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# OIML D 20

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# Initial and subsequent verification of measuring instruments and processes

Vérifications primitive et ultérieure des instruments et processus de mesure

OIML D 20 Edition 1988 (E)

ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION
OF LEGAL METROLOGY

# Foreword

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States.

The two main categories of OIML publications are:

- **International Recommendations (OIML R)**, which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity; the OIML Member States shall implement these Recommendations to the greatest possible extent;

- **International Documents (OIML D)**, which are informative in nature and intended to improve the work of the metrological services.

OIML Draft Recommendations and Documents are developed by technical committees or subcommittees which are formed by the Member States. Certain international and regional institutions also participate on a consultation basis.

Cooperative agreements are established between OIML and certain institutions, such as ISO and IEC, with the objective of avoiding contradictory requirements; consequently, manufacturers and users of measuring instruments, test laboratories, etc. may apply simultaneously OIML publications and those of other institutions.

International Recommendations and International Documents are published in French (F) and English (E) and are subject to periodic revision.

This publication – reference OIML D 20, edition 1988 (E) – which is under the responsibility of TC 3/SC 1 *Pattern approval and verification*, was approved by the International Committee of Legal Metrology in 1987.

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# INITIAL and SUBSEQUENT VERIFICATION of MEASURING INSTRUMENTS and PROCESSES

## CHAPTER I

## GENERAL

### 1.1. Introduction

This International Document is addressed to OIML Secretariats and to legal metrology officials concerned with the initial and subsequent verification of measuring instruments in general, with the drafting of International Recommendations or of regulations on these topics, and with the planning of the verification process to be followed in specific instances.

Because of its general nature this International Document has wide applicability in legal metrology to the verification of measuring instruments and processes in such fields as, for example, weights and measures, environmental protection, or medicine. It includes advice, procedures, and influencing factors bearing on the choice between alternative approaches to verification and on the procedures to be followed in the course of verification. Both traditional methods and alternative approaches to verification are included.

Initial verification seeks to ensure that measuring instruments that are to be put into service conform to an approved pattern and to regulations, have specified metrological characteristics that lie within permissible limits, and function properly. Subsequent verification seek to ensure that previously verified instruments, after some period of use, are continuing to operate at an acceptable level. Verification therefore constitutes an important component of efforts to assure the quality of measurements in areas of public concern. However, because many variables, conditions, and limitations bear on the approach to verification, it becomes necessary to choose between available alternatives and to plan a verification process to accommodate the particular case in hand.

Increasing demands on legal metrology services, coupled with austere economic policies, are forcing a rethinking of the use of traditional methods of metrological control. Variously, greater dependence on manufacturers for support in verification and careful statistical analysis of verification results may relieve the pressure on the service and, in some cases, provide both deeper insight into the metrolocical problems faced and useful suggestions as to their solution. While the objective of verification (to ensure that each instrument taken one at a time operates in an acceptable manner) is a worthwhile and necessary goal, it is actually a more important objective of metrological control to optimize the quality of measurement results obtained for a whole population of instruments. Focusing on the population of instruments and on the whole measurement process, of which the instrument is but one element, provides an alternative that deserves the most serious consideration by legal metrology services.

A companion International Document, « Pattern evaluation and pattern approval » is also available. It may provide some perspective when decisions need to be made as to which tests and inspections are appropriate to verification and which can be assumed to be part of pattern evaluation. The verification of packaged goods, which differs considerably from the verification of measuring instruments and processes, is not discussed in this document; it is dealt with in the work of Pilot Secretariat SP 20[(*)] on packaged products.

(*) OIML TC 6 *Prepackaged products*

## 1.2. Definitions

The terms in this Document are taken from the 1978 edition of the Vocabulary of Legal Metrology (VML), where appropriate. Definitions of terms not found in the VML are presented below.

1.2.1. Copy of a pattern

An individual instrument which conforms, within specified limits, to a given pattern in all respects.

