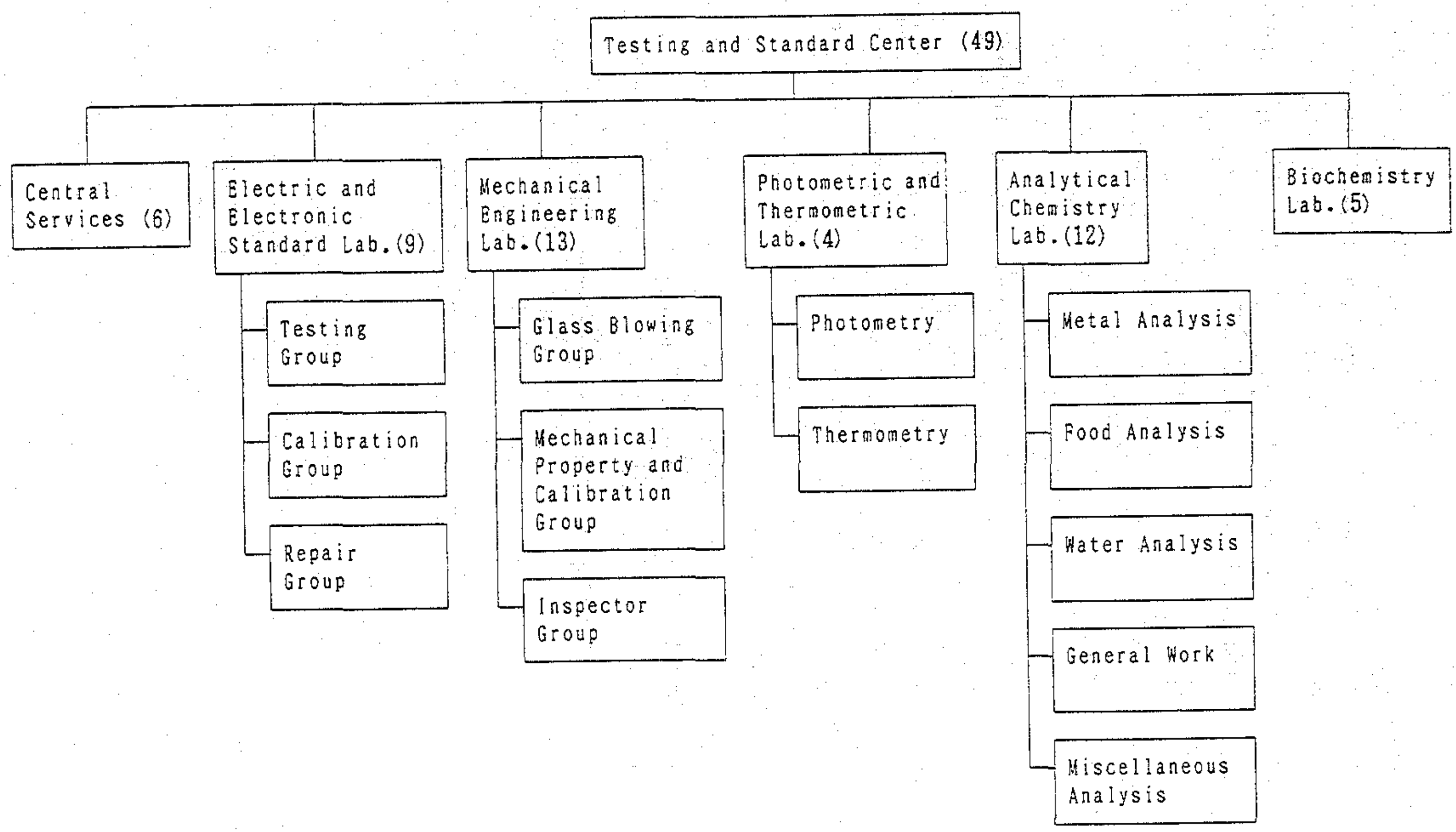


Fig. 3.5.2-1 Organizational Structure of TISTR

Organization of Testing and Standard Center TISTR



Note: Figures in parentheses represent number of staffs.

Fig. 3.5.2-2 Organization of Testing and Standard Centre, TISTR

(b) DSS

The DSS (Department of Science Service) was established in 1891 as a department of the Royal Development of Mines and Geology, later placed under the Ministry of Finance and then transferred to the Ministry of Science, Technology and Energy (MOSTE) in 1979, and continues to be a department of MOSTE.

Functions

Major functions of the DSS are as follows;

- to have the function of a scientific and technological research institute of the Government;
- to conduct chemical, physical and biological analysis services for government agencies and private enterprises;
- to carry out research activities relating to the effective utilization of natural resources and industrial/agricultural water in the country;
- to provide analysis and testing services for the certification and control of qualities of industrial products, foods and beverages;
- to train research staff from government agencies and private enterprises and college/university students in chemical analysis;
- to conduct information services on science and technology.

Organization Structure

The DSS consists of 7 divisions, as shown in Fig. 3.5.2-3, and conducts analysis and testing work for industrial standards entrusted by the TISI more than any other organization.

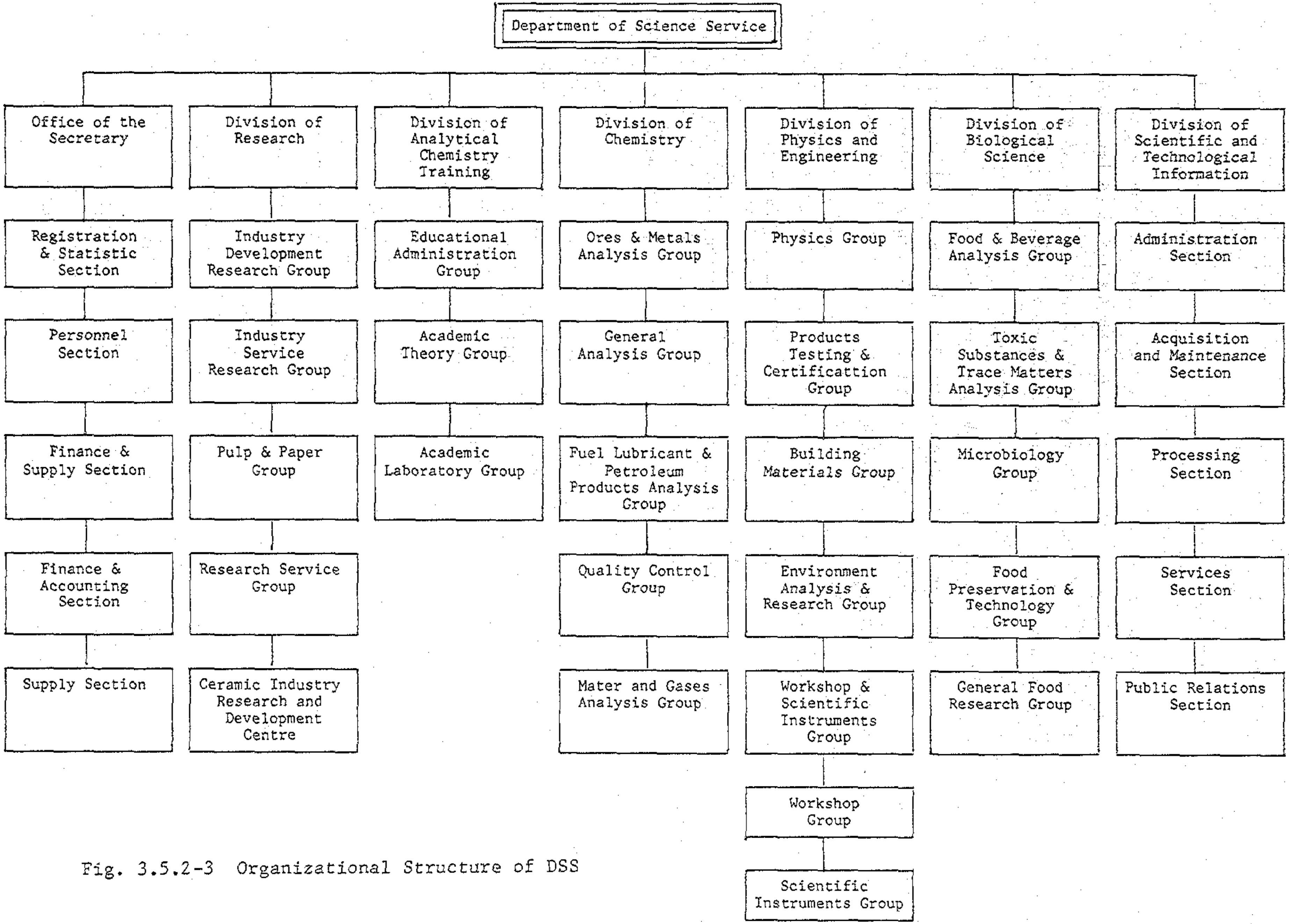


Fig. 3.5.2-3 Organizational Structure of DSS

(2) Data on Testing Laboratories

Industrial standard testing is to be conducted by the 49 testing laboratories designated by the TISI. Of the 49 laboratories, however, only the DSS and the TISTR may be qualified as general testing laboratories while the remaining laboratories handle tests of a limited nature only. Furthermore, only 22 out of 49 conducted any industrial standard testing in the period between 1984 and 1986. Since designated testing laboratories already have their routine works, it can be said that the ability of conducting tests pursuant to industrial standards accordingly.

TISI entrusted some non-designated testing laboratories with carrying out tests during 1984-1986 as shown in the following table.

Table 3.5.2-14 Testing Laboratories that Conducted Certain Tests without TISI Authorization

TIS No.	Category	Non-designated test lab.	No. of tests conducted
11	Electrical	DSS	1984: 23, 1985: 31 1986: 33
27	Mechanical	CCU	1986: 16
93	Mechanical	PEA	1984: 37
276	Metallic	DMR	1984: 2
301	Mechanical	CCU	1985: 1
420	Metallic	DMR	1984: 1, 1986: 5
435	Plastics	DMS	1986: 7
452	Consumer products	FECU	1984: 8
488	Mechanical	DMS	1986: 9
496	Non-metallic	DMS	1985: 76
514	Metallic	DMR	1986: 8
524	Plastics	DMS	1984: 2, 1985: 1 1986: 3
593	Civil engineering	UTW	1986: 4

The number of standards in each industrial field where more than one testing laboratory was assigned to conduct tests relating to the same standard in 1986 is as follows.

Chemical	3 out of 17 standards
Mechanical	7 out of 22 standards
Agricultural Products	1 out of 8 standards
Plastics	2 out of 7 standards
Electrical	9 out of 26 standards
Consumer Products	5 out of 19 standards
Pulp/Paper	1 out of 5 standards

Metallic	16 out of 20 standards
Civil Engineering	5 out of 14 standards
Construction	2 out of 15 standards
Non-metal	6 out of 14 standards
Foods	1 out of 27 standards
Electronics	0 out of 1 standard

Even if all of them are added, the total would be only 58 standards (29.5%) of the total 195 standards. The detailed study shows that this practice of multiple assignment was not necessarily introduced due to too many requests being placed for testing. On the question of allocating testing requests in the future, a more rational and efficient approach should be considered.

(3) Problem of Designating Testing Laboratories

Capabilities of a testing laboratory are closely related to the reliability, which is of central importance in the certification system, of testing results based on industrial standards. In particular, when multiple testing laboratories carry out the same test under the same standard and come up with different test results for the acceptance or rejection of a product, the validity of the certification system itself is in doubt.

With the designation criteria for testing laboratories, a draft has already been prepared by the TISI on the basis of ISO/IEC Guide 25 and major improvements can be expected when the criteria are established. The draft, however, lacks concreteness as far as designation criteria are concerned. Improvement on the following points is hoped for in designating testing laboratories.

(a) Absence of provisions on qualifications required of testing staff.

(b) Absence of provisions on minimum test equipment and facilities required of designated testing laboratories as well as provisions on maintenance/control of test equipment including their calibrations

(c) TIS standards have relatively concrete provisions on sampling methods, test methods, etc. in consideration of certification tests. However, a uniform interpretation of standards, etc. should preferably be established in advance, if tests are carried out based on the standards alone.

In order to expect fair and accurate test results from multiple testing laboratories, it is necessary to establish detailed rules for operation methods, etc., which should be done by the TISI as the designation body.

(DRAFT)

General Requirements for Testing Laboratories

1. Scope

1.1 This document specifies general requirements, organization, quality system, staff, testing equipment, calibration, test methods and procedures, environment, handing of samples, records and test reports for testing laboratories.

2. Definitions

2.1 Testing laboratory: An organization operating laboratory which measures, examines, tests, calibrates or otherwise determines the characteristics or performance of product.

2.2 Laboratory: A place where testing is conducted to determine the characteristics of performance of products

2.3 Testing: Testing activities consisting of measurement, examination, analysis and test of a given product to determine its characteristics.

2.4 Calibration: The direct comparison of a measurement device of unverified accuracy, to one of known accuracy, to detect and define any variation from its performance specifications.

2.5 Products: Manufacture items (including materials and products at various stages of manufacturing.

2.6 Technical staff: Staff who perform technical operation related to the testing of products.

2.7 Testing equipment: Apparatus or devices used for the purpose of measurement, examination, analysis and test.

2.8 Quality system: The organizational structure, responsibilities procedures, activities, capabilities and resources that together aim to ensure that products, processes or services will satisfy stated or implied needs.

2.9 Quality control system or quality assurance system: Product standard, standard test method or other product related standard. All those planned and systematic actions necessary to provide adequate confidence that a product, process or service will satisfy given quality requirements.

2.10 Standard: Product standard, standard test method or other product-related standard.

2.11 Reference standard: A standard, generally the best available at a alocation, from which the measurements at the location are derived.

2.12 Reference material: a material or substance one or more properties of which are sufficiently well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to material.

3. General requirements

The testing laboratory shall

3.1 be legally identifiable;

3.2

4. Organization

The testing laboratory shall

4.1 have an organizational structure and quality system that enable it to maintain the capability to perform satisfactorily the technical functions for which recognition is granted;

4.2 be organized so as not to subject staff members to undue pressure or inducement that might influence their judgment or results of their work;

4.3 be organized in such a way that each staff member is aware of both the extent and the limitations of his area of responsibility;

4.4 have a technical manager who has overall responsibility for the technical operations of the laboratory;

4.5 have adequate security rules and measures for protection of proprietary rights and confidential information.

5. Quality system

5.1 The laboratory shall operate an internal quality assurance programme appropriate to the work performed.

5.2 The quality assurance programme (as in clause 5.1) shall be documented in a quality manual which is available for use by the laboratory staff. The quality manual shall be maintained relevant and current.

5.3 The quality manual shall contain information regarding
(1) the structure of the laboratory (organizational charts);
(2) the operational and functional duties and services pertaining to quality;
(3) general quality assurance procedures;

(4) quality assurance procedures specific for each test, as appropriate;
(5) where appropriate, proficiency testing, use of reference material, etc.;
(6) satisfactory arrangements for feedback and corrective action whenever testing discrepancies are detected;
(7) procedure for dealing with technical complaints.

5.4 The quality system shall be systematically and periodically reviewed and corrective action initiated. Such reviews shall be recorded together with details of any corrective action taken.

6. Staff

6.1 Staff shall have the necessary education, training, technical knowledge and experience for their assigned functions.

6.2 The proportion of supervisory to non-supervisory staff shall be such as to ensure adequate supervision.

6.3 Information on the relevant qualifications, training and experience of the technical staff shall be maintained by the laboratory.

7. Testing equipment

7.1 The testing laboratory shall be furnished with or have access to all items of testing equipment required for correct performance of the tests.

7.2 The testing laboratory shall provide operating instructions for the staff using a particular item of equipment.

7.3 Testing equipment shall be operated only by the technical staff assigned for testing functions.

7.4 All equipment shall be properly maintained to ensure protection from corrosion and other causes of deterioration. Instructions for a proper maintenance procedure for those items of equipment which require periodical maintenance shall be available.

7.5 Any item of the equipment which has been subjected to overloading or mishandling, or which gives suspect results, or has been shown by calibration or otherwise to be defective shall be taken out of service and clearly labelled until it has been repaired and then shown by test or calibration to be performing its function satisfactorily.

7.6 Records shall be maintained of each major item of equipment. Each record shall include:
(1) The name of the item of equipment.
(2) The manufacturer's name and type identification and serial number.
(3) Date received and date placed in service.
(4) Current location.

(5) Details of maintenance.

7.7 In the case of measuring equipment, the record shall also include:
(1) Date of last calibration and calibration reports.
(2) The maximum period of time between successive calibrations.
(3) A label or tag indicating the date of the last calibration and the due date of the next calibration should be attached to equipment requiring calibration.

8. Calibration

8.1 Testing equipment used in the testing laboratory shall be calibrated where appropriate before being put into service and thereafter according to an established programme.

8.2 The overall programme of calibration of equipment shall be designed and operated accordingly. Where relevant, in-service testing equipment shall be subjected to checks between regular recalibrations.

8.3 Reference standards of measurement held by the laboratory shall be used for calibration only and for no other purpose, and shall be traceable to national or international standard of measurement.

8.4 Reference materials shall where possible be traceable to national or international standard reference materials.

9. Test methods and procedures

9.1 The testing laboratory shall have adequate documented instructions on the use and operation of relevant equipment and on the handling and preparation of test items. All instructions shall be maintained up-to-date and relevant to the work of the testing laboratory.

9.2 The testing laboratory shall have all the standards required which shall be readily available to the staff performing the test.

9.3 The testing laboratory shall use methods and procedures required by the reference standard against which the test items are to be tested. Where it is necessary to employ test methods and procedures which are non-standard, these shall be fully documented.

9.4 All manual calculation and data transfers shall be subject to appropriate checks.

10. Environment

10.1 The environment in which the tests are undertaken shall not invalidate the test results or adversely affect the required accuracy of measurement. The testing premises shall be protected as required from excessive conditions such as excessive temperature, dust, moisture, steam, vibration, electromagnetic disturbance, interference, and shall be maintained accordingly. They shall be sufficiently spacious to allow operators to make practical and precise movements. The premises shall have the equipment and energy sources needed for the testing. When the testing so requires, they shall be equipped with devices to monitor the environmental conditions.

10.2 Access to and use of all test areas shall be controlled in a manner appropriate to their designated purpose and entry by persons external to the laboratory shall be defined.

10.3 Adequate measures shall be taken to ensure good housekeeping in the testing laboratory.

11. Handling of samples

11.1 A system for identifying the samples or items to be tested or calibrated shall be applied, to ensure that there can be no confusion regarding the identify of the samples or test items and the results of the measurements made.

11.2 A procedure shall exist for (bonded) storage of items where necessary.

11.3 At all stages of storing, handling and preparation for test precautions shall be taken to prevent damage to the items which would invalidate the results. Any relevant instructions provided with the item shall be observed.

11.4 There shall be clear rules for the receipt, retention and disposal of samples.

12. Records

12.1 The testing laboratory shall provide the laboratory's notebook with serial number printed on each page to the technical staff.

