12. QA / QC for The Monitoring of Drinking Water Quality

<u>**Presenter**</u>

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CURRENT AND NEAR FUTURE ON QUALITY ASSURANCE AND QUAALITY CONTROL FOR DRINKING WATER IN JAPAN

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1. INTRODUCTION

After World War Ⅱ, the development of the water supply system has been quite rapid, and the population served has become 96.1 percent in 1997. Quality assurance (QA) is a set of operating principles that, if strictly followed during sample collection and analysis, will produce data of known and defensible quality. That is, the accuracy of the analytical result can be stated with a high level of confidence. Included in quality assurance are quality control and quality assessment. This paper reviews the protocols of QA and QC from actual condition of systems of monitoring and inspection laboratory for drinking water quality in Japan.

2. CLASSIFICATION OF WATER WORKS

2.1. Classification of Water Supply

Japan has four kinds of water works defined by the Water Works Law, i.e. large scale water supply system, small scale water supply system, private water supply system, and bulk water supply system.

(1) large scale water supply:

population to be served of more than 5,000

(2) small scale water supply:

population to be served of 101 to 5,000

(3) private water supply:

for private use for dormitory, sanatorium, etc. and populations to be served of more than 100

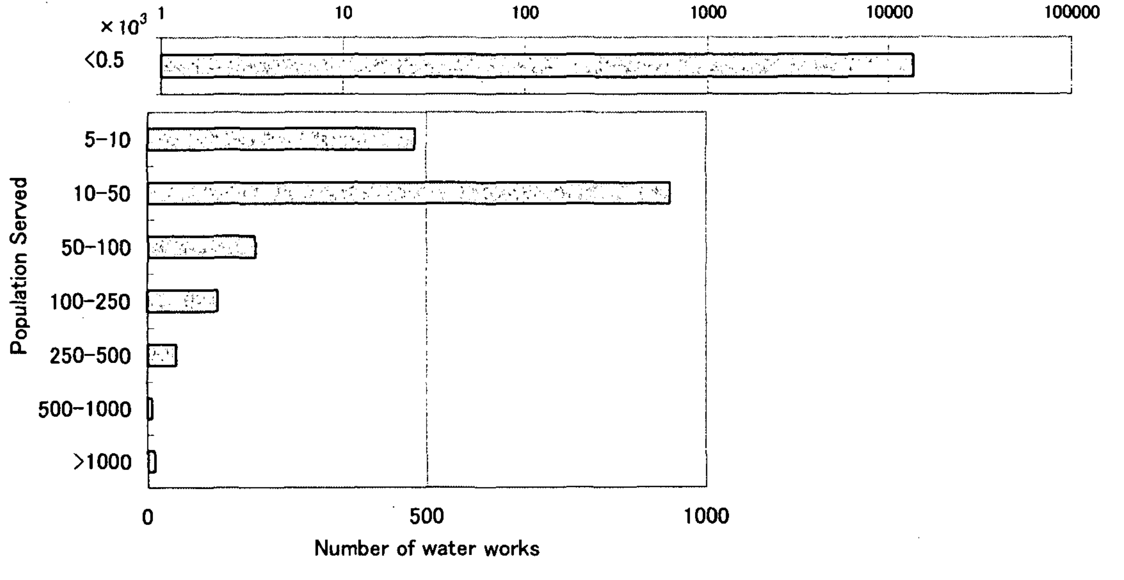
(4) Bulk water supply:

to supply purified water to large and small scale water supply systems Most of these are managed by municipal governments, i.e. city, town or village. And some prefectural governments also manage bulk water supply system of large scale public water supply system.