Note: The word « pattern » has been commonly used to refer to the definitive model of a measuring instrument as well as to the class of instruments that conform to it. The instruments produced by the manufacturer to replicate the pattern constitute a different class. The question of whether an instrument of the class conforms to the pattern is normally the subject of initial verification. Pattern approval not only implies the recognition that the pattern conforms to requirements but, generally, also relates to the instruments of the class produced by the manufacturer ; it usually conveys that these may be sold as legal for use and submitted for initial verification.

1.2.2. Legal character

The attribute of a measuring instrument whereby, having fulfilled all the administrative, metrological, and technical requirements of regulations, it is officially recognized to be legal for use in approved applications.

1.2.3. Verified measuring instrument

A measuring instrument which, in consequence of its verification, has been given legal character.

1.2.4. Acceptance of a measuring instrument

The decision and act of giving legal character to a measuring instrument after its initial verification or of reconfirming or restoring its legal character after a subsequent verification.

1.2.5. Application of a measuring instrument

For a particular copy of a pattern, the identification, by reference to all possible variables and constraints, of all measurements for which it may hypothetically be used and of all the sets of conditions under which these measurements can legally be made.

1.2.6. Measurement process (VIM 2.08)

All the information, equipment and operations relevant to a given measurement.

Note: This concept embraces all aspects relating to the performance and quality of the measurement ; it includes, for example, the principle, method, procedure, values of the influence quantities and the measurement standards.

1.2.7. Test object

A physical object, device, or material that is subject to a measurement and embodies the physical quantity to be measured or calibrated.

1.2.8. Blind test object (or blind material sample)

An unknown test object (or material sample) submitted for measurement to an organization in connection with an assessment of that organization's measurement capabilities.

1.2.9. Double-blind test object (or double-blind material sample)

A blind test object (or material sample) under the additional condition that the personnel of the organization whose capabilities are being assessed are kept unaware that the test object (or material sample) is, in fact, a blind test object (or blind material sample).

1.2.10. Lot (of measuring instruments)

The set of all the measuring instruments of the same type produced in a single production run.

Note: A part of a lot, as defined above, contained in a single shipment is sometimes also referred to as a lot.

1.2.11. Service organization

A non-governmental organization that calibrates, tests, repairs, or maintains instruments.

## CHAPTER II

## KINDS OF VERIFICATION

### 2.1. Kinds of verification

Verification of measuring instruments generally is of two forms: initial verification and subsequent verification. These are discussed below.

2.1.1. Initial verification

Initial verification of a measuring instrument is a series of tests and visual examinations carried out to determine whether an instrument manufactured to replicate a given pattern conforms to that pattern and to regulations, and that its metrological characteristics lie within the limits required for initial verification of copies of that pattern. If the instrument passes all tests and examinations, it is given legal character by its acceptance as evidenced by stamping and/or issuance of a certificate of verification.

Any instrument not previously verified may undergo initial verification. Requirements for initial verification may, depending upon the regulations in the jurisdiction, attach to the pattern, the category of instruments, the accuracy class of the pattern, or to the specific application of any one instrument.

2.1.2. Subsequent verification

Subsequent verification of a measuring instrument is a series of tests and visual examinations, usually carried out at the place of use by an official of the legal metrology service (inspector), to ascertain whether the instrument, having been in use for some time since the previous verification, continues to conform to, or again conforms to, regulations and maintains its metrological characteristics within required limits. If the instrument passes all tests and examinations, its legal character is either confirmed or re-established by its acceptance as evidenced by stamping and/or issuance of a certificate of verification.

When sampling of a population of instruments has been used in subsequent verification to gage the level of compliance with regulations of the population, all instruments in the population should be deemed to have been verified.

Requirements for subsequent verification in general differ from, and often are less stringent than those for initial verification. These requirements may, depending upon the regulations in the jurisdiction, attach to the pattern or its accuracy class, the category of instruments, or to the specific application of any one instrument.

## 2.2. Instruments and processes subject to verification

As required by law or regulation, initial verification is carried out, with some exceptions, for all new instruments or for samples of new instrument populations. It may also be required after the suspension from use, transportation, new installation or new application of an instrument.