12.2 The technical staff shall be strongly informed that any operation related to the testing activities, calibration and test results shall be recorded only in the notebook as of clause 12.1. Recording on a piece of paper and transferring to the notebook shall be prohibited.

12.3 The records for each test must contain sufficient information to permit satisfactory repetition of the test.

12.4 The laboratory's notebook as of clause 12.1 shall not be torn or destroyed.

12.5 The records of each test, calculation and calibration shall be retained for .... years.

12.6 All records and test reports shall be held secure and in confidence.

13. Test reports

13.1 The test reports shall be clear and accurate.

13.2 Each test report shall include at least the following information:

(1) name and address of testing laboratory;
(2) unique identification of report (such as serial number), and of each page of the report;
(3) name and address of client;
(4) description and identification of the test item;
(5) date of receipt of test item registered at the testing organization and date(s) of performance of test at the laboratory, as appropriate;
(6) a statement to the effect that the test results relate only to the items tested;
(7) identification of the test specification, method and procedure;
(8) description of sampling procedure, where relevant;
(9) any deviations, additions to or exclusions from the test specification, and any other information relevant to a specific test;
(10) disclosure of any non-standard test method or procedure utilized;
(11) tests and derived results, supported by tables, graphs, sketches and photographs as appropriate, and any failures identified;
(12) a statement on measurement uncertainty (where relevant);
(13) a signature and title of person(s) accepting technical responsibility for the test report and date of issue;
(14) a statement that the report shall not be reproduced except in full without the approval of the testing laboratory.

13.3 Corrections or additions to a test report after issue shall be made only by a further document suitably marked, e.g. "Supplement to test report serial number .....".

(4) Test Equipment and Number of Tests Handled

Test equipment/facilities and the number of tests handled are closely related to each other. Multiple sets of equipment/facilities, therefore, must be provided to ensure smooth operation if the number of tests to be handled increases.

Table 3.5.2-15 shows the list of equipment owned by the DSS, TISTR, MEA, FECU, DHW, PEA and CCU and the TISI. The provision of the equipment is unsatisfactory in view of the volume of testing required, constituting a factor of the prolongation of testing length. Although the investigation could not cover all test laboratories, it may be said that some equipment is too old and obsolete to meet the level required by standards, and the quality of equipment, including measuring accuracy, is also questionable. In addition, maintenance or repair work may not be possible in Thailand and expandables and spare parts may not be readily available. Furthermore, the calibration of testing equipment which is indispensable to maintain the reliability of testing results is insufficient. Information on equipment possessed by other test laboratories is very sparse but they are probably equivalent to or worse than those of the test laboratories visited by the Study Team according to the data on number of industrial standards tests handled.

Table 3.5.2-15 List of Test Equipment (DSS)

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
1	Abrasive tester	1	1974	abrasion of rubber ASTM		adjust before use
2	Abrasive tester	1	1974	plastic abrasion ASTM, JIS		adjust before use
3	Abrasive tester:Los Angeles	1	18yr	abrasion of concrete stone		
4	Abrasive tester:tooth paste	1	>10yr	abrasion		
5	Agtron	1	1974	colour concentration in food	std. color	
6	Air analyzer	1	7yr	portable		
7	Amino acid analyzer	1	12/25/80	with photoelectric cell	standard	per usage
8	Aniline point tester	1	>10yr	ASTM D 611		
9	Autoclave	1				adjust before use
10	Autoclave	1	5yr			
11	Autoclave	1	6yr			
12	Autoclave	2	>10yr			
13	Autoclave	1	>10yr			
14	Autoclave	3	6, >10yr	Sterilized microorganism		
15	Balance	2				
16	Balance	3			adjust	
17	Balance	2	4, >10yr			
18	Balance	5	19, 14yr			
19	Balance	2		max 2800g, top loading		adjust before use
20	Balance:analytical	2	18, 12yr			
21	Balance:analytical	2	4, 3yr			
22	Balance:analytical	2	8, >10yr			
23	Balance:analytical	1		200g, electrical, prec=.0001		
24	Balance:analytical	2	1983	max 180g, precision .0001, elec		adjust before use
25	Balance:electronic	4	3-7yr			
26	Bath:shaker	1	9yr	det. available phosphate		
27	Bending tester	1	13yr	for corrugated sheet (asbestos)		
28	Brick grinding	1	18yr			
29	Bursting strength tester	1		for paper max 8kg/sq.cm		
30	Calibration box:100tons	1	25yr	100tons		
31	Calibration box:300tons	1	7yr	horizon. tensile tester 300tons		
32	Calorimeter:atomic bomb	2	7, 3yr	heat capacity ASTM D240	ASTM D240	
33	Capacitance meter	1	1986		by DSS	vary with load
34	Carbon determinator	1	2yr	carbon content in iron steel	std. plate	
35	Carbon residue apparatus:Couradson	5	>10yr	carbon residue ASTM D189	ASTM D189	

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
36	Carbon tester	1	2yr	carbon content in iron steel	with std. steel	
37	Centrifuge:ultra	1	10yr	sedimentation speed max 20000rpm		
38	Centrifuge	3			control rpm per usage	
39	Centrifuge	2	1yr			
40	Centrifuge	1		JIS		adjust before use
41	Checker	1	1983	measure R, V, mA (VOM/TR checker)	by DSS	vary with load
42	Chromatograph:atomic absorption	1	1987			
43	Chromatograph:gas	1	1yr		cal. curve	per usage
44	Chromatograph:gas	1	1yr			
45	Chromatograph:gas-liquid	1	10yr	separate compound matter		
46	Chromatograph:gas-liquid	1	08/07/75	composition of element	standard	per usage
47	Chromatograph:liquid	1	2yr	high perf. UV detector 190-700mm, fluor.det 240-650mm		
48	Chromatograph:liquid	1	09/24/80	high perf. with photoelectric cell	standard	per usage
49	Clamp meter	1	6yr	current(ac), volt, resistance	by DSS	vary with load
50	Cleaning instrument:ultrasonic	1	1yr	cleaning glasswares		
51	Coating tester	1	18yr	crack of coating		
52	Colorimeter	1	1972			adjust before use
53	Colorimeter:ASTM	1	3yr	ASTM D 1500	ASTM D1500	
54	Comparator:color	1		for emulsion		
55	Compressive tester	1	25yr	concrete compression 100ton	cal.box & proving ring	
56	Compressive tester	2	1978	compressive strength ASTM		adjust before use
57	Concora fluter	1		corrugating		
58	Concrete pipe tester	1	21yr	10ton		
59	Conductivity meter	1	13yr			
60	Controller:moisture	3				adjust before use
61	Controller:temperature	2	3, 5yr	for chloroform bacteria		
62	Corrosion tester:copper strip	1	1yr	ASTM D130	ASTM D130	
63	Crusher	1		corrugated paper		
64	Crusher	1	1971			adjust before use
65	Diffractometer:X-ray	1	2 months	composition of ceramics		
66	Digestion set	2	2yr			
67	Distillation apparatus	2	10yr	petroleum product ASTM D86	ASTM D86	
68	Distillation apparatus:Kjeldahl	3	9yr	nitrogen in fertilizer		
69	Drying time tester	1		drying time of paint		
70	Ductility tester	1	>10yr	ductility of asphalt ASTM D113	ASTM D113	
71	Endurance tester	1	1971	endurance of chock-up ASTM		adjust before use

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
72	Erichson coupling machine	1	15yr	forming of steel plate		
73	Evaporator	1	4yr	at low temperature under vacuum		
74	Evaporator:centrifugal dry vacuum	1	08/08/84	evaporate at low temp. and low press	control rpm	per usage
75	Evaporator:rotary vacuum	2	1960, 1974	evaporate at low temp. and low press	control temp & press	per usage
76	Expansion tester	1	18yr	coef. of expansion:ceramics		
77	Fat extractor	2				
78	Fat extractor	1	3yr	portable		
79	Fatigue tester	1	18yr			
80	Fatigue tester	1	1971	fatigue of conveyor TIS		adjust before use
81	Feid vapour pressure	1	>10yr	vapour pressure ASTM D323	ASTM D323	
82	Fibre digestion apparatus	2	12			
83	Finess tester	1	16yr	for marl test		
84	Finess tester	1	15yr	finess of cement Blaine type		
85	Finishing surface concrete machine	1	18yr			
86	Flash point (closed) tester	2	8yr	ASTM D93	ASTM D93	
87	Flash point (open) tester	3	8, 8, 3yr	ASTM D92	ASTM D92	
88	Folding endurance tester	1		for school paper		
89	Folding endurance tester	1	1975	for plastic & rubber ASTM		adjust before use
90	Furnace:high temperature	1		1700c		
91	Furnace:muffle	3	18yr			
92	Furnace:muffle	2	12, 3yr			
93	Furnace:muffle	3				
94	Furnace:muffle	2	12, 13yr			
95	Furnace:muffle	2	>10, 1yr	ash		
96	Furnace:muffle	1	5yr	max temp. 1100c		
97	Furnace:organic combustion	1	8yr	carbon, hydrogen content ASTM D3178	ASTM D3178	
98	Furnace:volatile matter	2	5yr	volatile matter of coal ASTM D3175	ASTM D3175	
99	Glossmeter	1	1985	for pulp surface		
100	Glossmeter	1	1yr	gloss of paint		
101	Grinder	9	18, 14, 13yr			
102	Hardness tester	3	1979, 85, 86	ASTM		adjust before use
103	Hardness tester:Brinell	1	15yr	max. 3000kg	std plate	
104	Hardness tester:Rockwell	1	2yr	scale A-M	std plate	
105	Hardness tester:Rockwell, superficia	1	5yr	15T, 30T, 45T & 15N, 30N, 45N	std plate	
106	Hardness tester:plastic	1	15yr		std plate	
107	Heat of hydration apparatus	1	10yr	heat of the reaction		

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
108	Heater:extraction	1	10yr			
109	Heating unit	3	9yr	general analysis digest fertilizers		
110	Hot plate	2	18, 10yr			
111	Hot plate	2	6yr			
112	Hot plate	4				
113	Hot plate:oscillating	1	17yr	shaking heater		
114	Hydraulic testing machine:200	1	4yr	internal pressure of pipe max 200kgf/sq cm,		
115	Hydraulic testing machine:5000	1	12yr	internal press. of steel pipe max 5000ibf/sq.in		
116	Hydraulic testing machine:5000	1	2yr	hydrostatic test of vessel max 5000 ibf/sq.in		
117	Hydraulic testing machine:PVC	1	6yr	long term pressure test (PVC)		
118	Hydrometer	30	5yr	specific gravity	ASTM D1298	
119	Hydrostatic testing machine:200	1	6yr	for pressure vessel max 200 lb/sq.in		
120	Hydrostatic testing machine:bottle	1	25yr	for bottle		
121	Impact tester	1	10yr	impact of safety glass steel ball		
122	Impact tester:10 ft-lbs	1	20yr	impact of plastic & rubber		
123	Impact tester:220 ft-lbs	1	27yr	impact of steel Izod & charpy		
124	Impact tester:PVC pipe	1	15yr			
125	Impact tester:chip board	1	15yr			
126	Impedance meter	1	1986	resistance, capacitance, induction	by DSS	vary with load
127	Incubator	5	1, >10yr	microbioscopes		
128	Ion-activity meter	1	10yr	pH, ionized particles		
129	KBB sizing tester	1		water absorption of paper		
130	Kjeldahl apparatus	1	2yr	nitrogen in organic matter	ASTM D3179	
131	Leaf spring tester	1	13yr	loading of leaf springs		
132	Loading apparatus	1	10yr	loading of bicycle frame		
133	Melt flow index	1	1973	melting point of plastic ASTM BS		adjust before use
134	Mercury analyzer	1	5yr	mercury content		
135	Mercury analyzer	1	7yr	mercury 0.01ug		
136	Microscope	1			compare with structure	
137	Microscope	2	7, >10yr			
138	Microscope	1		for fibre of paper with camera		
139	Mill:laboratory	1		food milling vane type		adjust before use
140	Miller	1	17yr			
141	Miller	1	17yr			
142	Moisture tester	1		using infrared light		

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
143	Moisture tester	1	6yr	water content		
144	Multimeter	1	1986	measure R, V, mA (VOM:degital)	by DSS	vary with load
145	Multimeter	1	1985	measure R, V, mA (VOM)	by DSS	vary with load
146	Multimeter	1	8yr	measure R, V, mA (VOM)	by DSS	vary with load
147	Multimeter	1		measure R, V, mA (VOM)	by DSS	vary with load
148	Munsell	1	1982	colour concentration in food	with std. colour paper	
149	Nitrogen distillation apparatus	1	6yr			
150	Oil absorption tester	1		oil absorption of paper		
151	Oscilloscope	1	1984	electrical signal 60 MHz	by DSS	vary with load
152	Oven	2	18yr			
153	Oven	2	10, 3yr			
154	Oven	3				
155	Oven	2	1978, 1958		adjust heating coil cir.	
156	Oven	6				
157	Oven	2	9yr	moisture		
158	Oven	1	>10yr	volatile matter		
159	Oven	2	>10yr	moisture		
160	Oven	10	1968-83	50-250c		adjust before use
161	Oven	1	9yr	max 300c		
162	Oven:vacuum	1	1yr			
163	Ozone-resisting tester	1	1973	for plastic & rubber ASTM, BS, JIS		adjust before use
164	PCB tester	1	18yr			
165	Penetrometer	2	10, 3yr	hardness of asphalt needle & cone ASTM D5	ASTM D5	
166	pH-meter	1	7yr		pH-tester	6 months/time
167	pH-meter	1			comp. buffer	
168	pH-meter	2	1985		std solution	
169	pH-meter	1	>10yr			
170	pH-meter	1				
171	pH-meter	1	4yr			
172	pH-meter	2	21, 9yr	pH0-14(pre. 0. 1) & mv +1999, -1999		
173	Photometer:flame	1	5yr	Na, K content		
174	Photometer:flame	1	7yr	sodium & potassium content	standard sol.	
175	Photometer:flame	1	7yr	sodium & potassium content	standard sol.	
176	Pipette:Anderson	4	10yr	finess of soil unit:micron		
177	Potentiometer	1	9yr	total base number ASTM D664	ASTM D664	
178	Pour point apparatus	2	5, 3yr	pour point ASTM D97	ASTM D97	

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
179	Printability tester	1		printing prop. of paper (IGT)		
180	Probe	1	1986	digital logic probe	by DSS	vary with load
181	Proving ring	5	12yr	50, 500, 1500, 6000, 15000lbs		
182	Pump:vacuum	7	13, 3yr			
183	Pump:vacuum	1	9yr	det. phosphate fill sediment		
184	Quaront paper scales	2		basic weight of paper 120/1000 g/sq m		
185	Reflectrophotometer:elrepho-electric	1		opacity diffuse, 90deg refraction		
186	Refractive apparatus	1	13yr			
187	Refractive index apparatus	1		solid & liquid		
188	Refractometer:hand	4	1977, 1984	sugar content & sol. content	adjust inlet light	
189	Refractory testing app.:under load	1	18yr			
190	Roller:rubber	1		rubber mixing		adjust before use
191	SPS tester	1		smoothness, porosity of paper		
192	Sampler:high volume	1	1yr	dust & metal element in atmosp		
193	Scanner:densitometric chromatograph	1	1yr	UV/fluorescence 200-800mm		
194	Shaker:test sieve	1	1977	BS		adjust before use
195	Shawbury curometer	1	1973	ASTM & BS		adjust before use
196	Smoothness tester:Bekk	1	11/13/85	smoothness of paper digital readout	Tappi, ISO	2 times/month
197	Sodium & Potassium analyzer	1	19yr			
198	Softening point tester	1		softening point of plastic ASTM		adjust before use
199	Softening point tester	3	5yr	softening point of asphalt ring + ball apparatus	ASTM D2398	ASTM D2398
200	Solubility apparatus	1	10yr	milk		
201	Sound level meter	1	1987			
202	Soxhlet extractor	1	10yr	det. content with solvent		
203	Spectrofluorometer	2	23, 5	fluorescence 200-800mm sensitivity .01ppb		
204	Spectrophotometer:UV/VIS	1	5yr		cal. curve	per usage
205	Spectrophotometer:UV/VIS	1	08/11/83	concentration	standard	per usage
206	Spectrophotometer	2	17, 18yr	abs 400-800mm		
207	Spectrophotometer:UV/VIS	1	3yr			
208	Spectrophotometer:UV/VIS	1	4yr	det. matter		
209	Spectrophotometer:UV/VIS	1	14yr	190-900mm, abs -0.5 & 3.0		
210	Spectrophotometer:atomic absorption	1	4yr		standard sol	
211	Spectrophotometer:atomic absorption	1	4yr		standard sol	
212	Spectrophotometer:atomic absorption	1	6yr	flame AAS/atomic vapor operat		
213	Spectrophotometer:infrared	1	1981			adjust before use
214	Sterile miller	1	4yr	milling of sample		

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
215	Stiffness tester	1	1975	strength of plastic & rubber ASTM		adjust before use
216	Stiffness tester	1	1981	stiffness of plastic JIS		adjust before use
217	Stove:electric	1	1971	max 200c, temp. adjustable		adjudt before use
218	Sugar & starch analyzer	1	13yr			
219	Tearing tester	1		for paper		
220	Tensile tester	2	1978	500kg		adjust before use
221	Tensile tester	1	1975	tensile strength of rubber ASTM		adjust before use
222	Tensile tester	1	21yr	for cement, briquette shape		
223	Tensile tester:30kg	1		tension & elongation pendulum type		
224	Tensile tester:50kg	1	1979	constant-straining rate 20% elongation		
225	Tensile tester:100tons, horizontal	1	22yr	100tons	cal. box	
226	Tensile tester:wet	1	1972	initial wet strength		
227	Test bomb	2	1981, 1982	heating energy of rubber under oxygen atmosp		adjust before use
228	Texturometer	1	1973	stiffness of food	with std sample	
229	Thickness tester	1	1986	corrosion type, JIS, DIN, BS		adjust before use
230	Torsion testing machine	1	15yr	torsion of wire		
231	Tube tester	1	8yr	vacuum tube test	by DSS	vary with load
232	Turbidimeter	1	10yr	finess of cement		
233	Universal testing machine	2	25, 10yr	10tons	cal box & proving ring	
234	Universal testing machine	1	7yr	50tons	cal box & proving ring	
235	Universal testing machine	1	27yr	250tons	cal box & proving ring	
236	Universal testing machine	1	22yr	5tons	cal box & proving ring	
237	Viscometer	2	10yr	food(liquid)		
238	Viscometer	2		ASTM, BS		adjust before use
239	Viscometer:redwood	2	>10yr			
240	Viscometer:Saybolt Fural	2	>10yr	viscosity	ASTM D88	
241	Viscometer:kinematic	3	10, 9, 3yr	viscosity ASTM D445	ASTM D445	
242	Washability	1	8yr	abrasion of paint		
243	Water bath	2	5yr			
244	Water bath	1	5yr			
245	Water content tester:Cobb	1		water absorption of paper		
246	Water retention apparatus	1	8yr	water retention of lime		

List of Test Equipment (TISTR)