2.2. Scale of Water Works Bodies

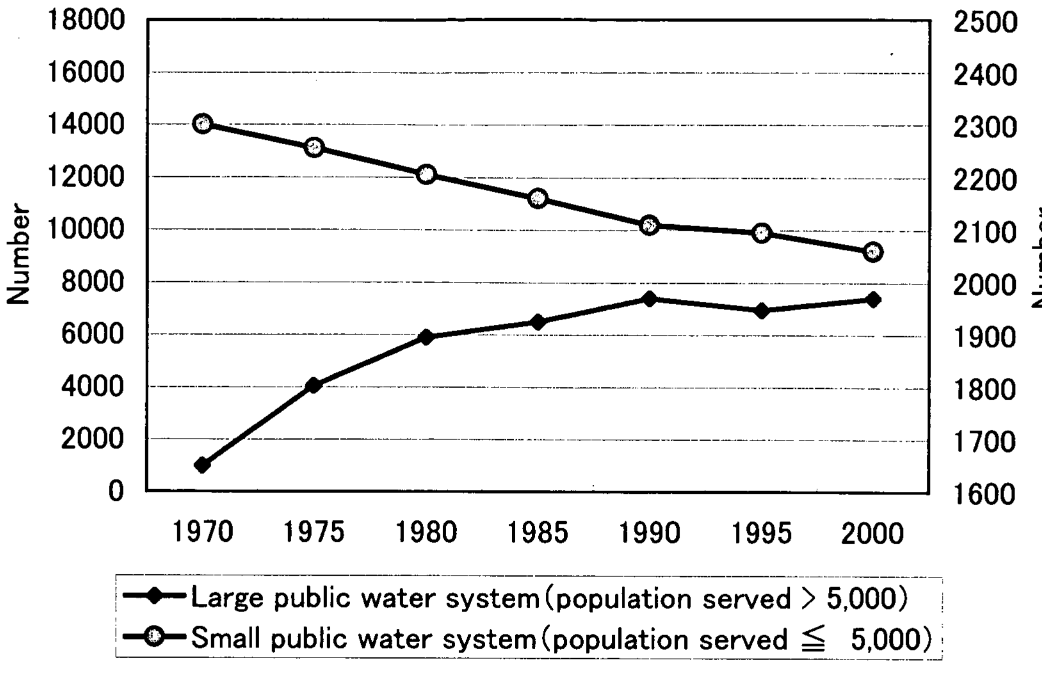
Number of each scale of water works bodies are shown in figure 1. Approximately 96 % of Japanese population is presently served by the public water supply, most of which belongs to a small-scale water supply with the exception of big cities. But, about 15,300 water supply are operating now and about 85% of them are small-scale water works. And then, the number of small-scale public water systems that serve less than 5,000 people was 9,549 in fiscal year 2000. Half of these small-scale water supply systems are generally using ground waters as water source. Thirty percent of them are using surface waters treated by rapid and slow sand filtration processes. However, technical and operational problems begin to increase due to deterioration of the surface water quality. Furthermore, it is becoming difficult for these small-scale systems to secure skillful and educated staffs, which raises new questions in water management in Japan. And then, the middle-scale water works (about 1610) such as served >5,000-<100,000 people was similar condition.

Figure 1 The Number of Water Supply Systems



Recently, the number of large public water supply systems has increased little by little, however on the contrary the number of small public supply systems has decreased ass a result of integration and so on (Figure 2).