There is a fundamental difference between the verification of a measuring instrument and the verification of the measurement process in which the instrument is employed. In either case, the questions of which instruments (or processes in which they are used) are subject to verification, what criteria to apply to decide this, and who makes these decisions require attention. While instruments are generally subject to both pattern approval and verification, there are instances where only one of these controls is exercised ; all these cases are discussed here.

### 2.2.1. Verification after pattern approval

Most categories of instruments covered by legal metrology controls are subject to pattern approval. Likewise, most instruments replicating approved patterns are subject to verification. Exceptions are discussed below.

### 2.2.2. Verification without pattern approval

In some jurisdictions, certain categories of measuring instruments are exempt from pattern approval. Exempt categories are generally specified in regulations along with detailed requirements as to their technical and metrological characteristics. Invariably, exempt instruments are subject to verification and are automatically accepted for initial verification. They are generally of simple design and construction and can be easily verified.

### 2.2.3. Pattern approval without verification

There are instances when a legal metrology service, upon approving a pattern, may decide that instruments intended to replicate the pattern need not be subject to initial or to subsequent verification. The general conditions for exemption from initial verification are that accuracy requirements on the pattern are modest, that reliable manufacture of the pattern is well within the capabilities of the manufacturer, that his quality control process is reliable and acceptable to the legal metrology service, and that there is virtually no possibility that the adjustment, accuracy, or functioning of the instrument can be impaired during transportation or installation. The service can sometimes rely on subsequent verification to gage the consequences of an exemption from initial verification.

Exemption from subsequent verification is possible when the metrological qualities of a pattern of instrument cannot change in use, short of total destruction.

## 2.3. Components of verification

Verification (initial and subsequent), is divided into three distinct components; metrological, technical, and administrative. Each component is discussed below.

### 2.3.1. Metrological examination

The metrological examination during initial verification is generally more comprehensive than that during subsequent verification of the same instrument. In both cases current metrological characteristics and performance are ascertained. While initial verification might include a systematic check of the operability of all switches, controls, and dials of an instrument, a subsequent verification might check these only to the extent that actual or simulated use of the instrument in a measurement might afford. In both cases the instrument is generally tested under operating conditions at extreme and mid-points of its range(s). These tests may be to determine the actual errors of an instrument or, especially during subsequent verification, simply to determine whether or not the error lies within permissible limits.

Some of the many metrological characteristics that may be included in a verification are:

— error of measurement or intrinsic error
— stability, repeatability, and drift
— resolution of readout, recorder trace width, and reading uncertainty
— calibration of internal standards
— susceptibility to electromagnetic interferences
— correspondence to each other of individual values of readouts and/or printouts, where an instrument has more than one
— code-reading reliability of automatic checkouts.

### 2.3.2. Technical examination

The technical examination can include diverse checks, for example:

— general condition of the instrument and indications of damage, dirt, or wear
— proper location of the instrument and visibility of the readout to both seller and customer
— completeness of printouts of computing scales so as to include weight, unit price, and total price
— potential or arrangements for fraud associated with an instrument and fraudulent practices related to its use
— sequence and control of interlocks.

### 2.3.3. Administrative examination

Administrative examinations differ substantially from one jurisdiction to another and depend, to at least some extent, on the instrument being verified. They may include examination of some of the following:

— identification tags, name plates, and inscriptions
— pattern approval marks and (previous) verification marks and dates
— integrity of seals, locks, and other metrological security devices
— display or availability of certificates concerning the instrument or its use
— availability of required technical documents and calibration charts
— calibration, repair, and maintenance records.

# CHAPTER III

# VERIFICATION PROCESS

## 3.1. General considerations

### 3.1.1. Standards and instruments used in verification

Standards and instruments used in verification should suit the purpose, be traceable to more precise standards, and be part of a reliable calibration program. The uncertainties associated with these standards and measuring instruments must always be known; they must be substantially smaller than the maximum permissible errors of the instruments or processes to be verified.

Verifying instruments may be used to measure the same quantity, or quantities directly related to it, as that measured by the instrument being verified or to measure certain other quantities that indicate performance. The inspector may also use calibrated test objects (standards), e.g., weights, in place of measuring instruments. The service may identify specific instruments or their characteristics for use in particular verifications. The work of Pilot Secretariat SP 23(*), «Methods and Means Used for Certification of Verification Devices», should be considered in this connection.