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
1	Ammeter:AC	2	1979	lamp current 0.5class, 100mA	TISTR	6 months
2	Carbon-sulphur analyzer	1	20yr	strohlein		
3	Compression tester:300tons	1	1967	static load grad.1/1000, hydraulic type	TISTR	1yr
4	Conductivity meter	1	4yr	Sybron		
5	Control chamber:temp & humid	1	1980	temp. rise test of ballasts -15 to 95c 25-95%	TISTR	regular check
6	Counter:electronic	1	1975	general measurement	TISTR	1yr
7	Fat extractor	1	20yr			
8	Fibre extractor	1	20yr			
9	Flash point apparatus	1	7yr			
10	Frequency meter	1	1974	general measurement	TISTR	1yr
11	Furnace	2	1980, 1981	endurance test of ballast capacity 35 ballasts	TISTR	regular check
12	Furnace:annealing	1	1975	glass-app., materials chamber 1000×500 ×500mm max 8	TISTR	1yr
13	Generator:square wave	1	1970	general measurement	TISTR	1yr
14	Glucose analyzer	1	4yr			
15	Hardness tester;Brinell	1	1980	materials	TISTR	6 months
16	Hardness tester;Rockwell	1	1978	materials	TISTR	6 months
17	Hardness tester;Rockwell, superficial	1	1967	materials 15, 30, 45N, 15, 30, 45T	TISTR	6 months
18	Hardness tester;Shore	1	1978	rubber	TISTR	prior to test
19	Hardness tester;Vickers	1	1967	materials 5-100kg	TISTR	6 months
20	Hydrostatic tester:volumatic expan.	1	1980	LPG cylinder, press. container hydro.pressure 10K psi	TISTR	6 months
21	Impact tester	1	1967	metal Izod & charpy		
22	Insulator conductivity tester	1	1970	insulation test hand driven type	TISTR	1yr
23	Insulator tester	1	1979	insulation test hand driven type	TISTR	1yr
24	Integrating sphere	1	1979	luminous flux dia.1.5m with std photorec	TISTR	6 month
25	Light stability testing apparatus	1	1986	safety glass for automobiles 600W UV lamp	TISTR	regular check
26	Mercury analyzer	1	10yr			
27	Multimeter:VOM	1	1969	general measurement	TISTR	1yr
28	Multimeter:digital	1	1986	electric values acc. 0.01%	TISTR	6 months
29	Multimeter:digital	2	1979, 1980	electric values acc.0.05	TISTR	6 months
30	NIR grain analyzer	1	5yr			
31	Oil bath	1	1983	PVC pipe dia.60cm height 40cm	TISTR	regular check

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
32	Oscilloscope	3	1975	general measurement	TISTR	1yr
33	Oven	1	1978	material drying 300 ×300 ×300mm max 270c	TISTR	1yr
34	pH-meter	1	15yr			
35	Photometer:Lux meter	1	1976	general measurement 300 lux	TISTR	1yr
36	Power factor meter	1	1976	general measurement lead-lag	TISTR	1yr
37	Rack	3	1985.1986	life test of fluorescent lamp cap.140 lamps		
38	Rack	4	1979.1985	life test of incandescent lamp cap.240 lamps		
39	Recorder:temperature	2	1979,1981	test specimens 6point, 0-200c, 0-400c	TISTR	6 months
40	Scanner:TLC	1	3yr			
41	Signal generator	1	1982	general measurement	TISTR	1yr
42	Spectrophotometer:atomic absorption	1	20yr			
43	Testing app.:distortion of vision	1	1986	safety glass for automobiles TIS, BS 857	TISTR	regular check
44	Testing app.:optical deviation	1	1986	safety glass for automobiles TIS, BS 857	TISTR	regular check
45	Thermometer:surface	1	1976	general measurement 300c	TISTR	1yr
46	Titrator:Karl Fisher	1	4yr			
47	Universal testing machine:50tons	1	1967	tension, compression, bending hydraulic type	TISTR	1yr
48	Universal testing machine:630kN	1	1986	static-dynamic load electronic type	TISTR	1yr
49	Viscometer	1	20yr			
50	Voltage regulator:AC auto	1	1979	lamp testing acc.0.3% 1kW	TISTR	regular check
51	Voltage regulator:AC auto	2	1984	lamp testing acc.0.5% 16kVA	TISTR	regular check
52	Voltage stabilizer:DC	1	1979	lamp testing acc.0.01% 1kW	TISTR	regular check
53	Voltmeter:AC	2	1979	lamp voltage 0.5class 300volts	TISTR	6 months
54	Voltmeter:AC	2	1978	general measurement portable type	TISTR	1yr
55	Voltmeter:DC	1	1976	general measurement portable type	TISTR	1yr
56	Wattmeter	1	1976	general measurement portable, single phase	TISTR	1yr
57	Wattmeter:AC	2	1979	lamp wattage 0.5class 120W	TISTR	6 months

List of Test Equipment (FECU)

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
1	Abrasive tester	1	15yr	for soil test		
2	Abrasive tester:Los Angeles	1	30yr	abrasion of stone		
3	Accellerometer	1	1yr	vibration		
4	Balance	1	1972	model 200		
5	Balance	2	1984	chemical lab. digital		
6	Balance	1	1978	dual type 2kg		
7	Balance:analytical	1	1976			
8	Balance:analytical	1	3yr			
9	Balance:analytical	1	1983	0.0001-200g wide chamber		
10	Balance:analytical	3	11.7.1	weighing prec. 0.0001	self adjust	
11	Balance:analytical	1	1979	chemical compound prec. 1mg		
12	Balance:coarse	1	1979	dual type		
13	Barometer:amplitude	1	1968	6000ft		
14	Bridge:Schering	1		capacitance, tanW		
15	Bridge:Strain gauge	1	4yr			
16	Calibrator:gas	1	1982	permeation tube		
17	Calorimeter room	1	1985	air-conditioning unit		
18	Capacitor voltage divider:100kV	3			sphere gap	
19	Capacitor voltage divider:600kV	1			sphere gap	
20	Carbon sulfer analyzer	1	12yr	C, S content		
21	Carbon monoxide analyzer	1	1980	0-50 ppm	std gas	24hr
22	Compression tester:150tons	1	2yr	compression		
23	Conductivity meter	2	1972, 1985	water conductivity	self adjust	
24	Controller:BOD	1	1979	for analyze BOD room temp. 20c		
25	Coupling capacitor	1		RIV of insulators 300kV 1133pF	Scher. bridge	
26	Current transformer:std	1				
27	Cutter:metal	1	2yr	sample preparation		
28	Dead weight tester	1		pressure		
29	Density tester	1	1985	density of compound(water-ore)		
30	Density tester	1	1yr	soil test 60kg/1bs		
31	Detector:bomb circuit	1	1977			
32	Distillation apparatus	2	1976, 1981	prepare distillation water	self adjust	
33	Dynamometer:hydraulic	2		power		
34	Ergometer	1	14yr			
35	Fatigue testing machine	1	4yr	fatigue of sample		

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
36	Flow meter	1	1985			
37	Flux meter	1	14 yr			
38	Frequency analyzer	1	14 yr			
39	Geiger counter	1	1984	analysis ore		
40	Generator; DC, 200 kV	1				
41	Generator: DC, 400 kV	1				
42	Generator: impulse 200 kV 0.3 kJ	1		transformer, insulator tests		
43	Generator: impulse 400 kV 0.6 kJ	1		transformer, insulator tests		
44	Generator: impulse 1200 kV 13.8 kJ	1		transformer, insulator tests		
45	Generator: unit-step 500 V	1		time const. of imp. volt. div.		
46	Grinder	5	4 yr	sample preparation		
47	Hammer: Schmidt	3	5 yr	concrete test NDT		
48	Hardness tester: Brinell	1	2 yr	metal		
49	Hardness tester: Brinell	1	19 yr	1-4000 kg		
50	Hardness tester: Brinell	1	1 yr	3000 kg/lb		
51	Hardness tester: Rockwell	1	2 yr			
52	Hardness tester: Rockwell	1	12 yr	metal		
53	Hardness tester: Rockwell	1	16 yr	15-150 kg		
54	Hardness tester: Rockwell	1	6 yr	60-150 kg		
55	Hardness tester: Shore	1	3 yr			
56	Hardness tester: Shore	1	8 yr	metal		
57	Hardness tester: Vicker, micro	1	4 yr	metal		
58	Hardness tester: Vickers	1	5 yr			
59	Hardness tester: Vickers	1	2 yr	metal		
60	Hardness tester: soil	1	15 yr			
61	Hardness tester: superficial	1	5 yr	Vicker, Brinell, Rockwell scale		
62	Hydrocarbon analyzer	1	1984	CH-4, non-CH 4 5,10,25,50 ppm	std. gas	24 hr
63	Hydrocyclones	1	1968			
64	Impact tester	1	6 yr	impact of sample		
65	Impact tester: 10 kgs	1	50 yr	impact strength of wood		
66	Ion scanning meter	1	1983	heavy metals in water solution	self adjust	
67	Jar test apparatus	3	12.4 yr	water coagulation 6paddle	self adjust	
68	Kipp apparatus	1	1964	gas preparation	self adjust	
69	Kjedahl apparatus	2	1977, 1984	ammonia, nitrogen content		
70	Manometer: BOD	2	1982, 1985	BOD content		
71	Microscope	1	20 yr	structure of steel		
72	Microscope	1	1980	test ore		

No..	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
73	Microscope	6		structure of metal		
74	Microscope	1	1 yr	record structure of sample		
75	Microscope	1	1970	model SIC ore		
76	Microscope	1	1983	test ore table type		
77	Microscope:polarize	1	1980	test ore, photograph		
78	Nitrogen oxide analyzer	1	1982	nitric oxide, nitrogen dioxide 0.25, 2.5, 25 ppm	std. gas	24 hr
79	Oscilloscope: impulse	1		with polaroid		
80	Oscilloscope: storage	1		with polaroid		
81	Oven	2	1982	for dry glass, sample		
82	Oxygen analyzer	1	1985	oxygen content		
83	Ozone analyzer	1	1980	0.001-99.999 ppm	self adjust	
84	Partial discharge meter	1		Bridge		
85	Partial discharge meter	1		pc-MV		
86	pH-meter	1	1984	temp. & pH digital		
87	pH-meter	3	8, 4, 1 yr	pH solution prec. 0.01	self adjust	
88	Polisher; electro	1	10 yr	sample preparation		
89	Polishing wheel	3	4 yr	sample preparation		
90	Power transformer: std.	1				
91	Proving ring: 10, 160 tons	2	35, 10 yr			
92	RIV meter	1				
93	Radiative analyzer	1	1984	test radiative substance		
94	Radiograph tester : X-ray	1	15 yr	welding joint		
95	Rain simulator	1		Flashover, wet		
96	Rate of reaction tester	1	13 yr			
97	Reflex tester	1	1984	test ore in liquid		
98	Reflux apparatus: COD	4	1975, 1982	COD content 12 unit		
99	S-C-T meter	1	1987	salty, cond., temp. water sol.	self adjust	
100	Sampler: dust	3	1980-1984	variable	oritice plate	1 month
101	Sampler: gas	8	1980-1986	several ranges		
102	Separator: Frants-Iso-dynamic	1	1976	sizing ore, magnetic		
103	Siesmic	1	2yr	homogeneity of concrete		
104	Sieve	2	20, 30 yr			
105	Sieve	1	1969	DSM		
106	Sieve	1	1971	sizing 200 mash		
107	Sieve	2	1980	test ore no. 100, 150, 200,		
108	Sight checker	1	14 yr			

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
109	Sizing tester	1	1966			
110	Sizing tester	1	1967	ore dia. 9 inch		
111	Soil porosity tester	1	15 yr			
112	Soil porosity tester	1	15 yr	clay content		
113	Sound level meter (noise meter)	1	14 yr			
114	Soxhlet apparatus	3	1977, 1986	fat, oil, grease content		
115	Spectrophotometer	3	9, 7, 1 yr	water solution content	self adjust	
116	Spectrophotometer	1	1972	test ore 335-1000 mm		
117	Spectrophotometer: UV/VUS	1	1884	test ore		
118	Speedometer	1	13 yr	light		
119	Sphere gap	1		calibrate voltage divider 1 m dia. overload protection		
120	Strain indicator: electrical	2	8 yr	strain of material, structure		
121	Strain indicator: mechanical	1	4 yr	strain in mech, structure		
122	Telescope	1	1971	surway		
123	Tensometer	1	12 yr	tensile strength		
124	Tensometer	1	17 yr	30-2000 kg		
125	Test set: CT-PT	1				
126	Test set: temp, press, moisture	1	1985			
127	Thermometer	1	2yr	molten metal		
128	Thermometer	1	14 yr	temp. of structure of metal max 1100c		
129	Tintometer : Lovibond	1	1979	compare color of waste	self adjust	
130	Torsion testing machine	1	6 yr	torsion of sample		
131	Torsion testing machine : 10 tons	1	43 yr	torsion of steel		
132	Transformer : 500 kV, 250 kVA	1				
133	Transformer : 10 kV, 5 kVA	3				
134	Turbidimeter : Hach	2	1979, 1974	turbidity of water	self adjust	
135	Turbidimeter : Hellige	2	1962, 1974	turbidity of water	self adjust	
136	Ultrasonic	1	5 yr	compression of concrete, steel, wood (NDT)		
137	Ultrasonic tester	1	6 yr	welding joint		
138	Universal testing machine: 4 tons	1	48 yr	impact strength of wood specific gravity, hardness		
139	Universal testing machine: 5 tons	1	53 yr	tension, compression, bending		
140	Universal testing machine:10 tons	1	47 yr	hardness, shearing, compression, bending		
141	Universal testing machine: 10 tons	1	3 yr	tension, compression, bending dynamic load		
142	Universal testing machine: 20 tons	1	32 yr	tension, compressing, bending		
143	Universal testing machine: 30 tons	1	49 yr	tension, compression, bending		

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
144	Universal testing machine: 40 tons	1	14 yr	tension, compression, bending		
145	Universal testing machine: 100 tons	1	45 yr	tention, compression, bending		
146	Universal testing machine: 500 tons	1	12 yr	compression, bending		
147	Universal testing machine: 60,000 lb	1	20 yr	compression, bending		
148	Vibration meter	1	4 yr			
149	Voltage divider: impulse capacitor	2		400, 200 kV		
150	Voltage divider: impulse resistor	4		1200, 600, 300, 100 kV		
151	Voltmeter: impulse peak	2				
152	Whiteness tester	1	1985	white element content		

List of Test Equipment (MEA)

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
1	Bridge: Kelvin	1	12 yr	resistance	with sames kind of equip	occasionally
2	Bridge: Schearing	1	10 yr	insulation dielectric loss		
3	Bridge: Wheatstone	1	7 yr	resistance	with same kind of equip	occasionally
4	High voltage tester: 150 kV	1	5 yr	high voltage test 0-150 KV, AC.		
5	High voltage tester: 350 KV	1	5 yr	high voltage test 0-350 KV, AC		
6	KWH & KVARH meter	1	5 yr	three phase	with same kind of equip	per day
7	KWH meter testing equipment	3	7, 3yr	single phase	with same kind of equip	per day
8	Microcomputer	1	1 yr	640 K with printer		
9	Photometer: Goniophotometer	1	5 yr	illumination		
10	Photometer: Lux meter	1	5 yr	illumination		
11	Projector: profile	1	7 yr	dimension precision 0.01mm		
12	Sound level meter	1	5 yr	sound level measurement		
13	Tensile tester: 50 tons	1	2 yr	tensile strength 0-2tons, 0-50 tons		
14	Test set: insulation power factor	1	10 yr		with same kind of equip	twice a year
15	Test set: insulation resistance	2	20, 5 yr	500 V, Meggar		
16	Test set: insulation resistance	1	20 yr	1000 V, Meggger		
17	Test set: oil dielectric	2	15 yr	oil dielectric tst 0-60 KV	with same kind of equip	occasionally
18	Thickness tester: NDT	1	7 yr	thin film coating thickness	with same kind of equip	occasionally
19	Transformer: current	1	1 yr	0-3000 A	with same kind of equip	per day
20	Transformer: potential	1	7 yr	12, 24 KV	with same kind of equip	per day

List of Test Equipment (PEA)

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
1	Abrasive tester	1	07/20/79			
2	Balance	1	9years	0-160 g, precision 0.0001 g		
3	Bath: temperature	1	08/22/80	amb.-100 c		
4	Bridge: Kelvin	1	01/24/72	10 E-6-10 ohm.		
5	Bridge: universal	1	12/16/71	R,L,C measuring		
6	C & S determinator	1	07/19/82			
7	Chamber: humidity	1	04/17/79	10-95 c		
8	Coating thickness	1	06/13/83	0-1000/um		
9	Dilectric: AC	1	04/02/77	0-20 KV, 500 VA		
10	Earth continuity	1	12/19/79			
11	Furnace	1	04/04/78	1200c		
12	Gauge block	1	01/24/80	1-100 mm.		
13	Hicurrent	2	06/19/79	0-2000 A, 15 KVA		
14	High voltage tester: 100 KV	1	04/22/83	AC 100 KV, 5 KVA, portable		
15	High voltage tester: 1200 KV	1	02/01/78	AC 200 KV, 5 KVA.		
16	Impulse tester: 12 KV	1	11/21/84	0-12 KV, 110 VA		
17	Impulse tester: 300 KV	1	03/13/86	0-300 KV, 7.5 KJ		
18	Leakage current meter	1	04/07/79	0-0.01, 1, 10 mA		
19	Oven	3	06/15/79	Amb.-220 c		
20	Oven	1	02/01/78	Amb.-350 c		
21	pH-meter	1	08/22/80	0-14 pH		
22	Porosity tester	1	01/11/83	0-6000 psi		
23	Projector: optical	1	08/02/79	10, 20,50 magnification		
24	Resister: standard	2	12/27/80	0.01,0.001 ohm		
25	Sound level meter	1	12/01/78	-10 +10 dB		
26	Spectrophotometer	1	03/25/86	UV=200-1000 nm		
27	Spectrophotometer: atomic absorption	1	09/01/78	composition of element		
28	Standard: volt & amp.	1	07/04/75	AC. 10-1000 V,100 mA-50 A		
29	Tensile tester : 250 kgs	1	02/21/78	0-250 kgs. speed 0-300 mm/min		
30	Tensile tester : 5 kN	1	07/18/78	0-5 kN, 0-50 N speed 0-500 mm		
31	Tensile tester : 10 tons	1	12/25/86	0-10,000 kg.		
32	Tensile tester : 10 tons	1	07/07/73	1,2,5,10 tons, tension, compres	by DSS	3 times/year
33	Tensile tester : 20 tons, horizontal	1	07/18/83	0-25 tons.	TISTR	3 times/year

List of Test Equipment (DHW)