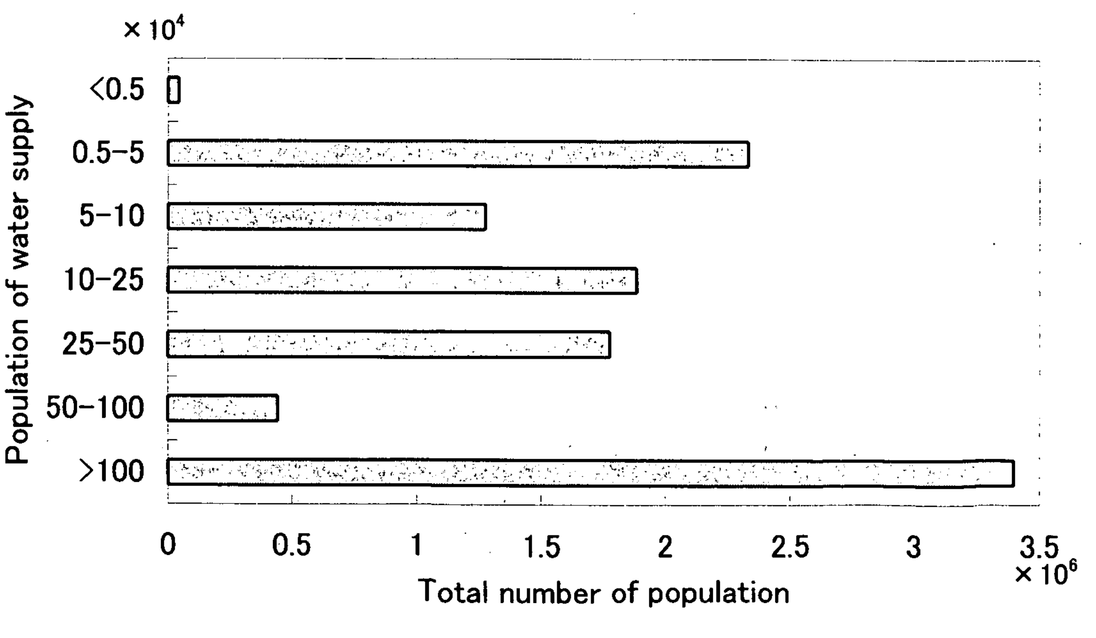
Figure 2 Shift in the number of water supply systems.



2.3. Population served of Classified Water Supply

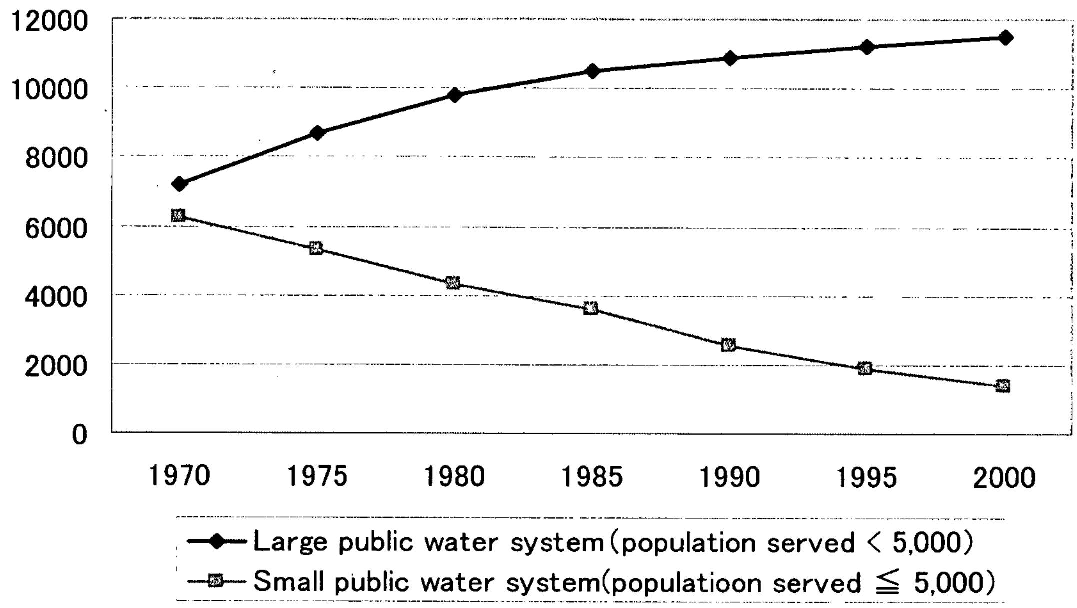
Most of the people served by large-scale water supply, and the people served by small-scale water supply of less than 5,000 is only 0.4 % (Figure 3). The population served by middle-scale water supply (32 %) is smaller than those of large-scale water supply (68 %).