### 3.1.2. Personnel

Inspectors should be trained in the fundamentals of metrology and of legal metrology. They should have short, specialized instruction in their specific areas of responsibility and a brief «apprenticeship» with an experienced inspector, followed by a check of their (initial) performance. Their performance may be evaluated on a continuing basis by analysis of the verification data. Inspectors belonging either to a legal metrology service or to other accredited organizations should be officially authorized to carry out verifications. Supervisory or more specialized officers, in addition to their other qualifications, should be trained in elementary statistics and be capable of correlation analysis.

## 3.2. Initial verification process

Initial verification is carried out to impart legal character to a measuring instrument. This is accomplished by examining each instrument to determine that it is a replica of the approved pattern and that it functions in accordance with the regulations. It may also serve to verify the correct installation of the instrument and its correct intended use.

### 3.2.1. Responsibility for initiating initial verification

Depending on circumstances and regulations, responsibility for initiating initial verification lies with the manufacturers, importers, vendors, or users of instruments.

### 3.2.2. Choice of verifying organization

Depending on circumstances and regulations, initial verification may be carried out by the legal metrology service, the manufacturer, or an authorized independent laboratory acting for one of the concerned parties. Choice, where one exists, will depend on economic factors, technical capability, and the type of instruments to be verified.

(*) OIML TC 3 *Metrological control*

### 3.2.3. Time of initial verification

Depending on circumstances and regulations, instruments undergo initial verification before leaving the factory, before sale by a vendor, upon installation, or before use.

### 3.2.4. Site of initial verification

Depending on circumstances and regulations, initial verification can take place at the factory, at user sites, at the laboratory of the legal metrology service or at an authorized independent laboratory. Still other locations may be necessary in the case of imported instruments. Also, initial verification may be accomplished in stages involving two or more steps in the process. For example, one part of the verification may take place in the legal metrology laboratory before installation of an instrument, and a second part take place once the instrument has been installed in its place of intended use.

### 3.2.5. Options to consider in initial verification

#### 3.2.5.1. Initial verification of each instrument

The inspector first determines that an instrument is of a type produced to replicate the approved pattern. When the instrument has already been installed at the user's site the inspector checks that the installation is correct. This might, for exemple, relate to the leveling of the instrument, to the adequacy of its environment and of environmental controls to electrical grounding and mains voltage regulation, or to the customers' view of scales or digital readouts.

After checking that the requisite conditions exist, e.g., reference conditions or normal conditions of use, and noting what these are, the inspector measures the relevant metrological characteristics of the instrument. These will above all include the intrinsic error of the instrument, or of the measurement process, at given points in the various ranges of the instrument. Where the rneasurand can be varied continuously or stepped automatically, respectively swept or stepped automatic test equipment may be used in lieu of the traditional point by point measurements.

In addition to determining the above errors, the inspector often tests some subsidiary metrological characteristics of the measuring instruments. These might, for example, include the base-line drift of a pen recorder, the hysteresis error of a scale, or the variation (noise) of a digital readout for zero applied measurand. The inspector may also examine such (non-metrological) technical characteristics as the proper functioning of the controls and malfunction-warning devices of the instrument.

The inspector records results, determines whether requirements have been met, and takes appropriate action, e.g., rejection, stamping or issuing a verification certificate.

#### 3.2.5.2. Initial verification by quality control (QC)

Various circumstances may induce legal metrology services to consider placing some or all of the burden of initial verification on the shoulders of manufacturers. These circumstances include the large numbers, diversity, and complexity of instrument patterns and instruments to be verified in perspective with the limitations of financial resources, test facilities and equipment, and specialized staff capabilities of the legal metrology service. For example, modern, electronic-equipped instruments pose considerable problems for inspectors when they must determine that production instruments conform to approved patterns. In such cases manufacturers might be required, on the basis of their QC, to certify that their production instruments so conform.