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
1	Applicator: film	4	4 yr	paint test		
2	Balance	1	15 yr	0-200 g	basic weight	
3	Balance	1	2 yr	0-200 gm, electrical		
4	Balance	1	>15 yr	0-200 gm, electrical		
5	Balance	1	13 yr	10 Kg	basic weight	
6	Balance	2	15 yr	100-500 g	basic weight	
7	Balance	1	>12 yr	100-500 gm	basic weight	
8	Balance	1	>15 yr	100-500 gm	basic weight	
9	Balance	2	13 yr	1500-2610 g	basic weight	
10	Bond Test	1	3 yr	ASTM D 1191		
11	Ca and S analyzer	1	>15 yr	range 0-14		
12	Centrifuge	1	>15 yr	large, 0-6000 rpm.		
13	Centrifuge	1	>15 yr	small, 0-1700 rpm.		
14	Charge particle tester	1	12 yr	ASTM D 244		
15	Cleveland Open Cup	1	>15 yr	ASTM D 92		
16	Colormeter	1	>15 yr	ASTM E 97		
17	Compression tester	1	16 yr	200 ton	Morehouse proving ring	
18	Compression tester	1	16 yr	200 ton		
19	Dean & Stark apparatus	1	>15 yr	ASTM D 95		
20	Ductilometer	1	>15 yr	ASTM D 113	measure distance/time	
21	Editdometer	1	1 yr	beed test		
22	Impact tester	1	> 15 yr	analyse soil		
23	Impact tester	1	1 yr	ASTM D 2794		
24	Mixer : soil	2	15 yr	sample preparation		
25	Oven	1	5 yr	0-200 c	thermometer	
26	Oven	1	17 yr	0-300 c	thermometer	
27	Oven	1	1 yr	0-300 c	thermometer	
28	Oven	1	15 yr	100-200 c		
29	Oven	1	15 yr	100-200 c		
30	Oven	2	15 yr	ASTM D 1754		
31	Panel: steel	3	>15 yr	with temp. adjustable, 65-370 c		
32	Panel: steel	1	10 yr	with temp. adjustable, 65-370 c		
33	Panel: steel	1	5 yr	with temp. adjustable, 65-370 c		
34	Penetrometer	3	>15 yr	ASTM D 5	by weighing	
35	pH-meter	1	1 yr	range 0-14, precision 0.01	Standard sol	

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
36	Photometer: flame	1	>15 yr	analyse Na, K, Ca		
37	Pump: suction	1	14 yr	electrical		
38	Reflective index meter	1	>15 yr			
39	Refractometer	1	>15 yr	paint test		
40	Regulator: air pressure	1	>15 yr	ASTM D 2131		
41	Spectrometer	1	>15 yr	analyse element		
42	Stirrer: heavy duty	1	1 yr	thermoplastic test		
43	Sterrer: magnetic	2	>15, 9 yr			
44	Sterrer: magnetic	1	1 yr	electrical		
45	Stormer: Kreb	1	4 yr	paint test		
46	Tag-open-cup	1	>15 yr	ASTM D 3143		
47	Tensile tester: 60 tons	1	16 yr			
48	Tensile tester : 100 tons	1	16 yr		Morehouse proving ring	1 time/year
49	Test set : distillation	2	4 yr	ASTM D 402		
50	Test set: distillation (oil)	3	13, 4 yr	ASTM D 244		
51	Test set: recovery	1	11 yr	recovery of asphalt ASTM D 1856		
52	Thickness tester: film	2	4 yr	paint test		
53	Viscometer: Saybolt Fural	4	15 ys	ASTM D 244	standard oil	
54	Viscometer : kinematic	1	12 yr	ASTM D 2170	standard oil	
55	Water bath	1	8 yr	0-100 c, accuracy 0.2 c	thermometer	

List of Test Equipment (CCU)

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
1	Amino acid analyzer	1	1981	microprocessor controller	standards	before use
2	Arsenic, mercury vapor analyzer	1		use with AA spector	standards	before use
3	Atomizer: graphite furnace	1		use with AA spector	standards	before use
4	Carbon & nitrogen analyzer	1	1981	det. N. C 40-500 mg	hippuric acid	before use
5	CHNO analyzer	1	1981	precision 0.2%, C, 0; 0.1% H, N	acetanilide	before use
6	Caloirimeter: bomb	1	1981	complete auto. with digital	benzoic acid	before use
7	Centrifuge : Ultra	1	1981	max centrifugal force 393600		
8	Centrifuge: refrigerate	1	1981	max:speed 20000rpm		
9	Chromatograph: gas	1	1981		std.	before use
10	Chromatograph: gas, computerized	1	1981		std.	before use
11	Chromatograph; liquid	1	1981	high perf.	std.	before use
12	Critical point drying device	1	1981	device for electron microscope		
13	Data processing and printer	1		use with liq. chromatograph LC-3A		
14	Detector: UV/VIS spectrometric	1		use with liq. chromatograph LC-3A		
15	Detector: fluoremetric	1		use with liq. chromatograph LC-3A		
16	Detector: refractive index	1		use with liq. chromatograph LC-3A		
18	Furnace: high temp & vacuum	1	1981	temp. max 2400 C size 45 mm(ID)x70 mm(H)		before & during use
19	Gamma counting system	1	1981	radioimmunioassay study auto, detec. I-125, Co-57, Cr-5	std. calib.	before use
20	Inductive coupled plasma: ICPS-50	1	1981	liq. sol. wave. 1800-7850A with 1.8 kw generator, 27.120 MHz	std.	before use
21	Ion sputtering device	1	1981	device for electron microscope		
22	Lamp: hollow cathode	1		use with AA spectro.	standards	before use
23	Microscope: electron	1	1981	combined transmission and scanning	std.	before use
24	Microscope: scanning electron	1	1981	2 channel wavelength and spectrometers energy dispersive X-ray	Metal Replic Standards	2 times/yr
25	Minicomputer	1		36K		
26	Nitrogen analyzer: Kjedahl	1	1981	Tecator 1002 Distilling Unit micro 12		
27	Particle size distribution analyzer	1	1981	0.1-150 microns	balancing	before use
28	Reactor: plasma	1	1981	chamber 3, power 500 W, oscillating freq. 13.59 MHz		

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
29	Scanner: thin layer chromatograph	1	1981	high speed, wavelength 200-630nm		
30	Soxhlet fat extractor	1	1981	tecator soxtec HT 6		
31	Spectrofluorophotometer; dual beam	1	1981	sys, wavelength 220-700 nm,	quinine sulfate	before use
32	Spectrometer: GC/Mass	1	1981	double focusing	perfluorokerosine	before use
33	Spectrometer: nuclear magnetic resol.	1	1981	observe isotopes, controller	ethyl bezene heavy waste	before use
34	Spectrometer: vacuum emission	1	1981	composition analysis of ferrous alloys	std.	before use
35	Spectrometer: X-ray fluorescence	1	1981	energy dispersive	detector resolution	1/yr
36	Spectrometer: X-ray fluorescence	1	1981	wavelength dispersive X-ray	peak position & std. calib.	before use
37	Spectrophotometer: UV/VIS	1	1981	wavelength 190-900 nm	didymium filter	before use
38	Spectrophotometer; UV/VIS	1	1981	wavelength 190-900 nm	holmium filter	before use
39	Spectrophotometer: atomic absorption	1	1981	for non-metals(27)	standards	before use
40	Spectrophotometer: infrared	1	1981	wavelength 5000-300 cm	polystyrene film	before use
41	Spectrophotometer: microflow	1	1981	wavelength 330-900 nm	pottasium dichromate	before use
42	Thermal analyzer: differential	1	1981	with DIA, DSC, TGA, EGA	std.	2 times/yr
43	Ultramicrotome	1	1981	device for electron microscope		
44	Universal Testing Machine: 10 tons	1	1981	revers. tension & compress. load 1gf-10000 kgf	weight calibration	1/month
45	Viscometer: Money	1	1981	automatic, viscosity 0-200 M		

List of Test Equipment (TISI) CERTIFICATION DIVISION

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
1	Balance, analytical	1	2 yr	Sauter weighing 200 g, readability 0.1 mg		
2	Balance, analytical	1	2 yr	Sartorius weighing 202g, readability 0.1 mg		
3	Digestion tester	1	5 yr	digest fiber of tapioca prod.		
4	Furnace, muffle	1	5 yr	temp. max 1200 c, readability 10 c		
5	Furnace, muffle	1	5 yr	temp. 93-1093 c, acc. 5.5 c		
6	Hot plate	2	1 yr	heater		
7	Moisture tester	2	3 yr	Brabender temp.max 170 c, acc. 0.1%, moisture maax 25%		
8	Oven	1	5 yr	temp. 40-260 c, readability 10 c		

List of Test Equipment (TISI)　STANDARDIZATION DIVISION

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
1	Abrasive tester	1	1983			
2	Acc light exposure & weathering machine	1	1984	rad. intensity 820 W/sq.m in wave 300-830 nm		
3	Balance	1	1982	weighing 2 kg, sensitivity 0.1 g		
4	Balance: analytical	1	1982	weighing 160 g, sesitivety 0.01 g		
5	Balance: mechanical	1	1984	max.30 kg, grad. 100 g		
6	Bath ; shaker	1	1984	27 cu. dm		
7	Bending testing machine	1	1983			
8	Bicycle frames tester	1	1982	235N		
9	Blender	1	1982	speed 7500/8000/9500/10500 rpm		
10	Board: control	1	1983	0-500 V, 0-200 A		
11	Centrifuge	1	1982	4000 rpm		
12	Chamber: temperature & humidity	1	1984	temp.5-95 c, hum. 20-98% RH		
13	Cleaner; ultrasonic	1	1983	tank cap. 10.4 cu.dm, frequency 6.7 kHz		
14	Coating thickness gauge	1	1984	non-conduct on non-mag.metal high 0-100 um, low 50-500 um		
15	Coating thickness gauge	1	1984	non-mag. coat on mg. material high 0-100 um, low 50-500 um		
16	Colorimeter	1	1985	mea.sys.X,Y.Z., mea.geo.2x45-0 std.observer 2, std.light C and A		
17	Comparator: pocket	1	1983			
18	Counter: magnetic	1	1983	AC-220V,10IMP/S		
19	Distillation apparatus	1	1983	4 l/h		
20	Finger: std. test finger	1	1983			
21	Furnace	1	1981	min.temp.1200 c		
22	Heating mantie	2	1982	450 c		
23	Hot plate	1	1982	450 c		
24	Hydraulic testing machine	1	1982	hydraulic expansion test 10 MPa, water jacket		
25	Indicator ; dial	1	1983	0.001-5 mm		
26	Insulator tester	1	1983	2000 V/5000 M		
27	Ion analyzer	1	1982	conc. 0.001-999 pH 0.000-13.399,mV -999.9 to +999.9		
28	Multimeter	1	1983			
29	Nitrogen & protein analyzer: Kjeldahl	1	1984	micro digest up to 6 sample		
30	Oscilloscope	1	1983	20 MHz		
31	Oven: universal	1	1981	temp. 5-300 c		
32	Regulator: slide	1	1983	10 KVA, 0-260 V		
33	Shaker: test sieve	1	1984	8 sieves, dia. 200 mm		

No.	Name of equipment	Qty	Production date	Specification	Calibration method	Calibration frequency
34	Shock absorbtion tester	1	1982			
35	Spectrometer	1	1982	wavelength 200-850 nm	as in manual	
36	Thermometer: digital	1	1983	-50 to 999 c		
37	Thickness indicator: ultrasonic	1	1983	Thickness 1.0-200.0 mm		
38	Transformer: high voltage	1	1983	1 phase, KVA, 50 Hz 220-4000 V		
39	Universal Testing Machine: 30 KN	1	1986	tension force 0.05N-30KN, speed 0.01-100mm/min		
40	Water bath	1	1981			
41	Wattmeter	1	1983	1 phase, 0-1.2 kW		

(5) *Testing Capabilities of Designated Test Laboratories*

The TISI divides test items of industrial standards into chemical, mechanical, physical, miscellaneous and bio-chemical, and designates different test laboratories for individual test items.

On such designation, technology and equipment owned by each test laboratory are used as the basic criteria. Some test laboratories are thus not authorized to handle certain test items required under the standards, as shown in Table 3.5.2-16. Such test items, therefore, have to be carried out by other test laboratories, making the testing procedure inefficient.

Table 3.5.2-16 List of Test Laboratories with Experience in Industrial Standard Testing but not Designated for Certain Test Items

TIS No.	Category	Item	Test labs. not designated for certain test items
78	Chemical	Laundry detergent powder	TISTR, DMS
207	Chemical	Liquid chlorine	DSS
356	Chemical	Lubricating oil	FOD
337	Chemical	Refined glycerine	TISTR
340	Mechanical	Exhaust systems	TISTR
27	Mechanical	Liquified petroleum gas cylinder	DMR
370	Mechanical	Liquified petroleum gas cylinder	DMR
385	Mechanical	Room air conditioners	FECU
86	Electrical	Aluminium conductors	MEA, PEA
293	Electrical	PVC insulated aluminium cables	TISTR
384	Electrical	Power transformers	MEA
354	Electrical	Insulators	PEA
132	Consumer products	Canvas shoes	TTO, DIP
523	Consumer products	Leather safety footwear	TTO
452	Consumer products	Letterpress and offset printing ink	TTM
345	Consumer products	Mosquito coils and sticks	DOA
353	Consumer products	Office steel storage cabinets	DSS
531	Consumer products	Plastic containers for sterile pharmaceuticals	DSS, DMS
216	Consumer products	Rigid PVC conduit for electrical wiring and telephone cables	DSS
451	Consumer products	Stainless steel wares	DMR

TIS No.	Category	Item	Test labs. not designated for certain test items
410	Consumer products	Stainless steel dining wares	DMR
331	Metal	Aluminium and aluminium alloy plates and sheets	TISTR, DMR
382	Metal	Cast iron: butterfly valves	TISTR, DMR
383	Metal	Cast iron check valves	DSS, DMR
431	Metal	Copper alloy gate valves	DMR
427	Metal	Electrically welded steel water pipe	DMR
348	Metal	Low carbon steel wire rods	DMR
49	Metal	Mild steel covered arc welding electrodes	DMR
194	Metal	Ordinary wires	DMR
24	Metal	Steel bars for reinforced concrete: deformed bars	DMR, DHW
20	Metal	Steel bars for reinforced concrete: round bars	DMR, DHW
95	Metal	Steel wire for prestressed concrete	DMR
116	Metal	Structural steel sections	DSS, DMR, CCU
449	Metal	Suspended ceiling steel grids	DMR
343	Metal	Water taps	DMR
188	Construction	Gypsum plaster for building purposes	TISTR
133	Construction	White portland cement	TISTR
520	Non-metal	Automotive nitrocellulose lacquer thinner	MSD
327	Non-metal	Gloss enamel paints	TISTR
496	Non-metal	Lacquer thinner	NSD
357	Non-metal	Priming paints for woodwork	DHW

Source: TISI

(6) Testing Equipment of TISI

The TISI only carries out factory inspection and does not conduct industrial standard tests under the TIS mark system, these tests being entrusted to other testing organizations. As shown in Table 3.5.2-15, the test equipment possessed by the TISI is limited to chemical analysis equipment related to the inspection of tapioca and standard development.

(7) Test Demand Prediction and Test Equipment

Assuming that the number of tests increases by 700 per year based on the actual increases in the 3-year period between 1984 and 1986, the number of tests in each field in 5 years' time and the increment on the basis of proportional distribution are shown in Table 3.5.2-17.

Table 3.5.2-17 Number of Tests (1984 - 1986 Average)

Category	No. of tests	After 5 years	Increment
Chemical	228	418	190
Mechanical	321	588	267
Agricultural products	490	898	409
Plastics	22	41	19
Electrical	628	1,152	524
Consumer products	419	768	349
Pulp/paper	29	53	24
Metal	871	1,597	727
Civil engineering	517	948	431
Construction	172	316	144
Textiles	3	5	2
Non-metal	212	389	177
Foods	275	505	230
Electronics/ communications	8	15	7

Further, the number of days required in testing for conformity with industrial standards was studies for those among the 38 standards for which TISI had indicated their target periods for testing. Among the tests calling for the use of testing equipment, those for which the longest periods were needed were picked out for the study.

Assuming the annual number of working days to be 300, this number was divided by the periods required for the tests requiring the longest periods, then obtain the number of tests performable in 1 year. Taking as 700 the annual increase of the testing workload, based on actual records for 1984 - 86, the expected increases after 5 years to be expected of the annual number of tests for the 38 standards in question were derived, and these values were divided by the number obtained above the tests performable in a year, to yield what is presented in Table 3.5.2-18.

Table 3.5.2-18 Ratio of Expected Increment against Number of Tests Possibly Handled per Year

TIS standard	Category	Number of tests handled per year	Increment	Ratio
7	Electrical	43	4	0.10
11	Electrical	43	178	4.16
17	Consumer products	100	84	0.84
20	Metal	300	150	0.50
23	Electrical	25	143	5.76
24	Metal	300	236	0.79
27	Mechanical	60	82	1.37
30	Chemical	150	1	0.01
49	Metal	100	15	0.16
64	Electrical	43	2	0.05
78	Chemical	150	69	0.43
86	Electrical	43	6	0.13
92	Electrical	150	10	0.07
93	Mechanical	150	10	0.07
118	Electrical	43	15	0.34
146	Mechanical	300	4	0.01
196	Mechanical	60	12	0.20
211	Metal	300	170	0.57
226	Electrical	43	7	0.17
236	Electrical	60	25	0.42
248	Metal	150	3	0.02
254	Mechanical	150	2	0.02
276	Metal	150	2	0.02
279	Electrical	60	10	0.16
291	Mechanical	300	7	0.02
293	Electrical	43	41	0.95
300	Mechanical	300	1	0.01

TIS standard	Category	Number of tests handled per year	Increment	Ratio
309	Consumer products	150	124	0.82
325	Metal	300	1	0.01
343	Metal	300	1	0.01
366	Electrical	150	10	0.07
369	Mechanical	100	4	0.04
476	Pulp/paper	60	7	0.12
496	Non-metal	150	56	0.37
520	Non-metal	150	33	0.22
531	Consumer products	21	4	0.18
539	Chemical	150	2	0.01
540	Chemical	150	19	0.12

The ratio of increment against the total number of tests handled per year indicates how many sets of test equipment have to be installed for the increment. According to Table 3.5.2-18, the ratio is smaller than 1 for most standards since each increment is small. The number of tests for some standards is expected to increase by 6 times. It is found, however, that all standards with the expected increment ratio of 1 or greater allow simultaneous testing of multiple products. Therefore, one set of test equipment should be sufficient for each standard, considering the duplication of test items between similar standards.

(8) Manpower, Education and Training

The number of technical staff at six designated testing laboratories, including the DSS, and educational background of the technical staff are given below.

DSS

	Master	Bachelor
Chemistry	9	47
Bio-chemistry	4	4
Food	7	4
Industrial		2
Physics		1
Mechanical		1
Others	10	27

Diploma 15
Certificate 1

Total 132

Faculty of Engineering, Chulalongkorn University

	Doctor	Master	Bachelor
Industrial	49	50	15
Others			1

Diploma 18
Certificate 4
Under Certificate 8

Total 145

MEA

	Master	Bachelor
Dynamics	1	2
Electric power	1	
Electric		4

Diploma 14

Certificate 2

Total 24

PEA

	Bachelor
Mechanical	1
Dynamics	2
Others	2

Diploma 10

Total 15

CCU

	Doctor	Bachelor
Chemistry		6
Bio-chemistry		5
Industrial		2
Standard		1
Others	2	1

Total 17

DHW

	Bachelor
Chemistry	7
Others	7

Diploma 9
Certificate 2

Total 25

Of the above, there are 51 staff members with a doctor's degree, 82 staff members with a master's degree and 142 staff members with a bachelor's degree, meaning that those with a high educational background of college graduation or higher account for 76.8% of the total number of technical staff.