Figure 3 Population served on each scale of water supply.



The population served by small-scale public supply systems has decreased every year, whereas the population served by large public water supply systems has increased every year (Figure 4).

Figure 4 Total population served on Large and Small-scall water supply system.



3. Quality Standards of Drinking Water

3.1. Quality Standards

Water works in Japan are required under the Quality Standards of Drinking Water based on the Water Works Law.

Due to the expanded use of various chemicals, those chemicals were detected in public water bodies. Moreover the revision of drinking water quality standards and guidelines on those chemicals by some international and overseas organization such as WHO was being carried out successively. Considering these facts, the quality standards (46 items) were revised by MHLW in Dec. 1992.

3.2. Items Relating to the Comfortability and Items Relating to Monitoring

In addition to the revision of the Quality Standards of Drinking Water, the MHW established the guideline values for two categories of items relating to the comfortability"(13 items) and relating to monitoring"(26 items). The "Items Relating to Monitoring" relate to human health.

These items contain 11 kinds of pesticides and 5 kinds of disinfection by-products. As for these items, the MHLW expects that each waterworks are informed of the result of the systematic surveillance by a representative waterworks appointed for every major river and use the result properly. However, analytical technique of these chemicals should be required to have staffs and instruments to high quality.

4. MONITORING

4.1. Large-scale Water Works

By the Water Works Law, every water-works are obliged to carry out regular and ad-hoc monitoring of tap water quality, and to install the instruments necessary for water quality monitoring (TABLE-1). As a rule, themselves of water works should do the monitoring. This is due to the reason that, if so, a prompt action can be taken in case of a water quality accident. Many large waterworks can do the examination in their own laboratories with professional staffs.

TAABLE-1 PERIODIC AND AD-HOC EXAMINATION OF WATER QUALITY

Examination	Examination Items	Number of Examination
Examination prior to starting water supply	46 Items residual chlorine	1 time 1 time / 1 day
Periodic examination Of water quality	Color, turbidity residual chlorine	
	46 Items	1 time / 1 month
Ad-hoc examination Of water quality	Necessary Items	When supplied water is apt not to meet water quality standards

4.2. Assistance to Small and Middle-Scale Water Works

However, many small and some middle-scale waterworks have similar problems: with shortage of budget, instruments, staffs, level of knowledge. Most of the small-scale and some middle-scale water works can not do whole analytical items. And then, analytical items of high level at these water works have entrusted public health or designated private laboratories authorized by the MHLW may do the examination for them.

5. VARIOUS KINDS OF MONITORING LABORATORIES

5.1. Number and Contracted Population of Monitoring Laboratories

There are four kinds of monitoring laboratories such as captive laboratory of Water works, Cooperative laboratory of Water Works, Public center of local government and designated private laboratory based on law for monitoring in supply water. Current total number of monitoring laboratories is 336 and half of total laboratory is designated private laboratories.

