

THE ENGINEERING EQUIPMENT AND MATERIALS USERS ASSOCIATION

EEMUA CODE OF PRACTICE FOR CALIBRATION AND CHECKING PROCESS ANALYSERS

Formerly IP Code 340

PUBLICATION No. 175 : 1995

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ISBN 0 85931 1201

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THE ENGINEERING EQUIPMENT AND MATERIALS USERS ASSOCIATION

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FOREWORD.

This Code of Practice has been prepared by the EEMUA On-Line Analyser Committee in association with the Institute of Petroleum in order to replace and consolidate the following 6 Existing IP Codes of Practice relating to analysers. IP 340/92, 341/82, 347/82, 348/82 349/82 and 353/82.

The above 6 documents have been reviewed and in view of present day practice and the wide variety of equipment available it has been considered that they are adequately covered by this one document. If any queries arise it is suggested that users refer to the specific Manufacturers operating instructions and other relevant literature.

Other associated EEMUA Publications are:-

Publication 138 1988 - Design and Installation of On-Line Analyser Systems

Publication 138 S1 1992 - A Guide to Technical Enquiry and Bid Evaluation for Analysing Equipment.

1. SCOPE

This code is a general guide to the principles and methods used for calibrating and checking process analysers. It covers initial calibration in the factory or on the plant, analyser validation (i.e. in-service checking) and routine calibration including the use of control charts.

It is impracticable to produce a specific calibration procedure applicable to a wide variety of analysers. This code therefore describes in general terms the various alternative and often complementary techniques available, and discusses their background, merits and limitations.

The content and presentation recognizes that the effort available for calibration is limited. The methods recommended therefore, require only reasonable expenditure of effort. In some cases this leads inevitably to procedures which, though adequate, may be less rigorous than could be evolved on purely technical and theoretical grounds. Also, the Code of Practice is intended for people directly involved with supplying, using and maintaining analysers, and these people are generally not specialists in quality measurement principles and techniques or conversant with statistics. Therefore, as far as possible, the Code of Practice avoids the explicit use of statistical methods and uses instead descriptions and explanations more familiar in conventional instrument work. Particular technical terms are defined in the text as necessary.

Throughout this document the word 'analyser' denotes a process analyser, also variously described by users as stream analyser, on-line or in-line analyser, product quality monitor, etc. The code is not intended to cover automatic or semi-automatic instruments used mainly in laboratories to analyse discrete samples, though some of the principles and techniques described may apply to such instruments.

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2 GENERAL CONSIDERATIONS.

The quality of process products is generally specified in terms of the standard laboratory tests laid down by such bodies as the IP, ASTM, DIN and AFNOR. Such tests are well established, of known precision and are widely accepted. However, product quality assurance and control based solely on laboratory testing is now incompatible with the process industry's methods of production and the scale and speed of modern operations.

Analysers have been developed and applied to measure continuously the quality of material within or drawn directly from the flowing line. The benefits are very considerable in terms of reduced sampling and testing time, improved precision, increased number of tests on each batch of product, the opportunity for automatic control of quality, and reduction in testing effort.

Of necessity, an analyser differs from the standard test apparatus and even the basic measurement technique may be different. For absolute properties (e.g. density, sulphur, viscosity) the result obtained should be independent of the type of equipment and the method used for its measurement. Thus, the analyser and the standard test should give identical results, provided that due account is taken of any difference in the precision of the two methods.

Empirical properties (e.g. flash point and octane number) are only definable in terms of the standard test. As the analyser is different in some degree, it cannot produce independent meaningful values and should be calibrated against the standard test.

Whatever the property and the type of analyser, the user should be able to assure himself and other interested parties that the analyser result is the same within acceptable limits as would be obtained by the standard test by which that property is specified.

Over the years a variety of calibration procedures has been evolved and successfully applied. This practice draws upon this accumulated knowledge and experience in an attempt to provide one generally acceptable practice for calibrating analysers which should enable analyser results to be substituted for standard test results with a subsequent improvement in the efficiency of operations.

The general term 'calibration' covers both initial calibration and any subsequent checking. *Initial calibration* accurately establishes the relationship between the analyser and the corresponding standard test results over its full range, and includes setting up the analyser zero and span, etc. It may be performed at the factory or at site, before or after installation on the plant. *Validation*, also referred to as in-service checking is specifically required whilst the analyser is in service. It is to confirm that the initial calibration has not changed and/or is valid for the particular stream being analysed at the time. Validation generally checks only one point within the analyser range, and is particularly important when the analyser is used for custody-transfer measurements. *Routine calibration checking* is a routine procedure using control charts for monitoring the analyser's performance over the longer term, largely to detect drift or other faults before these become serious.

Analyser calibration is not a single event but a continuing process. The effort necessary to achieve and sustain confidence in analyser results should not be underestimated, and can only be justified by the benefits accruing from using the analyser. Therefore, analysers should only be used on applications where worthwhile benefits are expected.

3 DEFINITIONS.

SPECIAL NOTE 1 The number of special technical terms used in the following text has been kept to a minimum and wherever practicable the terms are defined as they occur in the text. The following glossary defines those terms not defined elsewhere in the text or alternatively gives the text reference where the term is defined.