The breakdown of the highly educated staff in terms of their specialized fields is as follows. Those related to chemistry (including foods, bio-chemistry and pharmacology) amount to 95, accounting for 34.5% of the total. The staff level in mechanical engineering, metallic, and electric fields where testing demand is expected to increase is rather insufficient. Some 10% of them have experience of study in foreign countries, including Japan.

Of 4,952 tests conducted in 1986, the six testing laboratories mentioned above handled 3,434 tests. If 842 tests handled by 33 staff of the TISTR are added, the sum would amount to approximately 86% of all tests conducted in that year. The average number of tests conducted per staff was 10.9 however, which indicates the poor testing efficiency. In Japan, the relevant figure is 40-50. This gap could be attributed to the immature testing skill, inadequate understanding of test procedures, absence of developed test processing system, etc. on the part of Thailand. The on-the-job training at each testing laboratory constitutes the main training method for the testing staff and systematic and well planned education/training is not provided.

In terms of the system itself, it will be necessary to establish a testing staff qualification system to guarantee the status of the staff so that the testing capabilities of the staff the and testing reliability can be improved.

3.5.3 Tests Conducted by TISTR for R & D Purposes

(1) Roles of TISTR

The TISTR was founded under the Thailand Institute of Scientific & Technological Research Act B.E. 2522 in 1963 as a public corporation under the jurisdiction of the Ministry of Science, Technology and Energy (MOSTE), and is engaged in activities related to R & D with the following powers and objectives:

(a) to co-operate with other agencies, whether they are state or private agencies, with respect to the activities relating to scientific and technological research and utilization of the research results;
(b) to provide for and maintain the national physical standards for the purpose of measuring various quantities and qualities;
(c) to collect and propagate the scientific and technological information;
(d) to co-operate with other countries, organizations or other foreign agencies in scientific and technological activities.

The structure of the TISTR is shown in Fig. 3.3.2-1, and the Testing & Standard Centre (TSC) has the following functions:

(a) to provide testing and inspection services for national and private enterprises and educational institutions;
(b) to provide calibration services for national and private enter-

prises and educational institutions, using the primary and secondary standards maintained by the Institute;

(c) to provide guidance to private enterprises on quality control of industrial products.

The Centre owns and operates the following 5 metrological laboratories.

Electric & Electronic Standard Laboratory
Mechanical Engineering Laboratory
Photometric & Thermometric Laboratory
Analytical Chemistry Laboratory
Bio-chemistry Laboratory

The relationships between R & D and industrial standards and that between industrial level and products are as follows. First, standardization and the adjustment of the industrial level, etc. are promoted by industrial standards, resulting in the upgrading of the industrial level. The upgraded industrial level promotes the development of new products with adequate international competitiveness by leading manufacturers. As these products can satisfy standards in advanced nations, they trigger further upgrading of the industrial level and become the prime mover to push up the level of industrial standards. By repeating such processes, the industrial strength of the entire nation will be further boosted.

The relationship between R & D and testing in terms of the flow of product development is shown in Fig. 3.5.3-1.

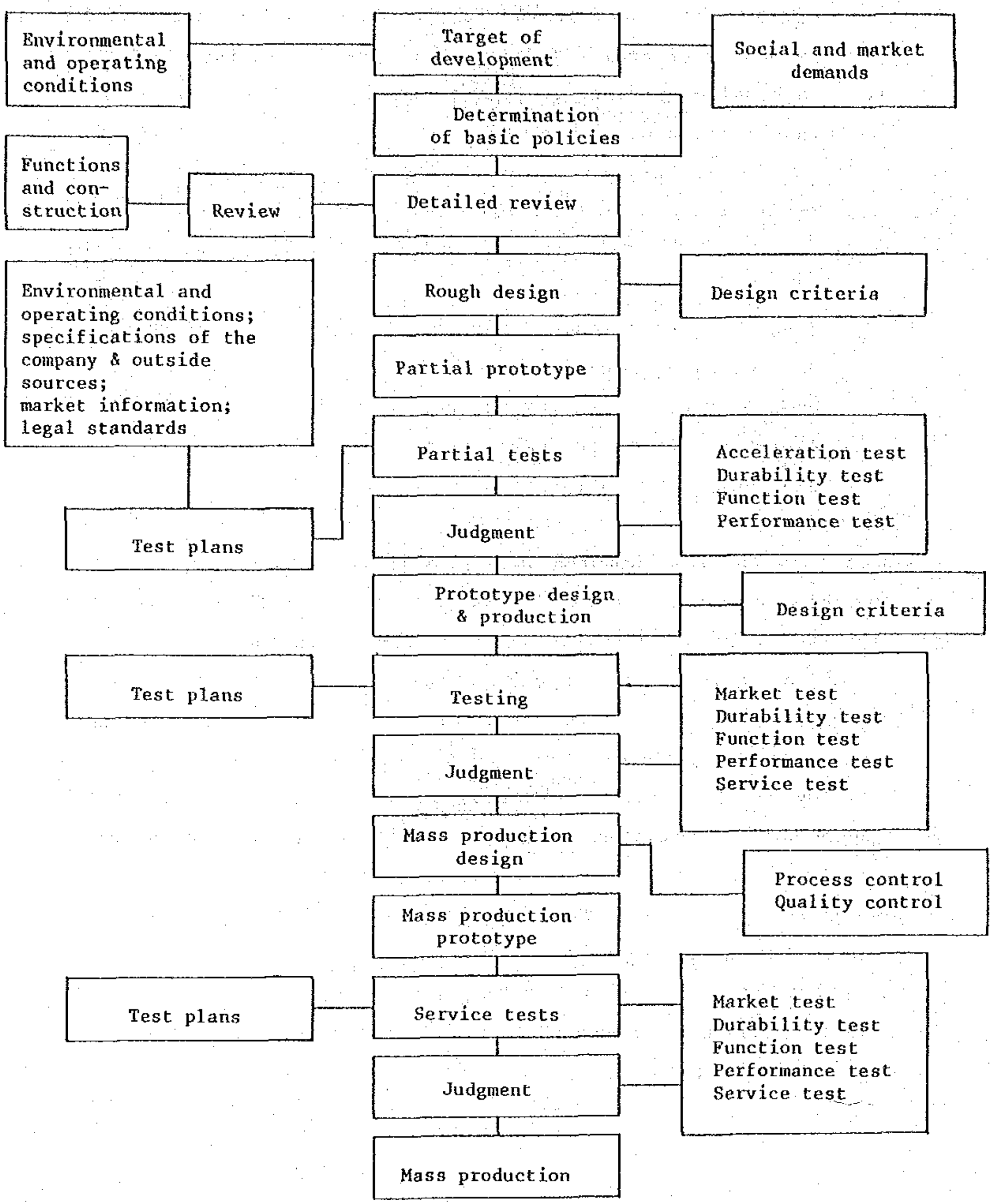


Fig. 3.5.3-1 Product Development and Testing/Inspection

In regard to product development, proper evaluation of the product should be carried out by testing it at different stages. As a result, an appropriate product can be developed in an economical manner through cost reduction and promotion of standardization such as to ensure interchangeability of parts. In this regard, various tests to be conducted at every stage of R & D play a crucial role for the expansion of market by providing a variety of product and/or the development of a product that can cope with international and foreign standards.

(2) Entrusted Tests and Applicable Standards

Standards used by the testing laboratories in Thailand are not only Thai industrial standards but also foreign and international standards listed in Table 3.5.3-1. This is due to the fact that such standards are applied when the certificate shows conformity of the product to an applicable foreign or international standard is required, or that their application is requested by a manufacturer for the development of a new product.

Table 3.5.3-1 Applicable Standards in Thailand

	Electric & electronic	Mechanical engineering	Photometric & thermometric	Analytical chemistry & bio-chemistry
TIS	+++	+++	+	+++
ASTM	-	+	-	++
IEC	++	-	-	-
JIS	+	+++	+++	+
BS	+	+	-	+
DIN	-	-	-	-
ISO	-	++	-	-
AOAC	-	-	-	+++
FTMS	-	-	-	+
USP	-	-	-	+
IUPAC	-	-	-	+++

+++ Very often used
++ Often used
+ Sometimes used
- Not used

TIS : Thai Industrial Standard
ASTM : American Society for Testing Materials
IEC : International Electrotechnical Commission
JIS : Japan Industrial Standard
BS : British Standard
DIN : Deutsche Industrie-Norm
ISO : International Organization for Standardization
AOAC : Association of Official Analytical Chemistry
FTMS : Federal Test Method Standard
USP : United States Pharma Copiea
IUPAC: International Union of Pure & Applied Chemistry

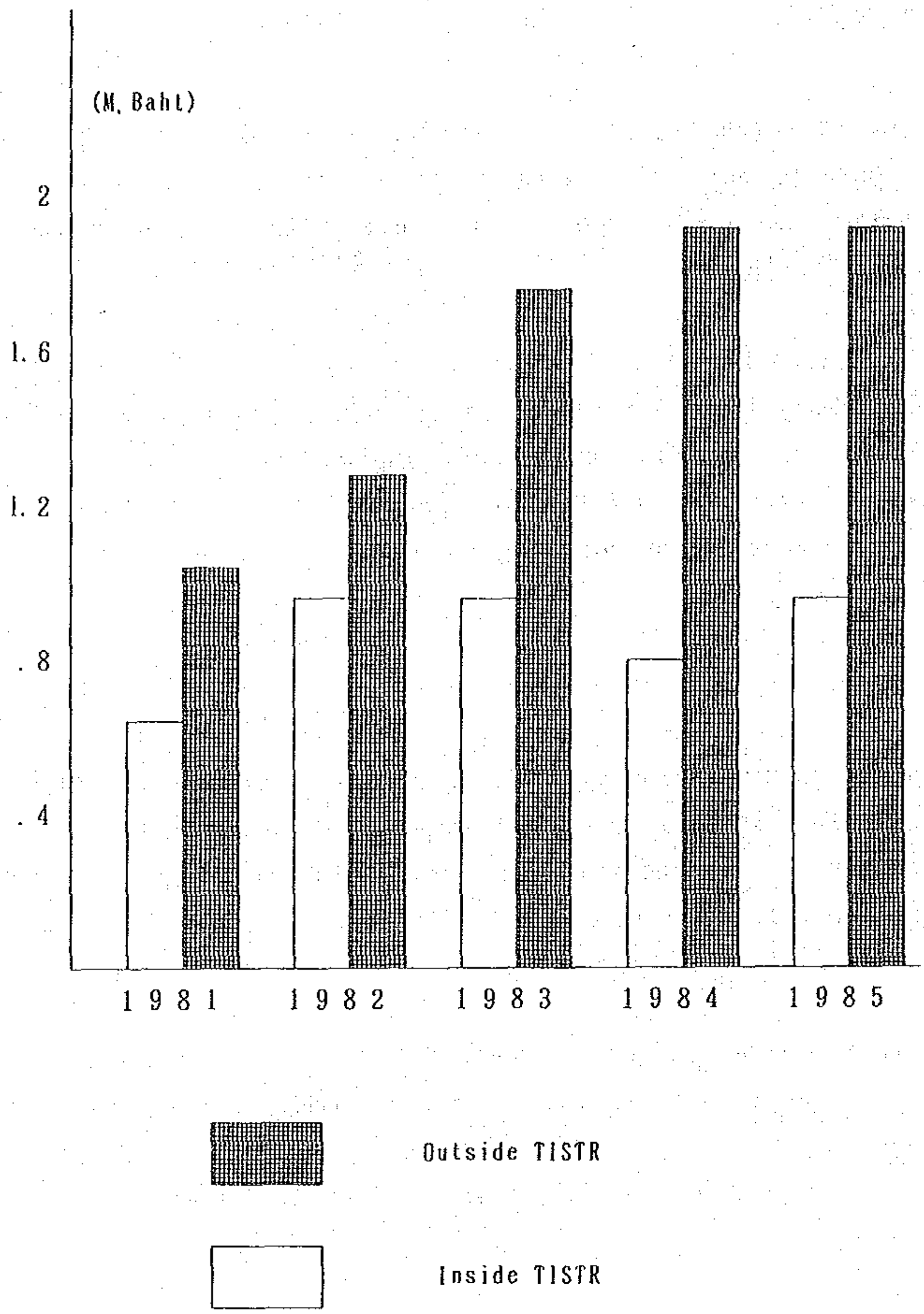
The TISTR/TSC carries out not only its own tests pursuant to TIS standards but also tests entrusted by government institutions or private companies, using the international standards or criteria mentioned above.

The product R & D flow is already given in Fig. 3.5.3-1. It is necessary for all testing laboratories to improve the arrangement of standards, criteria and reference documents for easy access in view of the fact that R & D efforts necessitate a great deal of reference work concerning standards and criteria of various fields.

(3) Transition of the Number of Entrusted Tests

The TISTR/TSC carries out not only its own testing but also metrological calibration services at its Electric & Electronic Standard Laboratory, Mechanical Engineering Laboratory and Photometric & Thermometric Laboratory. Two other laboratories of the TSC carry out testing only.

The business results of the TSC during the period from 1981 to 1985 are shown in Fig. 3.5.3-2. As the income amounted to some 3 million baht in 1985, almost doubling the figure for 1981, it is inferred that the number of requests accordingly increased.



Source: TISTR

Fig. 3.5.3-2 Testing & Standards Centre Service Values (1981 - 1985)

(4) Current Status of Test Equipment/Facilities and Testing Capabilities

Test equipment and facilities possessed by the TISTR/TSC are listed in Table 3.5.2-15 . According to the list, the equipment consists mainly of basic instruments such as voltmeters, ammeters, multimeters, etc., without a sufficient amount of special equipment. Although the special test equipment held by the R & D Division of the TISTR is used for testing, the shortage of test equipment in terms of both quantity and quality cannot be denied for the overall organization of the TISTR. Although tests are being done with the limited equipment, such adverse effects as the prolongation of testing, difficulty in ensuring accurate test results, etc. are observed. Calibration of the test equipment is also insufficient. The equipment is also far from an adequate level for the development of appropriate standards and, thus, it is difficult for Thailand to develop such standards by its own accord.

(5) Prediction on Test Demand and Test Equipment/Facilities

The number of tests for R & D is likely to increase in accordance with the progress of industry. The annual growth of Thai industry is estimated to be 6.6% in the 6th 5-Year Plan. However, 8% annual growth should be considered for the R & D tests since such tests constitute the basis of the industrial growth. In 5 years' time, therefore, the demand for testing is anticipated to grow by 1.5 times the present demand. The equipment currently held by the TISTR/TSC appears to be unable to cope with the present or future demand.

(6) Manpower, Education and Training

The TISTR/TSC currently has 49 staff members who are assigned to different departments as listed below.

Department	Testing	Measurement	Others
Central Service			6
Electric & Electronic Std. Lab.	5	4	
Mechanical Engineering Lab.	10	3	
Photometric & Thermometric Lab.	1	3	
Analytical Chemistry Lab.	12		
Bio-chemistry Lab.	5		
Total	33	10	6

Of the above, 28 staff members are college/university graduates.

The number of staff should be increased in the fields of electric/electronic and mechanical engineering where the test demand is expected to grow in the future. Tests for R & D of products do not have established criteria as in the case of industrial standard testing. Therefore, the test methods and evaluation criteria should be developed by studying products from various viewpoints. Significant shortage is also found in manpower level to fulfill this purpose. Since education and training for the testing consist of on-the-job training rather than special programmes, considerable time is necessary to educate technical staff so that they can understand the systematic concept of R & D and acquire testing skills with the ability to apply them in practice. Therefore, a systematic as well as flexible training system must be developed.

3.6 Current Status and Problems of Metrological Standards

The 6th 5-Year Plan became officially effective on October 1, 1986.

Major objectives include the enhancement of international competitiveness through improvements in productivity and quality and through reinforcement of technological strengths, promotion of exports and the consolidation as well as development of basic science and technology which play vital roles for national development.

It goes without saying that improvements of Thai industry and product quality require the balanced development of the following items.

(1) Introduction and development of new technologies
(2) Improvement of production control technology
(3) Improvement of quality control technology
(4) Consolidation of industrial standards
(5) Enhancement of testing technology
(6) Maintenance and calibration of standard models
(7) Improvement of processing technology
(8) Improvement of material quality.

Establishment of metrological standards and improvement of traceability system as parts of the basic technology are indispensable for both the development and improvement of science, technologies and industrial engineering. The following discussions will focus on the metrological standards and the calibration system.

3.6.1 Current Status of Legal Metrological System

3.6.1.1 Outline of the Law of Weights and Measures

Thailand enacted the Law of Weights and Measures on December 17, 1923, in order to ensure the implementation of appropriate metrology mainly in commercial areas for the unification of metrological units, and established the registration system for manufacturers of weighing and measuring instruments and the inspection system for such instruments in order to ensure the supply of accurate instruments.

The system of the Law of Weights and Measures consists of the following items.

PREAMBLE	
TITLE I	Preliminary
TITLE II	Definitions of Units
TITLE III	Manufacture, Importation and Sale of Weighing and Measuring Instruments
TITLE IV	Verification
TITLE V	Proceedings and Penalties
TITLE VI	Miscellaneous

Furthermore, eight Ministerial Regulations have been enacted based on the Law.

The outline of the said law is given below.

(1) Metrological units

Thailand became a member nation of the Convention of Meter in 1912, and uses metric units in principle, while units that have been used customarily over many years are also officially recognized as legal metrological units. For exportation and importation, the use of metrological units employed in other nations concerned is also accepted.

Metrological units in Thailand are defined for 5 kinds of values - length, area, volume, mass and capacity with the standards based on the "Prototype of the Metre" and the "Standard Prototype of the Kilogramme" provided to Thailand under the Convention of Meter. These prototypes are maintained by the Weights and Measures Division, Department of Commerce. The next table shows the comparison between customary units and metric units for 5 values.

Table 3.6.1-1 Customary Units and Metric Units used in Thailand

Quantity	System of unit	Name of unit	Symbol	Value
Length	Metric	Metre	m	-
	Customary	Sen Wah Sauk Keup	sn W sk k	40 m 2 m 1/2 m 1/4 m
Area	Metric	Square metre	m^2	-
	Customary	Rai Ngan Square Wah	r ng w^2	1,600 m^2 400 m^2 4 m^2
Volume	Metric	Cubic metre	m^3	-
Mass	Metric	Kilogramme	kg	-
	Customary	Standard picul Standard catty Standard carat	p c ct	60 kg 600 kg 20 kg
Capacity	Metric	Litre	ℓ	-
	Customary	Standard kwien Standard ban Standard sat Standard tanan	kw b st tn	2,000 ℓ 1,000 ℓ 20 ℓ 1 ℓ

Note: For units of the metric system, only names of respective basic units are given.