Figure 5 Number on each type of laboratories

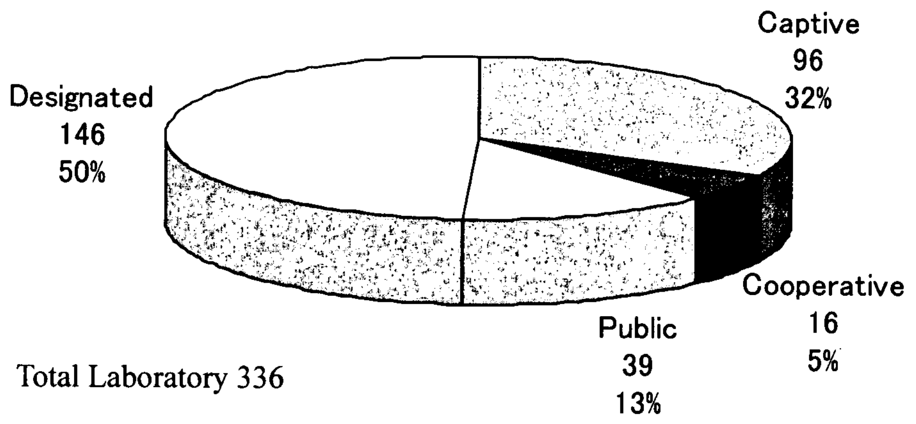
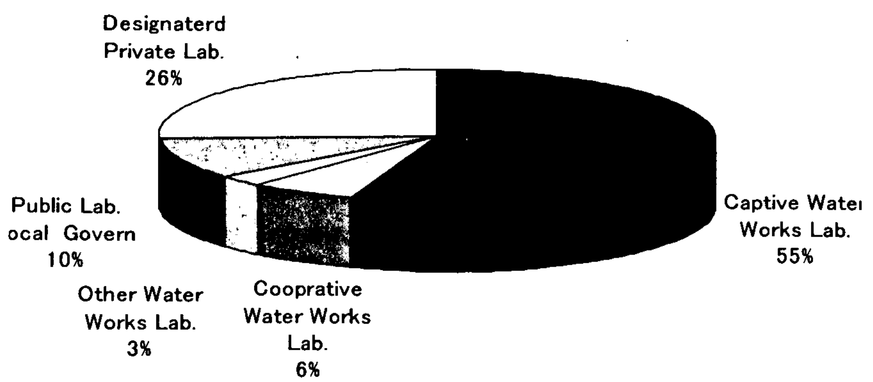


Figure 6 Rate of population supplied on various kinds of inspection laboratories population



However, the population included designated private laboratories is much smaller than captive laboratories to be operated large-scale water works (Figure.6).

5.2. Circumstances of Monitoring Laboratories and Various kinds Water Works

As mentioned above, the monitoring laboratories differ according to scale of water works (Table 3). Many large waterworks, especially the largest water works group of population to be served of more than 100,000 can do the examination in their own laboratories with professional staffs. However, middle or small-scale water works do not have equipment and staff. Therefore, these water works are entrusting to the contracted designated private laboratories to analyze continuously.

TABLE-3 EACH TYPE OF LABORATORIES AND WATER WORKS

	Total Water Works Lab.	Captive W.Ws Lab.	Cooperative W.Ws Lab.	Other W.Ws Lab.	Public Lab. local govern.	Designated Private Lab.
Large	1964	249 (13%)	157 (8%)	138 (7%)	670 (34%)	1290 (66%)
Bulk	110	57 (52%)	6 (5%)	7 (6%)	9 (8%)	22 (20%)
Small	9370	0	268 (2.7%)	323 (5%)	1147 (12%)	6073 (62%)
Private	3837	0	0	36 (1%)	1240 (30%)	1604 (69%)
Total	15281	306 (2%)	426 (3%).	683 (5%)	3066 (23%)	8989 (66%)

6. ANALYTICAL METHODS

In the revised standards, several methods including methods for simultaneous analysis of many items are introduced as the official methods (Table-2). And considering the improvement of analytical technology, new trace analytical methods such as inductively coupled plasma spectrometry (ICP, ICP-MS) for elements analysis, purge trap/gas chromatograph-mass spectrometry (PT/GC-MS), head space/gas chromatograph-mass spectrometry (HS/GC-MS) and purge trap/gas chromatography (PT/GC) for chlorinated compounds analysis, etc. are adopted. Most of the detection limits in the revised standards are 10-20% of the standard values.