It depends on the laws and regulations within any one jurisdiction whether initial verification by QC is possible. The QC approach may be applicable to some categories of instruments but not to others ; it may be implemented by some manufacturers but not by others ; it may be used to verify only a limited number of characteristics while the legal metrology service verifies others; or it may be carried out for all instruments of a given pattern with the service repeating the process on a limited control sample. In all cases, the QC procedure should take full account of regulations and the conditions of pattern approval.

Methods of accrediting a manufacturer under a QC plan might include:

— investigation by a specially constituted board, or by service staff of capabilities, personnel, methods, and standards for performing the necessary QC,

— with only limited initial investigation, actual performance by the manufacturer of QC, with the service reverifying results until it is satisfied with the reliability of the manufacturer's QC,

— permission given the manufacturer to perform QC on the basis of the manufacturer's statement concerning his capability for carrying it out, with the legal metrology service maintaining control on subsequent certification, complaint mechanism, and possible penalties.

Alternative means for supervising the manufacturer's QC include periodic or random inspections of the manufacturer's facilities, checks of continued maintenance of proper conditions for QC, and audits of instruments verified by the manufacturer; such audits can be at the plant or after delivery by the manufacturer. Supervision may base itself on complaint mechanisms or on the results of subsequent verification. In order to motivate the manufacturer, any of these methods may involve a variety of penalties imposed upon a determination that QC is inadequate, e.g., revocation of pattern approval, imposition of stricter inspections, or fines.

### 3.3. Subsequent verification process

Subsequent verification is carried out to check whether the legal character of instruments has been maintained and to provide the basis for reaffirming or withdrawing that status or for requiring corrective action to restore it. Each instrument of a pattern or a suitable sample of an instrument population may be verified. Subsequent verification of only a sample of the population is carried out to assure a continuing level of acceptable compliance with regulations of instruments in use. Subsequent verification may go beyond the instrument to verify its proper use, environment, or installation, to verify the complete measurement process, and to detect fraudulent practices.

Subsequent verification, other than for cause, is based on the probable deterioration of instrument performance due to ageing and wear of components, dust or dirt, environmental influences such as vibration, and maladjustments resulting from normal use. Some instruments are especially susceptible because of their sensitivity to mechanical or electrical shock, sensitive adjustments, or low tamper resistance.

The history of the level of compliance or of problems associated with specific instruments, patterns, manufacturers, applications, users, or locations may also constitute reasons for subsequent verification or for changing the interval between verifications. Cause for subsequent verification includes repair, recalibration, and certain adjustments, known or suspected shock to the instrument, and observed malfunction or complaints.

3.3.1. Responsibility for initiating subsequent verification

Responsibility for subsequent verification, other than for cause, generally lies with the legal metrology service, although users may be required to submit instruments at specified times. Responsibility, especially where cause is involved, may be placed on users or repair or calibration services. Complaints from customers may also trigger subsequent verification.

3.3.2. Period of validity of subsequent verification

Validity of verifications may be limited to specific periods or continue up to the next verification. Validity will generally expire automatically when cause is involved. Problems arise when validity is limited to a specified period but the inspector fails to perform subsequent verification prior to the expiration date.

3.3.3. Choice of verifying organization

Generally the legal metrology service will perform subsequent verification. However, an independent service organization may be retained or authorized to do this by the service; similarly some users may be permitted or required to do this. In such cases the legal metrology service should qualify the verifying organization and may perform spot checks of its performance of subsequent verification.

3.3.4. Subsequent verification intervals

Verification intervals may be required by regulation or conditions of pattern approval or may be decided administratively by legal metrology services. Verification for cause is performed when circumstances require; otherwise, verification may be periodic, dictated by a given number of measurements performed since the last verification, determined by some time randomization scheme, or based on the results of prior verifications. Where the instrument population is sampled periodically the instruments verified during the last 1, 2, 3, or n periods might be excluded from the population to be sampled in the next period so that the verification interval for instruments actually verified is at or exceeds a specified minimum.