(2) Manufacture, Importation, Sale or Repair of Weighing and Measuring Instruments

(a) Any person desirous of carrying on the business of manufacture, or importing, or selling weighing or measuring instruments, must apply for a license for that purpose to the Minister of Commerce.

(b) The scope of weighing and measuring instruments covers "Weighing Instrument", "Measuring Instrument of Length" and "Measuring Instrument of Capacity or Volume". Furthermore, weighing instruments are classified into 5 types of "Weighing Instruments (scales/balances)", "weights" and "for Dry Materials" under the Ministerial Regulations enacted separately from this Law.

For the purpose of registration mentioned in (a) above, the instruments are classified into 2 categories of weighing instruments and other instruments.

(3) Verification of Weighing and Measuring Instruments

(a) There are 2 types of verifications - the verification to be done at the initial stage after the manufacture or importation is referred to as "initial verification", while the periodic verification or the re-verification for an instrument in use is referred to as "secondary verification".

(b) All weighing and measuring instruments to be used in business transactions, etc. must bear the verification mark to show that they were subjected to verification at the initial stage and passed the verification test. Those without the verification mark constitute an offence under the Law and their sale is prohibited.

(c) Weighing and measuring instruments repaired by a repairer cannot be returned to their original owners or offered for sale unless they go through the secondary verification and pass the verification test.

(d) Every manufacturer, importer or repairer of weighing and measuring instruments must have a private mark which must be registered and affixed to such an instrument before submitting it for verification.

(e) Verifications are to be conducted to verify whether the a) type, b) construction and material, and the c) allowable error (tolerance) of the instrument conform to the requirements set forth in the Law and the Regulations. The verification test on the tolerance is to be done by comparison with the standard prototype concerned.

(f) Those registered in relation to weighing and measuring instruments and the traders using the instruments are subject to inspections twice a year and premise inspections as called for.

3.6.1.2 Legal Metrological Institution

The Weights and Measures Division, Department of Commercial Registration of the Ministry of Commerce is responsible for the enforcement of the Law of Weights and Measures. As shown in Fig. 3.6.1-1, the Division consists of the General Affairs Section, Registration Sub-Division, Verification Sub-Division, Inspection Sub-Division and 23 provisional branch offices. A total of 185 people are engaged in the registration of metrology-related businesses, maintenance of verification standards, verification of weighing and measuring instruments, regular inspections and premise inspections. The Divisions is also responsible for safely keeping the Prototype of the Kilogramme and the Prototype of the Meter provided to Thailand under the Convention of Meter.

(Department of Commercial Registration,
the Ministry of Commerce)

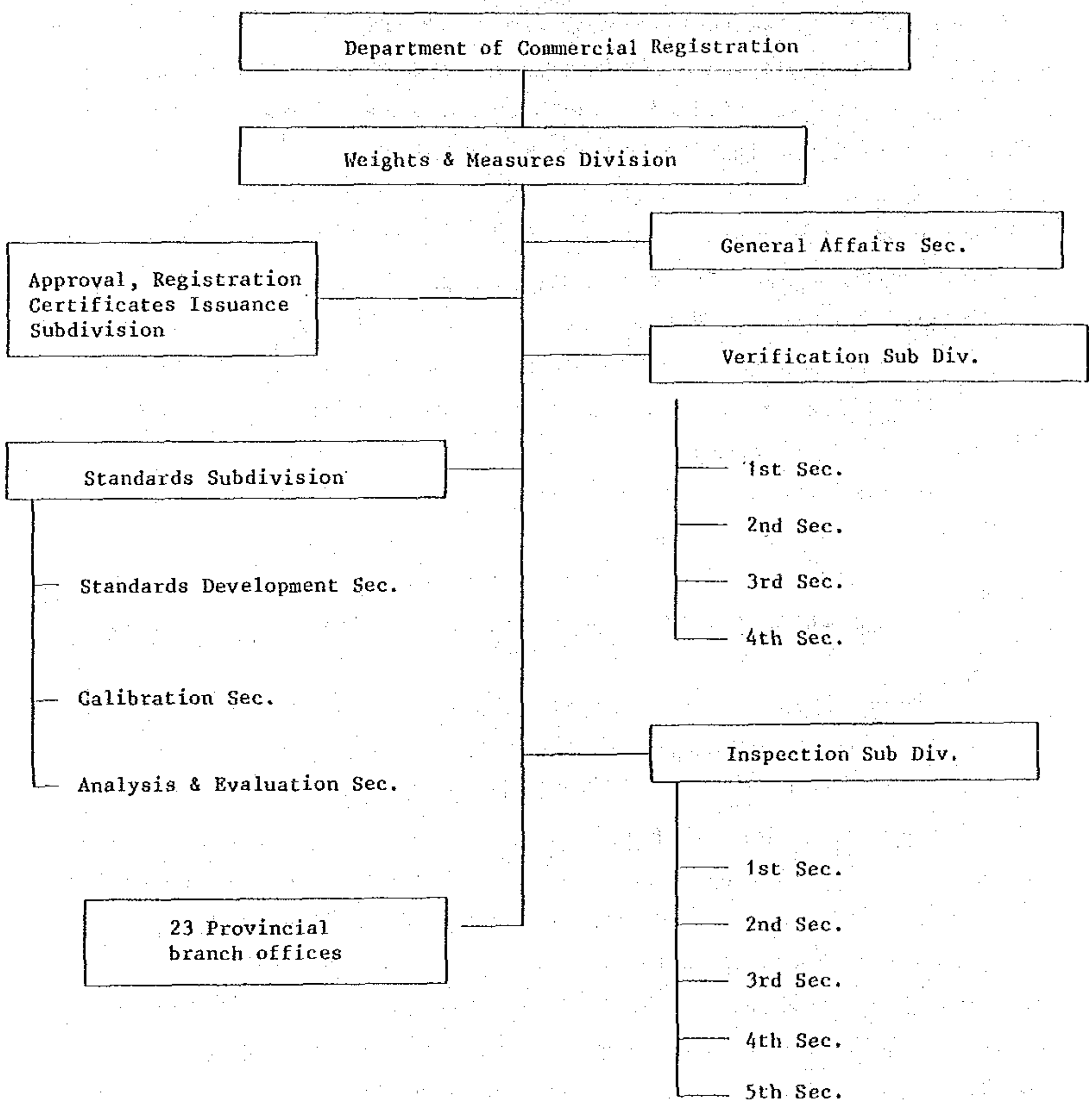


Fig. 3.6.1-1 Organization of Weights and Measures Division

3.6.2 Problems of Legal Metrological System

Although no specific problems are seen in the current legal metrological system consisting of the registration system and the verification systems, etc., the following items should be examined in accordance with the recent development of Thai society, economy and industrial technologies.

(1) Metrological Units

(a) Although only 5 types of values - length, mass, areas, volume and capacity - are prescribed under the existing law, the scope of legal metrology has recently been extended to include temperature, pressure, density and electrical units, etc. Accordingly, the present provision has become insufficient.

(b) The (international) definition of the unit of length "metre (meter)" was changed from that of the "Prototype of the Meter" to a physical definition by the wavelength of light in 1960, then changed again to the velocity of light adopted by the 17th Conference General des Poids et Mesures (CGPM) held in 1983. Therefore, the Prototype of the Meter lost its position as an international prototype and simply became a standard instrument.

(c) The unit of capacity "litre (liter)" is separately defined (in the Law) as "the volume of one kilogramme of pure water, free from air, at the temperature at 4° Centigrade, under normal atmospheric pressure" from the volume of a "square meter". At the Comite International des Poids et Mesures (CIPM) held in 1964, however, it was decided that the "litre" was a special designation of "cubic decimeter".

(d) Thailand has not yet adopted the SI Units which are the rationalized system of metric units and which are being increasingly accepted by many countries.

(2) Legal Weighing and Measuring Instruments

At present, legal weighing and measuring instruments have been introduced for length, mass and volume. This scope of the legal metrology is rather limited in view of the expanding scope of legal metrology in recent years.

(3) Standard Metrological Instruments

It is stipulated that the instrumental error test of individual weighing and measuring instruments for verification be done by comparing them to each standard concerned, but explicit provisions on standards are not found in the Law of Weights and Measures.

Standards for verification are generally referred to as "Verification Standards", for which a higher precision is required than ordinary weighing and measuring. In order to ensure this high precision, these verification standards must be calibrated periodically by the standards of higher precision. The Laws of Weights and Measures lacks provisions of the precision, performance, frequency of calibrations, etc. for such standards of higher status.

(4) Qualifications of Verification Officers and Their Training

Verification officers who verify weighing and measuring instruments pursuant to the Law of Weights and Measures are administrative officers to judge the verification test results, and must have the capability to interpret and administer related laws and regulations, extensive knowledge on verification techniques and technological capabilities. It is necessary to establish a system to carry out systematic education on basic knowledge of metrology and training on the verification techniques for newly appointed officers, in addition to the on-the-job training. Furthermore, it is also necessary to carry out training on new metrological equipment and verification techniques to raise the capability of those officers.

The Law of Weights and Measures does not have provisions on qualifications of verification officers and their education/training system.

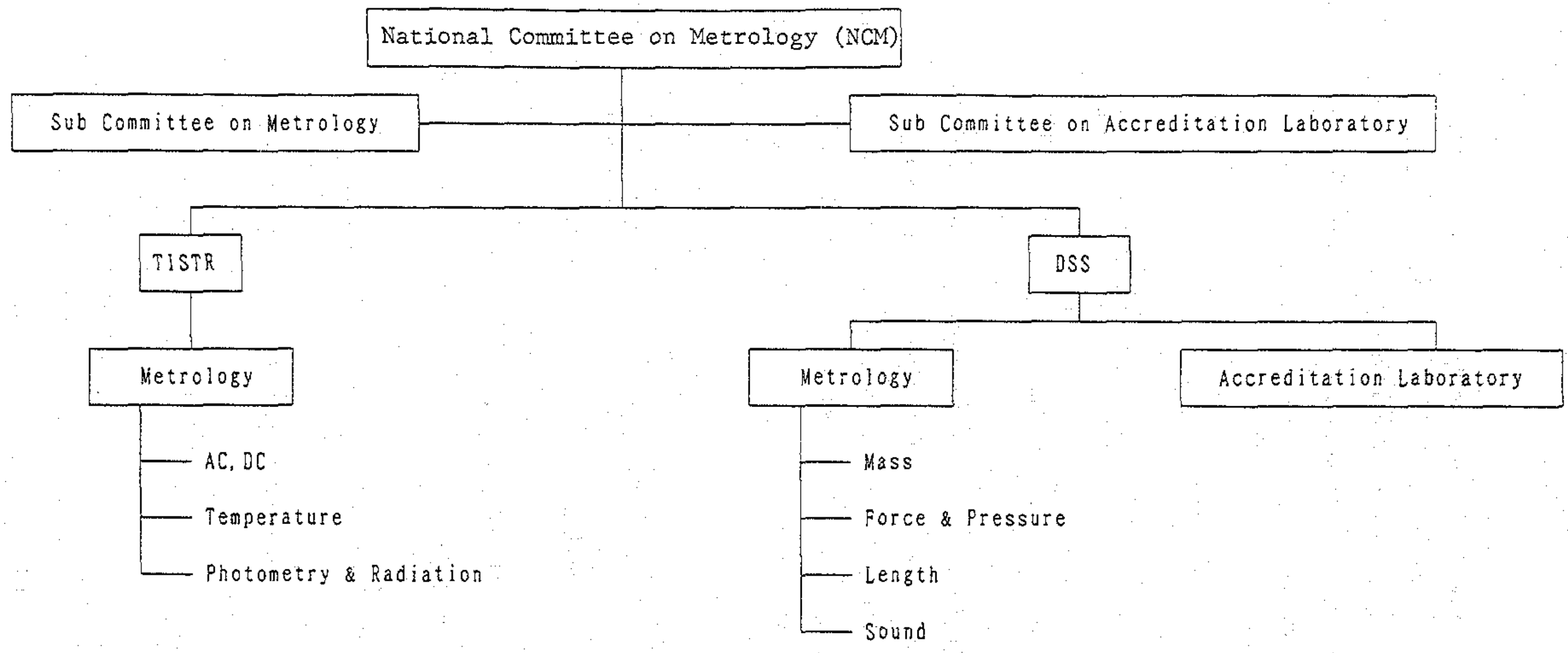
3.6.3 Current Status of Industrial Metrological Standards

3.6.3.1 National Committee on Metrology (NCM)

Thailand had no central organization to establish, maintain or provide national standards, and responsibilities for metrological standards were divided among different ministries in the past. In this regard, the National Committee on Metrology (NCM) was founded in 1985 as the highest decision-making organization on metrological standards to coordinate these different ministries.

(1) Structure of the Committee

As shown in Fig. 3.6.3-1, NCM consists of members that are representatives (vice-ministers) from 7 ministries including the Ministry of Science, Technology and Energy, Ministry of Industry and Ministry of Commerce, and the Permanent Secretary from the Ministry of Energy acting as the chairman of the NCM.



Members of the National Committee on Metrology

1. Permanent Secretary of Ministry of Science Technology and Energy
2. Representative from Ministry of Agriculture and Cooperatives
3. Representative from Ministry of Public Health
4. Representative from Ministry of Industry
5. Representative from Ministry of Commerce
6. Representative from Ministry of University Affairs
7. Representative from Ministry of Defence
8. Representative from Ministry of Science Technology and Energy

Fig. 3.6.3-1 Thai National Committee on Metrology (NCM)

(2) Functions of the Committee

Two Sub Committees - the Sub Committee on Metrology and the Sub Committee on Accreditation - are placed under the NCM. The primary function of the former is the collection of data on metrological standards and that of the latter is the accreditation of responsible organizations for primary standards, i.e. national standards.

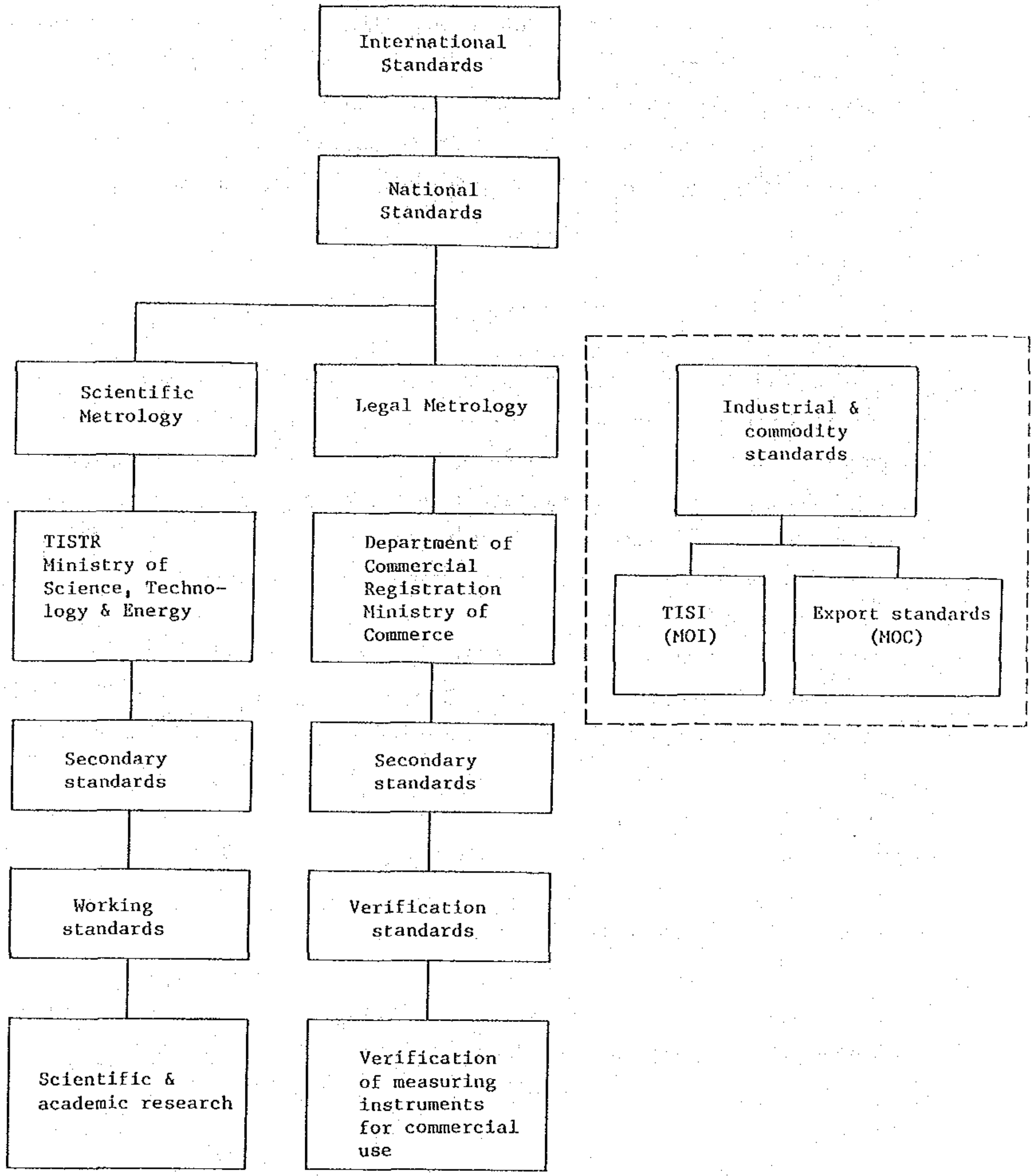
3.6.3.2 Arrangement of National Metrological Standards

The responsibilities to maintain and control the national metrological standards in Thailand have been allocated to test research laboratories of individual ministries in accordance with the historical background and technological capabilities accumulated over the years by each ministry or laboratory concerned. Owing to the recent establishment of the NCM, however, the adjustment and reconfirmation on allocated responsibilities have been made and each organization is to assume the responsibility of maintaining national standards assigned to it (Fig. 3.6.3-2). The criteria adopted by NCM in determining this assignment of responsibilities are hitorical circumstances and current equipment and technical capability.

The maintenance of prototypes of the meter (it has already lost the international significance as prototypes) and kilogramme given to Thailand under the Convention of Meter, is the responsibility of the Weights and Measures Division, the Ministry of Commerce.

Allocation of responsibilities for the maintenance and control of metrological standards in Thailand is given in Table 3.6.3-1.