TABLE-2 ANALTICAL METHODS OF QUALITY STANDARDS OF DINKING WATER

Item	Methods
Cadmium	AAS, ICP, ICP/MS
Mercury	AAS
Selenium	AAS, ICP/MS
Lead	AAS, ICP, ICP/MS
Arsenic	AAS, ICP/MS
Chromium(Ⅵ)	AAS, ICP, ICP/MS
Cyanide	AS
Nitrate- and Nitrite- Nitrogen	IC, AS
Fluorine	IC, AS
Carbon Tetrachloride	PT/GC-MS, PT/GC
1,2-Dichloroethane	PT/GC-MS
1,1-Dichloroethylene	PT/GC-MS, HS/GC-MS, PT/GC
Dichloromethane	PT/GC-MS, HS/GC-MS, PT/GC
Cis-1,2-Dichloroethylene	PT/GC-MS, HS/GC-MS, PT/GC
Tetrachloroethylene	PT/GC-MS, HS/GC-MS, PT/GC
1,1,2-Trichloroethane	PT/GC-MS, PT/GC
Trichloroethylene	PT/GC-MS, HS/GC-MS, PT/GC
Benzene	PT/GC-MS, HS/GC-MS, PT/GC
Chloroform	PT/GC-MS, HS/GC-MS, PT/GC
Dibromochloromethane	PT/GC-MS, HS/GC-MS, PT/GC
Bromodichloromethane	PT/GC-MS, HS/GC-MS, PT/GC
Bromoform	PT/GC-MS, HS/GC-MS, PT/GC
1,3-Dichloropropene	PT/GC-MS
Simazine	SPE/GC-MS, SPE/GC
Thiram	SPE/HPLC
Thiobencarb	SPE/GC-MS, SPE/GC
Zinc	AAS, ICP, ICP/MS
Iron	AAS, ICP, ICP/MS, AS
Copper	AAS, ICP, ICP/MS
Sodium	AAS, ICP, ICP/MS
Manganese	AAS, ICP, ICP/MS
Chloride Ions	IC, Titration
Calcium, Magnesium, etc.(Hardness)	Titration, IC, ICP/MS
Methylene Blue Activated Substance	AS
1,1,1-Trichloroethane	PT/GC-MS, HS/GC-MS, PT/GC
Phenols	AS
Organic Substances (Consumption of Potassium Permanganate)	Titration

Abbreviations:

AAS	Atomic Absorption Spectrophotometry
AS	Absorption Spectrophotometry
GC	Gas Chromatography
HS	Head Space
HPLC	High Performance Liquid Chromatography
IC	Ion Chromatography
ICP	Inductively Coupled Plasma Spectrometry
MS	Mass Spectrometry

PT Purge Trap
SPE Solid-Phase Extraction

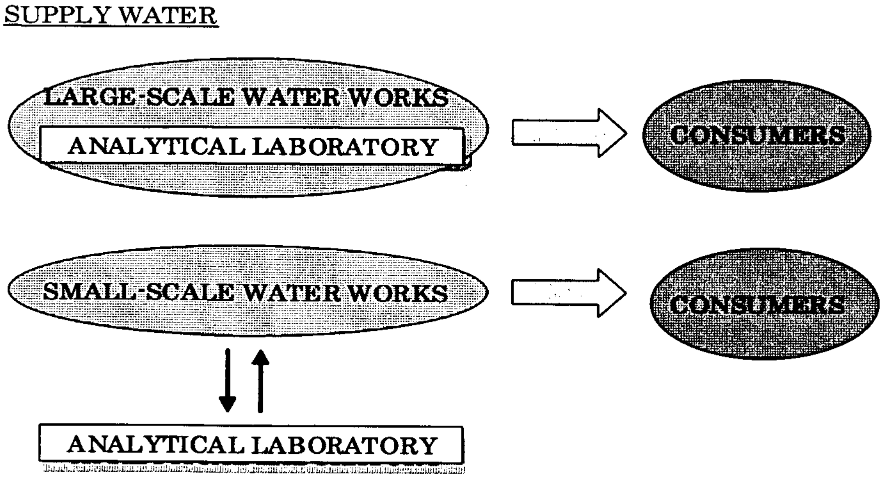
7. HOW TO SECURE RELIABILITY OF THE ACCURACY ON LABORATORY

As mentioned above, these methods are required high analytical technology and monitoring laboratories used with these methods are included with many levels to analytical techniques. And then, the each data measured from the monitoring laboratories are involved much unreliability. The quality standards prescribed water works law should be require that analyses for determining compliance with the standard values be conducted by a laboratory approved by the primary regulating authority. This requirement will be evolved into a formal certification program for drinking water laboratories as described in the MHLW publication "Manual for the Certification of Laboratories Analyzing Drinking Water,