3.3.5. Site of subsequent verification

Though it depends on circumstances and regulations, the site of subsequent verification is generally the place of use. Commodity samples and some instruments can be verified at legal metrology or other authorized laboratories. The transportability of both the instruments to be verified and the verifying instruments may dictate the choice of verification site. Verification of a measurement process must take place at the user's site.

3.3.6. Options to consider in subsequent verification

3.3.6.1. Subsequent verification of each instrument

Before verification, it will have been decided whether the focus is on the instrument (intrinsic error) or the measurement process with the subject instrument (error of measurement). If the verification is of the measuring instrument the specified reference conditions are provided before tests commence and the tests are carried out by the inspector, who must carefully attempt to minimize all errors except the intrinsic error of the subject instrument.

If the verification is of the measurement process, the inspector should, as far as possible, provide the same conditions during the test as exist during the routine use of the instrument. This might involve posing as a customer and the use of double-bind test objects, with the measurements made by the user's normal staff.

In subsequent verification there is greater emphasis on the overall performance, i.e., error, of the subject instrument (or process) than in initial verification. Subsidiary metrological characteristics that may be checked are usually only those that can change with time or through use of the instrument, for example, the mechanical or electrical zero of an instrument, its repeatability or dead band, or the accuracy of its internal standards.

The inspector will also note, as required, the proper placement of the instrument, customers' view of readouts, the presence of required nameplates, warnings, and stamps, or the integrity of seals. All relevant data are recorded and, if requirements have been fulfilled, the inspector stamps the instrument and/or issues an up-dated verification certificate.

3.3.6.2. Subsequent verification by sampling

The main objective is to assure a general level of compliance of the population to be sampled. Conclusions drawn from analysis of data must be vigorously pursued, not only by rectifying root causes for failures to meet requirements, but also by concentrating verification efforts on the least complying segment of the instrument population to identify as many non-complying instruments as possible in the shortest time.

The sample used for any one « round » of verifications can be chosen in various way: it can, for exemple, be a random sample of the total population, a random sample of the part of the population not verified in the course of the last one, two, or three rounds, or a sample somehow biased toward instruments that were not found to be acceptable during prior verifications. While choice of the particular type of sample will presumably serve some specific objective well, it will also affect the statistical distribution within the sample. As a result, proper statistical analysis of the data may become very difficult or even impossible. Care must be taken in such cases not to apply analyses valid only for normal distributions.

3.3.6.3. Subsequent verification by user of the instrument

A user (or service retained by the user) should be allowed to perform subsequent verification only if the instrument population in question is sufficiently large, if the legal metrology service has properly accredited the user to conduct verifications, and if the service will itself re-verify at least a sample of the tested population.

If the uncertainties of the user's verification process are judged to be acceptable, but somewhat larger than those of the legal metrology service, requirements may have to be tightened to compensate.

Legal metrology staff should ensure that the user has a sufficiently large number of instruments in use to make accreditation of the user economically sensible. At the service's discretion, the user may be authorized to apply verification marks. Penalties for failure to carry out verifications properly may motivate the user or the service organization.

## 3.4. Verification of test-laboratory process

This section refers only to chemical, biological, and clinical laboratories. In many instances any one measurement made by such a laboratory depends directly on a number of instruments and on chemical or biological materials. Because the independent verification of these instruments and materials would shed very little light on the measurement results obtained by their combined use, it becomes essential to verify the complete process by focusing on the results obtained by these laboratories in measurements on blind or sometimes even double-blind test samples.

The necessary test samples, which must have special properties, may be evaluated by reference methods by the legal metrology laboratory, or may be obtained by it from authorized or reliable sources. Samples are generally taken from a common, homogeneous stock and are invariably used up in the course of the measurements made by the laboratories being evaluated. As the first step of the verification, each laboratory receives one or more test samples and later reports the results of its tests on these to the legal metrology service. The service then determines the acceptability of each reported result and, by inference, of the laboratory process that produced it.

When quantitatively evaluated samples are used, the accuracy of reported results may be obtained by comparison to the reference-method result. Under other circumstances, an average of the results of qualified laboratories may be employed in lieu of a reference-method result ; such a procedure indicates precision (constancy of results obtained by the laboratory population) and, usually only to a lesser extent, accuracy. The « measurements » made by these laboratories are not all measurements of proper physical quantities in that they also include numerical counts and comparisons to scales of reference.