System on National Metrological Standards in Thailand



Source: TISTR

Fig. 3.6.3-2 System of National Metrological Standards in Thailand

Table 3.6.3-1 Table of Metrological Standards in Thailand

Standards Unit	Prototype & primary standard	Secondary standards	Working standards
Length	DSS	DSS, TISTR	DSS, MOC
Mass	MOC, DSS	DSS, TISTR	TISTR, MOC
Electric			
DC, Low Frequency	TISTR (Japan)	TISTR, DSS	TISTR, DSS
High Frequency	TISTR (Japan)	TISTR, DSS	TISTR, DSS
Temperature	TISTR (Australia)	TISTR, DSS	TISTR, DSS
Volume, Flow	DSS	MOC	MOC
Pressure	DSS	TISTR	TISTR
Force	DSS	TISTR	TISTR
Density		TISTR	TISTR
Viscosity		TISTR	TISTR
Hardness		TISTR	TISTR
Acoustics	DSS	TISTR	TISTR
Photometry	TISTR (Japan)	TISTR	TISTR
Non-Ionizing Radiation	TISTR	TISTR	TISTR
Ionizing Radiation			AEP
Standard Gas			

Source: TISTR

AEP : Office of Atomic Energy for Peace

DSS : Department of Science Service, Ministry of Science, Technology & Energy)

MOC : Ministry of Commerce

TISTR : Thailand Institute of Scientific & Technological Research

Note 1: The underlined institutions will be responsible for maintenance and control of metrological standards in the future

Note 2: The country in brackets is providing metrological standards to Thailand.

3.6.3.3 Organizations for Maintenance and Control of National Metrological Standards

National standards should be established, maintained and provided under responsibilities of the central government as it is necessary to ensure the unification among domestic standards and their harmonization with international standards. As the establishment and maintenance of standards in particular require high technological capabilities and significant costs, national laboratories are normally engaged in the establishment and maintenance of these standards in any country.

With regard to industrial metrology, the TISTR and the DSS are assigned the responsibility for maintaining and controlling the national metrological standards. As shown in Table 3.6.3-1, the TISTR is responsible for electricity, temperature, photometry and radiation, while the DSS is responsible for mass, length, pressure, force and sound. Descriptions of the metrological divisions of these two organizations are given next.

(1) TISTR

One of the TISTR's authorized duties is the establishment of national scientific standards aimed at measurements of quantities and qualities of various kinds and the maintenance and control of such standards. The Testing and Standard Centre (TSC) a division of the organization, is currently engaged in the maintenance and control of national standards on electricity (AC and DC), thermometry, photometry and non-ionizing radiation.

The organizational structure of the TSC is shown in Fig. 3.5.2-2.

(2) DSS

Although the maintenance, control and provision of metrological standards are not directly stipulated as DSS's functions and authorities, it is stipulated by the NCM that the DSS is responsible for the maintenance and control of national standards on mass, length, pressure/force and acoustics in view of the present possession of standards and technical capabilities of the DSS. The organizational structure of the DSS is already shown in Fig. 3.5.2-3.

The DSS is currently constructing a research laboratory in order to reinforce the metrological standard division.

3.6.4 Problems of Industrial Metrological Standards

(1) NCM

The authority ascribed to the NCM and its organization is still unclear, partially because of its relatively new foundation. Accordingly, it appears that the NCM is not sufficiently functioning as the highest decision-making organization for metrological standards.

(2) Arrangement of National Metrological Standards

The current status of metrological standards is far from sufficient in terms of present industrial scientific and technological levels and the levels expected to be reached in the foreseeable future. Even if the improvement measures shown in Table 3.6.3-1 are taken, it will be necessary to consider further improvement measures for each unit of standards as the next stage. With regard to the current standards improvement in accuracy, expansion of coverage, etc. are required.

3.7 Current Status and Problems of Metrological Calibration

The calibration service for industrial measuring instruments in Thailand is provided by the TISTR for government institutions, educational institutions and private enterprises, etc. pursuant to the TISTR Act. As the calibration services provided by the DSS and MOS are rather limited compared to that of the TISTR, the current status and problems of the TISTR's calibration service are discussed below.

3.7.1 TISTR

(1) Organizational Structure

As shown in Fig. 3.5.2-2, the TSC of the TISTR has 5 laboratories, 3 of which offer metrological calibration services, i.e. Electric and Electronic Standards Laboratory, Mechanical Engineering Laboratory and Photometric and Thermometric Laboratory.

(2) Staff

The TSC currently employs 49 people, of which 28 are university graduates, showing the high percentage of employees with a high educational background (see Table 3.7.1-1). Of 49 employees, 6, 12 and 31 are engaged in the general services, the metrological field and the testing field respectively.

Table 3.7.1-1 TSC Staff Distribution

	Current Number of Staff		
	University/College Education or Higher	Others	Total
Central Service	4	2	6
Electric and Electronic Standards Laboratory	3	6	9
Mechanical Engineering Laboratory	5	8	13
Photometric and Thermometric Laboratory	3	1	4
Analytical Chemistry Laboratory	9	3	12
Biochemical Laboratory	4	1	5
Total	28	21	49

(3) *Budget and Revenue of Handling Fee*

The budget of the TSC tends to increase every year as shown in Table 3.7.1-2, particularly showing a rapid increase in the last 2-3 years.

Table 3.7.1-2 TSC - Budget

(Unit: Baht)

Fiscal year	1982	1983	1984	1985	1986
Personnel cost	3,421,980	3,782,030	4,607,840	5,035,280	5,363,280
Equipment & facilities	565,000	793,600	3,241,000	2,250,000	2,255,000

The personnel cost and equipment/facility cost in 1986 were 5,363,000 baht and 2,255,000 baht respectively, showing a relatively high ratio of equipment/facility cost vis-a-vis the personnel cost.

The revenue of the TSC from the handling fees for testing and calibration services was some 1,500,000 baht in 1981 but increased to 3,000,000 bahts in 1985, doubling in the 5-year period as shown in Fig. 3.5.3-2.

(4) Overseas Training

11 staff members were sent overseas to industrial countries for education and technical training between 1973 and 1986 (Table 3.7.1-3).

The training courses included Colombo Plan, UNDP, JICA and ADAB and the host countries were Korea, Japan (NRLM and JEMIC), Switzerland, USA (NBS), Australia (NML and NATA) and Germany (PTB). The training periods varied from 1 month to 2 years. Six staff members have undergone JICA's training course.

Table 3.7.1-3 Staff Training Records of Mechanical Engineering Lab. (TISTR)

Description	Place	Under	Year	No. of Staff
Standards Engineer	Indian Standard Institute (India)	Columbo Plan	1973	1
Mechanical Standard Laboratory Organization & Operating Repair & Maintenance of Mechanical Standards	K-SRI (Korea) NRLM (Japan) SIP of GENEVA (Swiss) NBS (U.S.A.) Morchouse, Co., Ltd. (U.S.A.)	UNDP UNDP	1979 1980	2 1
Force Standards	NBS (U.S.A.)	UNDP	1980, 1981	2
Standardization & Certification	JSA, JEMIC, JMI (Japan)	JICA	1982	1
Metrology Course - Mass - Length - Force - Pressure - Volume - Flow - Density - Temperature	NRLM (Japan)	JICA	1982, 1984	2
Pressure & Force Measurement Course - Vacuum Standards - Industrial Standards - Barometry - High Pressure Standards - Force Standards - Engineering Metrology	NML (Australia) NATA (Australia)	ADAB	1986	1

Description	Place	Under	Year	No. of Staff
- Hardness Standards - Laboratory Accreditation				
Metrology Course	PTB (Germany)	CDG	1986, 1987	1

Source: TISTR

(5) Arrangement of Standard Apparatus and Calibration Equipment

Status of standard apparatus, calibration equipment, etc. currently maintained by laboratories of the TSC is as shown in Tables 3.7.1-4 - 3.7.1-8.

Levels of standards held by the TSC are as follows.

(a) Primary standards .... Electric (DC and AC: (Low and high frequency)), thermometric and photometric standards

(b) Secondary standards ..... Mass, length and pressure

(c) Working standards .... Force, hardness, viscosity and density

The maintenance and control of the primary standards for the above 3 quantities and radiation are stipulated as obligatory requirements by the National Committee on Metrology. However, no metrological equipment is available for radiation at present.

According to the TISTR Act, the maintenance of standards for all physical quantities is made obligatory but the standard apparatus other than those mentioned above are not provided for.

For quantities of sound, vibration, radiation, volume and flow, the maintenance of their standards and the implementation of the calibration services are being planned.

(6) Calibration Service Performance

Calibration services at the TSC cover on extensive range of a general weighing and measuring instruments, electronic/electric instruments, photometers and thermometers. The actual performance is, however, inadequate and the precision level is often that of instruments used on market. Actual services done in 1986 were 65 cases of instruments for physical quantities, 212 cases of electronic/electric instruments and 82 cases of thermometers.

Table 3.7.1-4 Existing Equipment in Electric & Electronic Standard Laboratory (DC)

Equipment	Manufacturer & Model	Description	Quantity
Standard Cell	YEW, 2748	1.018V	1
Standard Cell	EPPLEY, 121	Transportable	1
Electronic Standard Cell	CROPICO	1V 1.018V	1
Potentiometer	L&N, 7556	Six Dial	1
Voltage Calibrator	Fluke, 343A	10,100, 1000V	1
Voltage/Current Calibrator	YEW, 2850	1200V, 36A	1
Standard Volt Ratio Box	YEW, 2746	1500V	1
Ref. Voltage Divider	Fluke, 750A	1100V	1
Volt Ratio Box	YEW, 2744	1500V	1
Standard Current Shunt	YEW	2A	1
Differential Voltmeter	Fluke, 887AB	1-1000V	1
Constant Current Supply	YEW, 2854	Max. 100mA	1
Galvanometer	YEW, 2709	Electronic	1
Standard Resistor	L&N, -	1	1
	L&N, 4020-B	1	2
	YEW, 2781	1	1
	L&N, 4025-B	10	2
	ETL, -	100	2
	L&N, 4030-B	100	2
	YEW, 2792	1000	1
	L&N, 4035-B	1000	2
	YEW, 2792	10000	1
	YEW, 2792	1000000	1
Direct Reading Ratio Set	L&N, 4398	Six Dial	1
Wheaston Bridge	YEW, 2768	Five Dial	1
Kelvin Double Bridge	YEW, 2752	Five Figures	1
Decade Resistor	YEW, 2793-03	Max. 100MΩ	3
Digital Multimeter	-01	Max. 1KΩ	1
Digital Multimeter	Fluke 8505A		1
Voltage Divider	YEW, 2805		1
Lead Compensator	Fluke 720A	1000V	1
Null Detector	721A		1
Null Detector	845AB		1
Standard Voltage Divider	750A	1100V	1
DC. V/A Calibrator	382A		1
DC Voltage Calibrator	335A	1000V	1
Digital Multimeter	7740A		1

Source: TISTR

Table 3.7.1-5 Existing Equipment in Electric & Electronic Standard Laboratory (AC)

Equipment	Manufacturer & Model	Description	Quantity
Thermal Transfer Standard	ETL	10 V 100 V 5 mA 10 mA	2 2 2 7
Thermal Transfer Standard	Fluke 540B	1-1000V	1
Standard Watt Converter	YEW, 2885		1
Voltage/Current Calibrator	YEW, W858		2
Standard AC Shunt	Fluke A40	0.01 A 0.1 A 1 A 10 A	1 1 1 1
Standard Capacitor	GR - 1404	1000 PF	3
Standard Capacitor	Towa -	0.1 μF	2
Standard Inductor	GR 1482-B	100 μH 10 μH 1 H	1 2 1
Capacitance Bridge	GR 1615-A		1
Inductance Bridge	GR 1632-A		1
AC Calibrator	Fluke 5200		1
Transconductance Amplifier	Fluke 5220A	(AC/PC) 20A	1
Meter Calibrator	Fluke 5100B		1

Source: TISTR

Table 3.7.1-6 Existing Equipment in Photometric and Thermometric Laboratory (Thermometric standards)

(Basic Temperature Standards of TISTR)

Standards	Temperature Range, °C	Quantity
Reference Standard Thermocouple	400 to 1200	2
Reference Standard Resistance Thermometer	0 to 600	2
Secondary Standard Thermocouple	400 to 1200	2
Secondary Standard Resistance Thermometer	0 to 600	2
Tungsten Strip Lamp	800 to 2500	5

(Basic Equipment for Maintaining Temperature Standards)

Equipment	Quantity
Lead & Northrup Potentiometer Type-K4	1
AC Bridge, Automatic Systems Laboratory	1
Cell for Triple Point of Water	1
Fixed Point Furnace for Tin	1
Fixed Point Furnace for Zinc	1
Fixed Point Furnace for Silver	1
Melting Point Furnace for Gold	1
Ice Point Chamber	1
Water Bath	2
Oil Bath	2
Salt Bath	1
Comparison Furnace	1

Source: TISTR

Table 3.7.1-7 Existing Equipment in Photometric and Thermometric Laboratory (Photometry)

(Basic Equipment for Photometric Standards)

Equipment	Description	Quantity
Photometric Sphere	ϕ 1.50 m	1
Photometric Bench	3.5 m	1
Standard Photoreceiver		1
Voltage Regulator	DC, ±0.01%	1
Voltage Regulator	AC, ±0.3 %	1
Monochrometer	0 - 999mm±0.5mm	1

(Fundamental Standards in Photometry)

Equipment	Quantity
Primary Standard Incandescent Lamp for Luminous Flux	3
Primary Standard Incandescent Lamp for Luminous Intensity	2
Secondary Standard Incandescent Lamp for Luminous Flux	3
Secondary Standard Incandescent Lamp for Luminous Intensity	3
Secondary Standard Fluorescent Lamp (white light)	3
Secondary Standard Fluorescent Lamp (daylight)	3

Source: TISTR

Table 3.7.1-8(1) Existing Equipment in Mechanical Engineering Laboratory (Length)

Equipment	Description
1. Gauge Block	05-100 (49 pcs) Set * class 0
2. Micrometer	0-100 mm/.001 0-25 mm/.01x2 0-25 mm/.01x2
3. Height Gauge	0-1000 mm/.10, .001" 0-600 mm/.01
4. Vernier Caliper	0-200 mm/.02x3 0-200 mm/.05x5 0-150 mm/.02x1 0-150 mm/.05x3 0-150 mm/.01, .0005"
5. Dial Indicator .001	0-1 mmx1 0-5 mmx2
6. Dial Indicator .001	0-10 mmx2 0-3 mmx2
7. Optical Parallel Set	25 mm (4 pcs)
8. Coating Thickness Meter	0-0, 100mm 0.050-0.500mm
9. Projector	

Source: TISTR

Table 3.7.1-8(2) Existing Equipment in Mechanical Engineering Laboratory (Mass)

Equipment	Description
1. Mass Sets	100g-1kg (5 pcs) set #1 10mg-100g (19 pcs) set #2 100g-1kg (6 pcs) set #1 10mg-100g (19 pcs) set #2
2. Balances	
Hand-Operated Balance	1000g/0.5mg
Balance	15kg/5g
Balance	60kg/50g
Electronic Balance	7000g/0.1g
Analytical Balance	100g/0.1mg
Electronic Balance	5000g/0.01g
Spring Balance	500g/10g
Spring Balance	50g/0.5g
3. Force	
Proving Rings (Tension & Compression)	5 ton
Proving Rings	50 ton
Proving Rings	10 ton
Galvanized Forge Steel Weight	1kgfx25
Chrome Steel Weight	2kg, 1kg, 10g
Painted Steel Weight	20gx5
4. Pressure	
Deadweight Pressure Tester (Oil)	10-8000 psi
Deadweight Pressure Tester (Oil)	5-3000 psi
S&D Test Gauge (Oil)	100-1000 psi
Aneroid Barometer, Fortin Barometer	1000-1500 mbar

Source: TISTR

3.7.2 Current Status of Each Physical Quantity

(1) Electrical Quantities

(a) Provision of Equipment

Electric standards and calibration equipment maintained at the TSC are capable of precise measurements for DC and low frequency owing to aid from the United Nations (UNIDO), grants from the Thai Government and the TISTR's own budget, etc. The electric standards and the calibration equipment are shown in Tables 3.7.1-4 and 3.7.1-5.

(b) Technical Level of TSC and ITIT Project

The establishment of electric standards for DC and low frequencies and the transfers of relevant technologies were implemented through the ITIT Project conducted by joint efforts of the ETL (Electrotechnical Laboratory) in Japan and the TISTR in the 8 years between 1975 and 1982. The ITIT Project was aimed at the consolidation of the foundation to make Thailand an industrial-oriented nation as part of joint studies for the establishment of electric and photometric standards, which contributed markedly to the upgrading of the technological level, as well as the establishment of the standards in Thailand.

Since many of the electric measuring instruments calibrated at the TSC on request are relatively low precision instruments, the TSC seems to have an adequate technical level to meet the calibration need for DC and low frequency instruments in particular. For those in the high frequency range, the ETL and the TISTR jointly has been carrying out the ITIT Project continuously from 1984, and high frequency power standards and high frequency signal standards are established as of 1987. Technology transfers of high frequency signal standards are also planned in the future.

Further upgrading of the capability, however, will be required since higher reliability will be needed in line with the growth of electric and electronic production in Thailand.

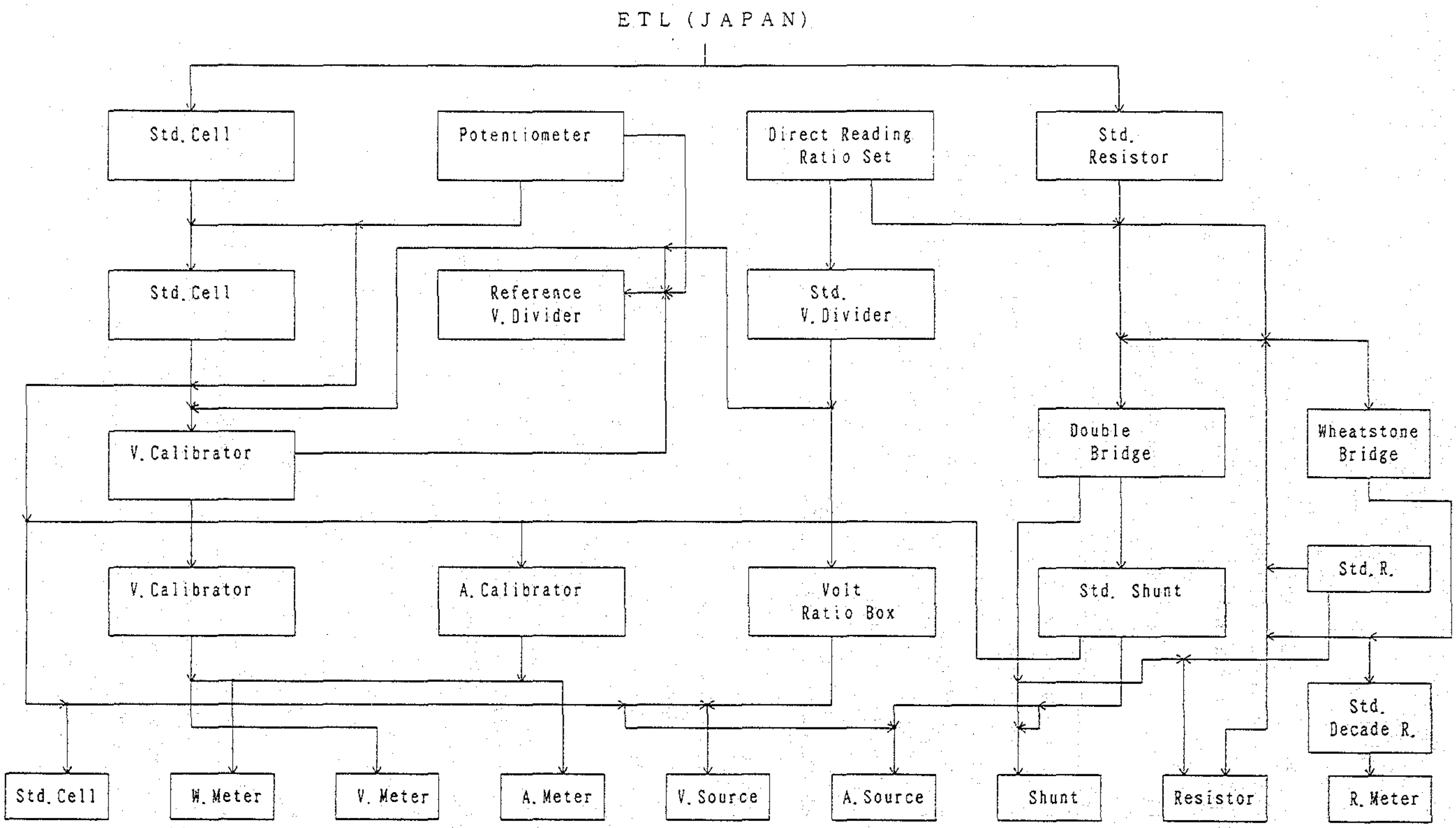
(c) Staff Members of Electric and Electronic Laboratory

The Electric and Electronic Laboratory (EEL) of TSC has 9 staff members in total - 3 with college/university education and 6 others with high school or lower education. About 4 of them constitute the standard and calibration group, and all of them have 10 years or longer experience in the same laboratory. It appears that they are contributing greatly to the maintenance of the TSC's technical level.