7.1. Problems on Various Kinds of Monitoring Laboratories

The internal and external quality control for monitoring laboratories should be done by themselves. The systematization of quality control had only recently been developed and started for designated laboratories. The quality control comes into effect to the designated private laboratories contracting small-scale water works in response to require to MHLW. But, the internal and external quality control to the large monitoring laboratories was not obligated to be required by MHLW. As previously explained, in spite of largest captive or cooperative water works laboratories have big population,

Figure 7 DIFFERENCE OF ANALYTICAL SYSTEM IN LARGE AND SAMLL-SCALE WATER WORKS



laboratories of these water works do not carried out quality control (Fig. 7).

7.2. Quality Control

Quality control measures have always been part of analytical work. The basic principle is that measurements should be as comprehensible, as plausible and as accurate as possible, or at least interpretable.

Today, such monitoring works are carried out quality control for only designated private monitoring laboratories.

7.3. Quality Assurance

For a laboratory to produce consistently reliable data, it must implement an appropriate program of quality assurance procedures. Analytical methods must be validated as fit for their purpose before use in the laboratory. If possible, validation should be achieved by means of collaborative trials that conform to a recognized protocol. These methods must be fully documented, laboratory staff must be trained in their use, and control charts should be established to ensure that the procedures are under statistical control. If possible, all reported data should be traceable to reliable and well-documented reference materials, preferably certified reference materials. When certified reference materials are not available, traceability should be established to a definitive method. Accreditation of the laboratory by the appropriate national accreditation scheme, which should in turn conform to accepted standards, indicates that the laboratory is applying sound quality assurance principles. ISO 17025 (Guide 25) describes the general guidelines for assessing a testing laboratory's technical competence. Although proficiency tests can be executed independently, accreditation assessments now use the information produced by proficiency tests.

Participation in proficiency testing schemes provides laboratories with an objective means of assessing and demonstrating the reliability of the data they are producing.

Although various protocols for the design and operation of proficiency testing schemes have been produced to cover particular areas of analytical chemistry, a harmonized protocol that would be universally acceptable is needed for the organization of proficiency testing schemes.

7.6. Problems of Analytical Quality Assurance Systems

The use and documentation of quality assurance procedures are indispensable for tests, in order to ensure that test results are really valuable, comprehensible, and justifiable. However, methods of quality assurance should be regarded realistically, as even with accredited or GLP-conforming tests, errors or inconsistencies can occur. The written formulation of quality assurance criteria by a laboratory is still not a sufficient guarantee of the quality of work. In case of doubt the customer can only instruct the company to use several different tests on an identical sample. In addition identical samples from the same source can be tested several times under different designation.

The use of and adherence to quality assurance procedures usually increases the costs of tests. Whether this leads to better quality and more comprehensible and more comparable results depends on the individual case and the reliability of the test.

Quality assurance is the definitive program for laboratory operation that specifies the measures required to produce defensible data of known precision and accuracy. The laboratory quality system will consist of a QA manual, written procedures, work instructions, and records. The manual should include a quality policy that defines the statistical level of confidence used to express the precision and bias of data, as well as the method detection limits. Quality systems, which include QA policies and all quality control processes, must be in place to document and ensure the quality of analytical data produced by the laboratory and to demonstrated the competence of the laboratory.

Quality systems are essential for any laboratory seeking accreditation under state of federal laboratory certification programs.