### 3.5. Verification by « self-certification »

The term « self-certification », when used in connection with verification, implies that the manufacturer or user of an instrument or a service organization carries out the verification tests and then certifies that the instrument meets verification requirements ; it further implies that the service responsible for verifications recognizes this certification.

Legal metrology services may decide to rely on self-certification for economic reasons, provided that the law in the jurisdiction permits it. It should be seriously considered when the self-certifier's incentive for carrying out the verification is sufficiently strong and when, at the same time, there is some control mechanism, such as spot checking by the service or instituting investigations on the basis of complaints from customers. In any case, the self-certifier must first be properly qualified and instructed by the service.

## CHAPTER IV

## VERIFICATION RESULTS

### 4.1. General considerations

The result of initial verification may be acceptance or rejection of the instrument or, possibly, its acceptance subject to the fulfillment of specific conditions. Acceptance of the instrument conveys legal character to it. The appropriate stamp or mark is affixed to the instrument to testify to its status or a verification certificate may be issued. When an instrument (population of instruments, or measurement process) meets the requirements of subsequent verification, its legal character is maintained or, perhaps, re-established and it may be kept in service.

Under some circumstances verification may be conditional and subject to the later demonstrated fulfillment of specific conditions. When such an instrument, etc., does not meet the requirements of subsequent verification it loses its legal character and may not be kept in service. When an instrument has previously lost its legal character, the result of verification may be the reattribution of its legal character or the maintenance of its non-legal status. Depending on the outcome of verification, an appropriate stamp or verification mark is affixed to the instrument and/or a certificate of verification is issued, or the instrument is rejected. When an instrument is rejected the inspector or the service should disclose to the user the reason for the rejection and, where appropriate, suggest to the user how the instrument's legal character can be established or restored.

### 4.2. Verification certificates and notices

Verification certificates or notices are issued by the inspector or the service to the user, who, depending on regulations, must prominently post them, attach them to the instrument, or have them available for inspection on demand. In subsequent verification existing certificates may simply be re-endorsed by the inspector. Information entered on a certificate generally includes the owner's identity and location, identification of the instrument, dates of inspection and validity, any special restrictions on use, and the name and signature of the inspector. It may also include the date of the next required inspection.

### 4.3. Verification marks, stamps, or seals

Verification marks or stamps are affixed to the instrument by the inspector, or if regulations permit or require this, by the user or a service organization verifying the instrument. Depending on the outcome of verification, a verification or rejection mark or stamp may be affixed so as to indicate the legal status of the instrument and its duration. In the cases when an instrument loses legal character, verification marks are obliterated.

Seals of various types or protective marks are affixed to protect the integrity of the instrument, its calibration, adjustments, software, etc. In price-computing instruments, where unit prices may fluctuate and the metrological and computing portions of the instrument include seals, the portion which stores unit price(s) will generally not be sealed unless a (unit) price control function is being exercised simultaneously with the metrological function.

### 4.4. Control of verification process and compliance

The effectiveness of a verification process and the validity of verification results depend strongly on the efforts made to control the verification process itself. This process comprises regulations governing verification, verification methods, personnel, equipment, verification intervals, sampling plans, user involvement, choice of verification time and place, and any effort to control the verification process itself.

A control plan should be drawn up that anticipates the variables of the verification process to be controlled, the variables of the instrument population subject to this verification process, and the method of evaluating these variables. It should also prescribe the data to be recorded. This data should be stored in an easily retrievable manner and be periodically analyzed for level of compliance as a function of the controlled variables. In consequence of the results of the analysis, actions should be taken intended to improve both the verification process and the basis for compliance of the instrument population being verified. Inspectors can serve the verification process by recommending verification times, verifying instruments and standards.