- 3.1 *Analyser (Process Analyser)* - An instrument to measure continuously and automatically a quality property of a process stream. The input to the instrument is a sample or portion of the process stream within a specified range of conditions with respect for example to flow, pressure, temperature, cleanliness etc. The output is an electrical or pneumatic signal. Certain services (e.g. power, air, water) are required each within a specified range of conditions, to operate the analyser. At least part of the analyser is generally located in the process area and so should be constructed to be safe and otherwise suitable for such location. Also, many analysers have a control unit located remotely, in the plant control room.
- 3.2 *On-line Analyser* - An analyser (3.1) operating on a sample of the process material withdrawn continuously from the process line or vessel via a sampling system (3.4). This is by far the most common arrangement and the measurement may be continuous (3.6) or intermittent (3.7).
- 3.3 *In-line Analyser* - An analyser (3.1) in which the measurement sensor is located within the process line or vessel. Examples are certain types of analyser for density, pH, viscosity and oxygen. Such analysers do not involve a sampling system, and of necessity are of the continuous type (3.6).
- 3.4 *Sampling System* - The assembly of pipes, valves, filters, coolers, gauges, control/regulating devices, etc., required to draw a sample of the process stream from the line or vessel and deliver this to the analyser at the specified conditions. The sampling system (often also referred to as the sample conditioning system) also includes those facilities included to dispose of the sample, the fast loop flow if used, the actual sample connection or probe to the line, any built-in calibration sample facilities, and any conditioning equipment for the analyser services for water, air, etc.
- 3.5 *Analyser System* - The complete instrumentation system connected directly to a process plant to measure a quality property continuously and automatically and to display the measured value at the location where the result needs to be observed and acted upon. The analyser system typically comprises the sampling system, the analyser, the read-out instrumentation and all associated piping and wiring.
- 3.6 *Continuous Analyser* - An analyser in which the sample flows continuously to/through the measurement sensor and the actual measurement/reading is continuous.
- 3.7 *Intermittent (Cyclic) Analyser* - An analyser which operates on a discrete portion of the sample, makes the appropriate measurement by a 'batch' test, records the result, then automatically starts a new tests on a new discrete portion of the sample. An excellent example is

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chromatography. In many such analysers, arrangements are included for 'trend' recording, i.e. the output signal displayed shows only the result of the measurement and this value is held until up-dated by the next measurement. The appearance is of a continuous reading.

- 3.8 *Sampling Lag* - The time required for a sudden change in the quality of the process stream within the process line or vessel to pass through the sampling system and appear at the inlet to the analyser. When the sampling system is largely small bore piping only, the lag will be a dead-time, i.e. the output change will be identical to the input change but delayed in time. However, if the system includes items with significant volume/mixing capability, the sampling lag will then include both dead-time and exponential effects.
- 3.9 *Analyser Time Constant* - For a continuous analyser (3.6) this is the time interval between the initial response and the time to reach 63% of the final output value, for a step change in the measured property. For an intermittent analyser (3.7) the time constant is the analyser cycle time.
- 3.10 *Analyser reading* - the measured quality property displayed by the analyser readout instrumentation in terms of the accepted quality units.
- 3.11 *Readout instrumentation* - the device used to accept the signal from the analyser and display the measured quality property in terms of the accepted quality units.
- 3.12 *Absolute property* - where the measurement result is independent of the type of equipment and the method used for its measurement. The result from the analyser and the standard test should be identical.
- 3.13 *Empirical property* - where the measurement is only definable in terms of the standard test. The result from the analyser and the standard test may differ, and the analyser should be calibrated to agree with the standard test.
- 3.14 *Initial calibration* - to accurately establish the relationship between the analyser and the corresponding standard test result.
- 3.15 *Validation* - to confirm that initial calibration has not changed and is still valid.
- 3.16 *Routine Calibration checking* - a routine procedure to monitor the performance of the analyser, over the long term, using control charts, mathematical, or computer methods, whichever best suits the user.
- 3.17 *Test precision* - the degree of agreement between measurements of the same property expressed in terms of the dispersion of test results around the arithmetic mean.

- 3.18 *Test reproducibility* - a quantitative measure of the variability associated with operators working in different laboratories, each obtaining single results on identical test material. It is defined as that difference between two such single and independent test results as would be exceeded in the long run in only one case in twenty in the normal and correct operation of the test method.
- 3.19 *Test repeatability* - is a quantitative measure of the variability associated with the same operator in a given laboratory obtaining successive repeated results on the same apparatus. It is defined as that difference between two such single results as would only be exceeded in the long run in one case in twenty in the normal and correct operation of the test method.
- 3.20 *Analyser precision* - definition as in (3.17) but to apply to analysers.
- 3.21 *Analyser reproducibility* - is a quantitative measure of the variability associated with analysers working in different locations each obtaining single results on identical test material. It is defined as that difference between two such single independent test results as would be exceeded in the long run in only one case in twenty in the normal and correct operations of the analyser.
- 3.22 *Analyser repeatability* - is a quantitative measure of the variability associated with the same analyser in a given location obtaining successive repeat results on identical test material. It is defined as that difference between two such single results as would only be exceeded in the long run in one case in twenty in the normal and correct operation of the analyser.
- 3.23 *Error* - the difference between the analyser reading and the result of the laboratory standard test on identical test material.
- 3.21 *Accuracy* - the closeness with which the reading approaches the true value of the measured property of the sample.