(d) Traceability and Asia/Pacific Metrology Program

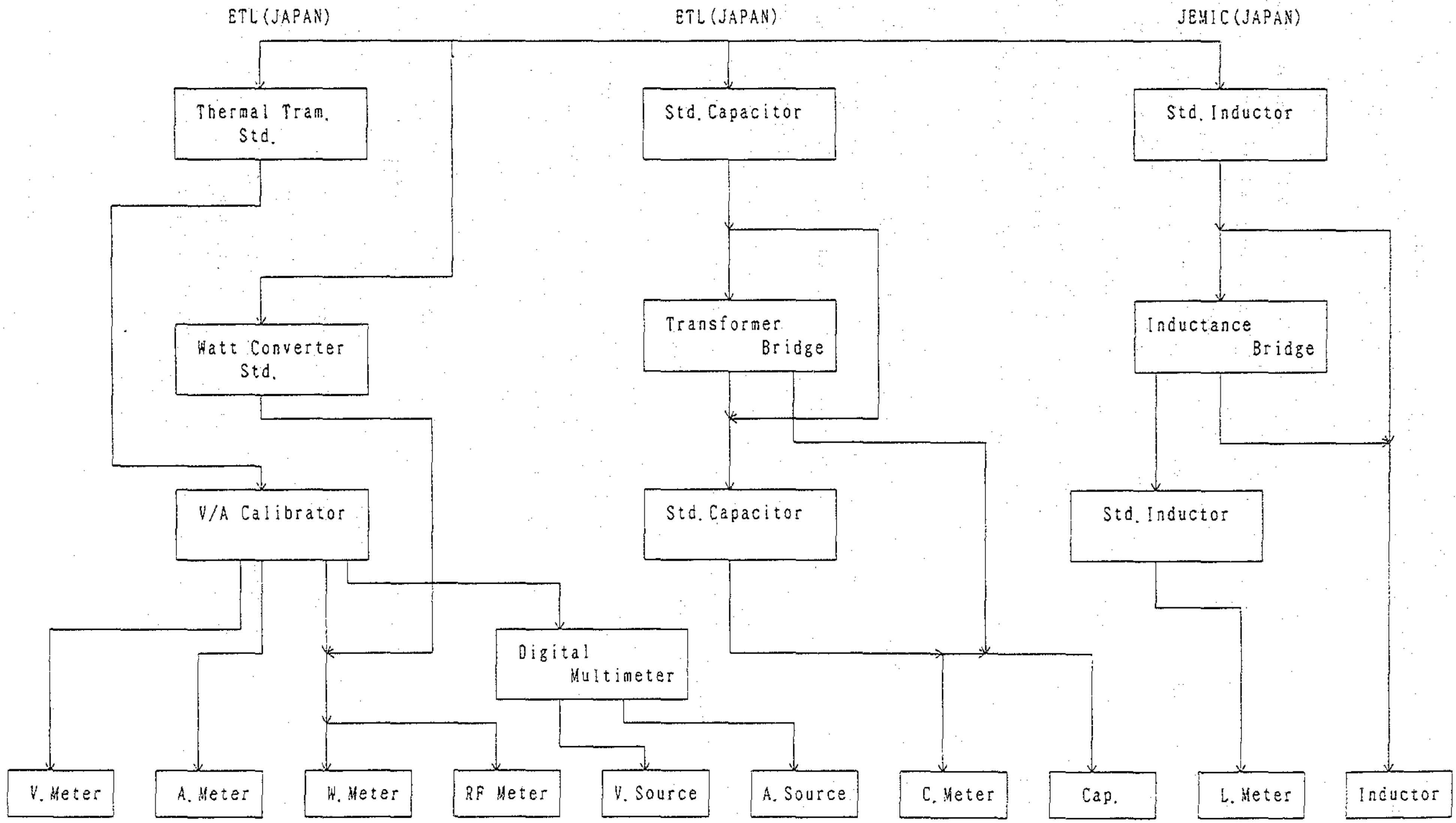
The traceability system is established for DC and low frequency range, owing to the technological cooperation between the TISTR and the ETL for the ITIT Project, and equipment and technological aids from the United Nations (UNIDO) and foreign nations, as shown in Fig. 3.7.2-1.

Basic electric units in Thailand consist of voltage standards, resistant standards and electrostatic capacity standards. Electric quantities relating to above standards and the AC/DC conversion standards are provided by the ETL (Fig. 3.7.2-2).



Source: TISTR

Fig. 3.7.2-1 DC Traceability System



Source: TISTR

Fig. 3.7.2-2 AC Traceability System

Inductance standards and which is derived units are provided by the Japan Electric Meters Inspection Corporation.

For the high frequency range, the traceability system has not been established though the power and voltage standards have been established under the ITIT Project.

National electric standards are provided by Japan but not necessarily on a regular basis due to the transportation cost, etc.

APMP (Asia/Pacific Metrology Program) is an international program for the maintenance of standards. This Program is aimed at upgrading the metrological level by assigning tasks to each participating country, circulating various metrological standards among these countries, publishing and providing measured data to each other and confirming the level of maintenance of standards of each country concerned.

At present, such major Pan-Pacific Asian countries as Australia, India, Indonesia, Japan, Korea, Malaysia, New Zealand, Singapore and Thailand are participating in the Program with the USA participating as an observer.

Thailand is also actively participating in the APMP for the maintenance and control of national standards. The calibration of standard cells has been already done and the calibration of AC voltage/current is in the preparation stage.

The calibration of standard resistance under the Program is planned as the next project, and application for participation in the standard condenser project is currently being made.

As described so far, the traceability system has been formally established in Thailand, but the system has not effectively been operated.

(e) Maintenance and Control Conditions of TSC's In-house Standards

The maintenance conditions of standards and measuring instruments owned by the TSC are as follows.

* Control criteria for measuring equipment are determined.
* Calibration procedure manuals are prepared.
* Control file on measuring equipment is made available.
* Periodic calibrations of measuring equipment are done at regular intervals and records are maintained.

Based on the above, it appears that the control of standard equipment held by the TSC is properly carried out.

(f) Condition of Electric Standards Laboratory

The electric laboratory of the TSC has an area of approximately $70m^2$ which is inadequate in view of the existing equipment and the demand level.

(g) Calibration Services of Electrical Quantities

The scope of calibration services set for the TSC is extensive, ranging from the standard battery and standard resistance that constitute basic units of electricity, to AC voltage, current and power. The performing of the calibration services is as follows.

Table 3.7.2-1 Performance of Electrical Quantity Calibration Services

Year	No. of services
1984	135
1985	142
1986	212

Source: TISTR

Although it appears that the actual calibration services level is still low, it shows an upward trend with the number of cases increasing by 49% in 1986 from 1984. Significant increase in the future is anticipated because of the expansion of the scope of calibration services at the TSC.

Details of the calibration services carried out in 1986 are shown in Table 3.7.2-2. Oscilloscope performance tests and requests of calibrations for measuring instruments used in the field with accuracies of 0.5% or higher deviations accounted for 67% of the total.

Given this situation, the fact that there were 6 requests for calibrations of potentiometers requiring relatively high accuracy should be noted in predicting calibration demands in the future.

The present situation where requests on calibrations with low accuracy account for the majority is proof of the fact that calibration is mostly needed for instruments used in the field by private companies, such as electronic parts manufacturers and household electric appliance manufacturers, which do not have a "standard laboratory" for the quality control (quality enhancement) of their own products. The number of days required per calibration is as relatively short as from one week to 10 days.

Table 3.7.2-2 Actual Work done for Calibration
(Electric Standards)

1986

Equipment	Range	Accuracy	Number
1. Oscilloscope	(Performance check)	-	54
2. Digital Multimeter	DC. A 200μA - 2A DC. V 200mA - 1200V AC. A 200μ - 2A AC. V 200mV - 1200V R 200Ω - 20μΩ	0.5 %	65
3. Curve Tracer	(Performance check)	-	8
4. Decade Resistance Box	Up to 100μΩ	1.0 %	6
5. Potentiometer	0 - 1.6V	0.03%	6
6. Insulation Tester	500V	1.0 %	10
7. Others	-	-	63
Total			212

Tested instruments from public laboratories: 5%
instruments from private factories : 95%

Source: TISTR

(2) Temperature (Thermometric standards)

(a) Provision of Equipment

The equipment held at the TSC for the calibration of thermometric standards and other related instruments is as shown in Table 3.7.1-6. The setting of thermometric standards is conducted in a suitable manner to make them as national standards (primary standards) using the following fixed-point systems specified under the International Practical Temperature Setting of 1968 (IPTS-1968).

Cell for triple point of water	0.01 °C
Fixed point furnace for tin	311.97 °C
Fixed point furnace for zinc	419.58 °C
Fixed point furnace for silver	961.93 °C
Melting point furnace for gold	1,064.43 °C

In addition to the above, a variable temperature vessel in the range of 0°C to 600°C is installed, together with adequate standard sensors and measuring equipment including standard resistance thermometers.

(b) Technological Level and Traceability

The level of thermometric measurements is rather high, owing to the technical cooperation and training conducted between the TISTR and National Research Laboratory of Metrology (NRPM) of Agency of Industrial Science & Technology, the Ministry of International Trade & Industry (MITI) of Japan, and those conducted between the TISTR and the NML of Australia, as well as equipment aid from the United Nations.

In regard to the thermometric standards, international comparisons were made among 9 countries, i.e. - Australia, India, Indonesia, Japan, Korea, Malaysia, New Zealand, Singapore and

Thailand, together with the special participation by the USA, following the decision made by the ASCA (Association for Science Cooperation in Asia) in 1979. The aim was checking the levels of thermometric standards in each country to improve them.

In the case of Thailand, the TSC participated in the measurement of thermocouples and the PED (Physics and Engineering Division of the DSS) participated in thermocouple and tungsten strip lamp measurements in 1979.

According to results of international comparison, calibration values of the TSC are ranked very high for their validity, as shown in Fig. 3.7.2-3.

Thermometric standards at the TSC are provided by the NML, and the traceability system is established (Figs 3.7.2-4, 5)

The provision/receipt of thermometric standards between the National Measurement Lab., Australia (NML) and TISTR is carried out in the following manner. The NML's value marking and that of the TSC are cross-checked using standard platinum resistance thermometers and standard thermocouples marked by defined fixed points, in turn determined under the ITPS-68, and are used for the marking of lower standards.

(c) Staff engaged in Thermometry in Photometric and Thermometric Laboratory 4 employees are assigned in this laboratory. Among them, 3 are university graduates and the rest at certificate level. 2 of the university graduates are engaged in the work of maintenance and control of metrological standards and of the calibration services related to thermometry.

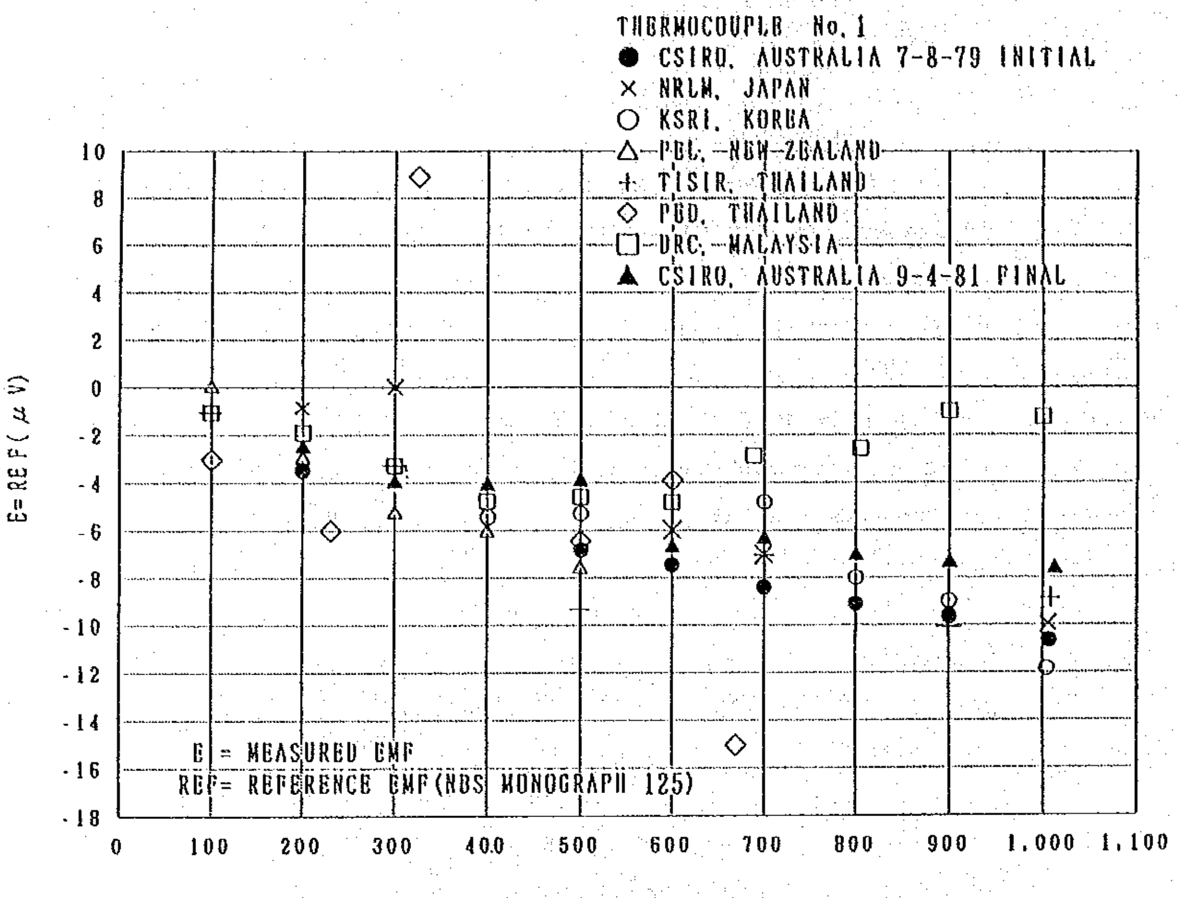


Fig 1. Intercomparison of calibrations of thermocouple no. 1

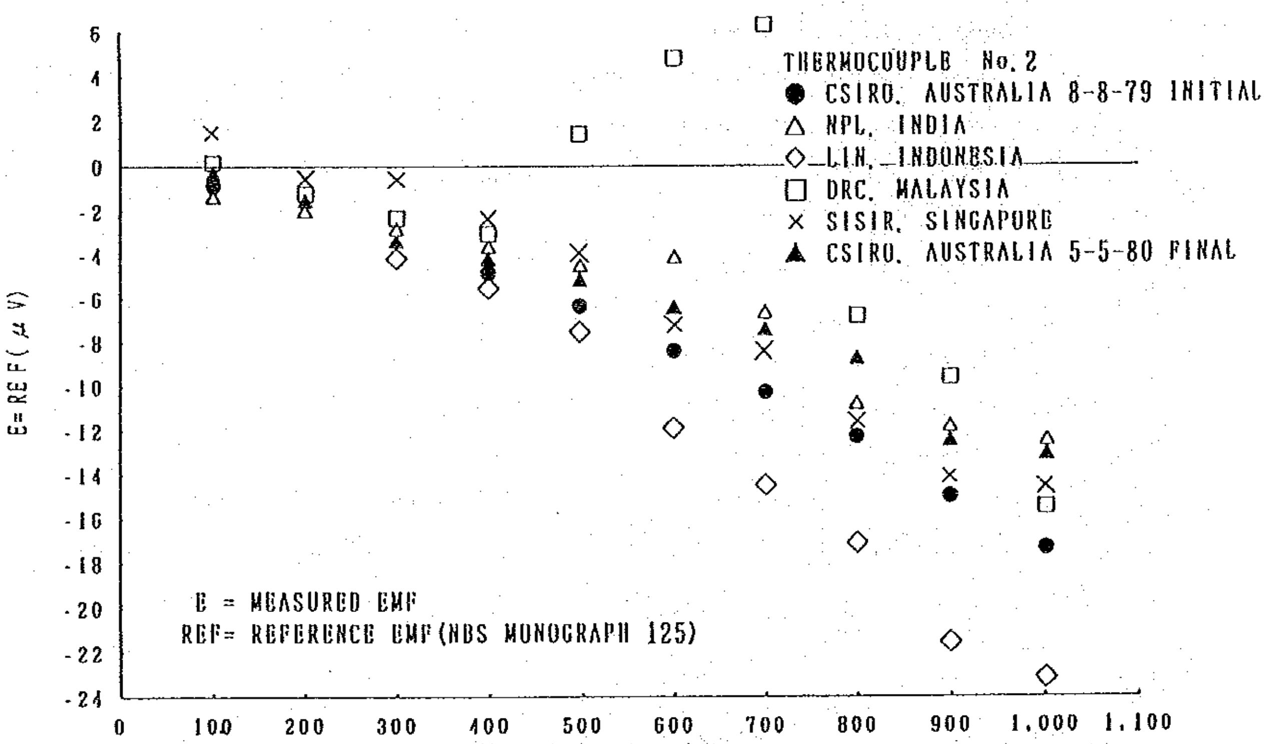


Fig 2. Intercomparison of calibrations of thermocouple no. 2

Source: TISTR

Fig. 3.7.2-3 International Comparisons of Calibrations of Thermocouples