### 4.5. Records of verification and data

Verification data needs to be available both to the inspectors concerned and for analysis. This may imply duplicate records, with one set available locally to inspectors and another in a central file or in computer storage. To make analysis of trends possible, long term storage of records should be anticipated. Depending on the variables to be controlled, the data may include details concerning the:

— owner, operator, location, and environment of the instrument,

— manufacturer, model, and serial number of the instrument,

— application of the instrument and manner, frequency, and time of use of the instrument,

— recent calibrations, adjustments, or repairs on the instrument ; their dates and by whom performed; date of last verification,

— the metrological, technical, and administrative data about the instrument taken by the inspector,

— time of day, season, and ambient conditions of inspection,

— method of verification and identification of verifying instruments and standards,

— legal status of instrument prior to and subsequent to the inspection,

— identity of the inspector and of the owner's personnel who took part in verification measurements.

### 4.6. Analysis of records and data

Data gathered in verification can be analyzed not only to identify and resolve problems with instrument categories or with measurement processes, but can be used as feedback concerning the verification process itself. Data may, for example, disclose that a subsequent verification interval is unnecessarily long and should be shortened or that a particular instrument pattern meets requirements much more frequently than another, so that verification efforts should be concentrated on the former at the expense of the latter. In brief, verification sometimes can be managed as an adaptive process and used judiciously to concentrate or reallocate the limited resources of a verifying service.

The recorded verification data represents the inspector's observations in comparing the actual condition of an instrument with verifying instruments and standards and with the requirements of regulations. Objectively the instrument being verified as well as the verifying instruments and standards or the inspector's comparison procedure and observations may be in error; they all contribute to the result — be it positive or negative — of the verification. Analysis of records seeks to trace the source of errors by identifying common denominators. Examples are: instruments of a given manufacturer and those verified with a given standard have a high level of noncompliance, and the level of compliance of a particular type of instrument is unusually high when verified by a given inspector.

Analysis of level of compliance as a function of one or perhaps a combination of controlled variables may be done routinely for all variables when adequate computer facilities are available; it may be done only for cause, e.g., as the result of inspector's suspicions or customers complaints that implicate a particular variable; or, as resources permit, it may be done over a long period, taking one variable after another.

Control charts showing compliance levels as a function of time for the whole or for particular segments of the instrument population will give indications of trends that may be attributed to particular events or problem sources. Examples are an increasing level of compliance with the introduction of new instrument types, a sudden drop in compliance level after a change in the method of verification used by all inspectors, and seasonal fluctuations in compliance.

Correlation analysis of data or control charts is best performed by trained personnel with good acquaintance with both the instruments being verified and the components of the verification process. The broader the data base analyzed, the greater the promise of sucess will be.

### 4.7. Corrective actions

In taking corrective actions based on the results of data analysis it is as well to keep in mind that the underlying objective of verification is to minimize the errors of measurement made with legal instruments and that granting, withdrawing, or denying legal character to individual instruments is only one means to that end. In fact the corrective actions that can stem from data analysis cannot relate directly to individual instruments but can only relate to identified, more general problem sources. Legal metrology services should therefore seek, within the limits of the various constraints on them, to eliminate such problem sources by implementing changes in their own operation, by requiring or suggesting permissible and appropriate changes to be made by the manufacturer or user of the instrument, or by causing changes to be made in the approved pattern or even in the regulations. Some of the actions that can be considered by the legal metrology service are:

— request the pattern approving authority to modify a pattern approval, restrict the application of a pattern, or withdraw approval of a pattern,

— inform the manufacturer, with the concurrence of the pattern approving authority, of the need to make certain changes in a method of manufacture or of inspection or to change materials,

— suggest or require the user to change maintenance procedures, manner of use, calibration interval, environment, and operating personnel or to make seasonal adjustments on instruments,

— require authorized independent calibration or repair service organizations to increase their capabilities or improve their work methods, if they are to continue to be authorized,

— implement, within the legal metrology service, changes in personnel assignments, verification methods, or instruments and standards, reallocate verification efforts from more to less complying populations, vary verification intervals or sample sizes, add variables to be controlled for better problem identification and drop variables that prove to be inconsequential, institute control charts in newly uncovered problem areas.

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CHAPTER IV — VERIFICATION **RESULTS**