International Standard ISO 8158

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Evaluation of the performance characteristics of gas analysers

Évaluation des caractéristiques des analyseurs de gaz

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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Contents

Evaluation of the performance characteristics of gas analysers

1 Scope and field of application

This International Standard defines the main instrumental characteristics to be taken into consideration during the evaluation of gas analysers (continuous and discontinuous) and indicates the general principles and procedures of the test methods to be used in this evaluation. However, for some commercial transactions between manufacturers and users, the routine tests detailed in IEC document IEC/SC 66 D (Secretary) 20, *Expression of performance of gas analysers — Part 1: General* can be applied.

It can act as a guide to the official certification of gas analysers which comes within the scope of national legal metrology services.

2 General test conditions

2.1 Principle of an evaluation

Tests intended to determine the metrological characteristics consist in observing the operation and the indications of the instrument when it is receiving sequences of samples of gas of either known or stable and reproducible composition during the measuring period.

The environmental conditions under which the instrument is evaluated shall be known and recorded. Tests are applied to an instrument assembly that is defined and considered as a single entity (black box) for which the relation between the input and output is studied.

Generally separate aspects of the input/output relation of the instrument are studied by initiating an appropriate change in the input sample composition and observing the corresponding output signal. The procedure used should be suitably described and should be the most reliable possible. It should be based on the use of calibration gas mixtures, where these exist, the preparation of which has been laid down by ISO/TC 158/SC 1, *Methods of preparation and definition of gas mixtures for calibration* (see the annex for a list of available documents on this subject).

A single evaluation is defined by the following items:

- description of the measuring assembly;
- installation of the analyser;
- definition of measuring sequences;
- environmental conditions;
- test mixtures;
- calibration procedure,

and depends **strongly** in particular on the definition of the **measuring sequence** within time.

These conditions are fixed at the beginning of the evaluation procedure not too far from usual operating conditions.

The principle of processing of the obtained data is given for every characteristic, without fixing in detail the acquisition and processing methods.

The values obtained are influenced by the imperfections of the test methods, including acquisition and processing of the data, and only represent estimates of those characteristics within the capabilities of the test equipment.

The significance of the results of tests carried out on a single analyser during a short period of time is obviously limited. It is indeed possible that for a given apparatus the results vary as a function of time and that these results are not always identical for two sets of apparatus of the same type. If it can be done, a repetition of tests enables this drawback to be limited.

2.2 Description of the measuring assembly to be evaluated

Gas analysers are generally complex measuring trains consisting of

- a system for sampling and transfer lines;
- a sensing cell or transducer;
- a system for processing the signals (for example an amplifier);
- an output assembly for reading, recording or data processing.

The same type of analyser can be used in many different applications with appropriate modifications of the measuring assembly. For a given evaluation all the separate points of the measuring assembly listed above shall therefore be clearly stated.

2.3 Installation of the analyser

Before operating the analyser, the user shall comply with the manufacturer's operating instructions particularly with regard to the installation of equipment and the quality and quantity of the consumable products necessary. Evaluation of the analyser shall furthermore be performed taking account of the warm-up time.

2.4 Continuous and discontinuous analysers — Definition of measuring sequences

According to the characteristic to be evaluated, it may be necessary to distinguish between analysers with continuous and discontinuous response.

For analysers with a continuous response, each measurement from 4.2 onwards shall be carried out under stable conditions, i.e. after a waiting time t_1 which is long enough for the analyser to become stable. The value of measurement is taken as the mean value of the signal over a time interval t_2; t_1 and t_2 are fixed and recorded by the experimenter, they are chosen taking account of the dynamic response characteristics in order to obtain a significant measurement under stationary conditions.

The mean of the signal obtained over the time interval t_2 defines, by convention, an independent measurement. Each independent measurement is obtained after performing a complete cycle determined on the basis of t_1 and t_2.

For analysers with a discontinuous response, each measurement will be carried out during an interval of time corresponding to a specified number of sequences and located beyond the response time.

2.5 Environmental conditions

According to the characteristic to be evaluated, tests shall be carried out either under laboratory conditions, i.e. environmental conditions considered as stable and with little constraint, or under extreme environmental conditions simulated in the laboratory. In the two cases, the conditions are known and reported, and if possible fixed. Tests in the field are not covered by this International Standard.

2.5.1 Tests under laboratory conditions

The reference conditions for testing shall be within the following limits:

- temperature: between 17 and 29 °C;
- relative humidity: between 45 % and 75 %;
- pressure: local atmospheric pressure;
- electrical supply.

The conditions of supply (system voltage, supply frequency, distortion of the supply with alternating current) can be selected from one of the categories of use given below (in accordance with IEC Publication 359, *Expression of the functional performance of electronic measuring equipment*).

However, under certain special conditions (apparatus operating conditions, national regulations) different values may be chosen.

2.5.1.1 System voltage (with distortion of the wave-form)

		Direct or alternating current (effective value)	Alternating current (peak value)
Reference value		Nominal voltage	Nominal voltage
Tolerance on reference value		± 1 %	± 2 %
Nominal region of operation	I	± 10 %	± 12 %
	II	− 12 % to + 10 %	− 17 % to + 15 %
	III	− 20 % to + 15 %	− 30 % to + 25 %
Limit area of operation		Identical with the nominal region of operation, unless otherwise specified.	

2.5.1.2 Supply frequency

Reference value: nominal frequency

Tolerance on reference value: ± 1 %

Nominal region of operation I and II:
nominal value ± 5 %

Nominal region of operation III:
nominal value ± 10 %

For each measurement, the value of each of these parameters, together with their variations (as low as possible), shall be recorded and shall be compatible with the sensitivity of the analyser for assessment with regard to these parameters.

The characteristics evaluated under these conditions include the characteristics defined in 4.1 to 4.8.

2.5.2 Operating tests under extreme environmental conditions simulated in the laboratory

These tests may relate to the following effects:

a) apparatus parameters:

- atmospheric pressure,
- temperature,
- relative humidity,
- supply voltage and frequency, and supply interruptions,
- vibrations,
- shocks,
- electrostatic discharges, electromagnetic interference,
- etc.

b) sample parameters:

- flow, pressure, temperature, moisture content, etc.

The choice of parameters and of their extreme values depends upon the apparatus concerned and its future conditions of use.

2.6 Test mixtures

According to the characteristics to be evaluated, the concentrations of test mixtures shall be either known with their uncertainty range or stable within a range which is approximately known. For the preparation of these test mixtures, references shall be made to the documents listed in the annex.

3 Gauging[1)]

Prior to any evaluation, the analyser shall be gauged under reference conditions with calibration gas mixtures prepared according to the methods standardized by ISO/TC 158/SC 1; the positions of different controls (measurement range, potentiometers, flow, etc.) will be detailed and as far as possible shall not vary from the beginning to the end of the evaluation (if this is not the case, any change shall be noted).

4 Characteristics to be evaluated

4.1 Response time — lag time — rise time (or fall time)

4.1.1 Definitions

4.1.1.1 response time: Time interval from the instant at which a step change of sample concentration occurs at the input of the analyser to the instant at which the output reading reaches a level corresponding to 90 % of the final change in output reading.

4.1.1.2 lag time: Time interval from the instant at which a step change of sample concentration occurs at the input of the analyser to the instant at which the output reading reaches a level corresponding to 10 % of the final change output reading.

4.1.1.3 rise time (or fall time): Difference between the response time and the lag time.

4.1.2 Principle of the test method

A concentration C_1 is sent to the analyser, its response is Y_1, then the input concentration is instantaneously changed from C_1 to C_2: the response of the analyser then changes from Y_1 to Y_2.

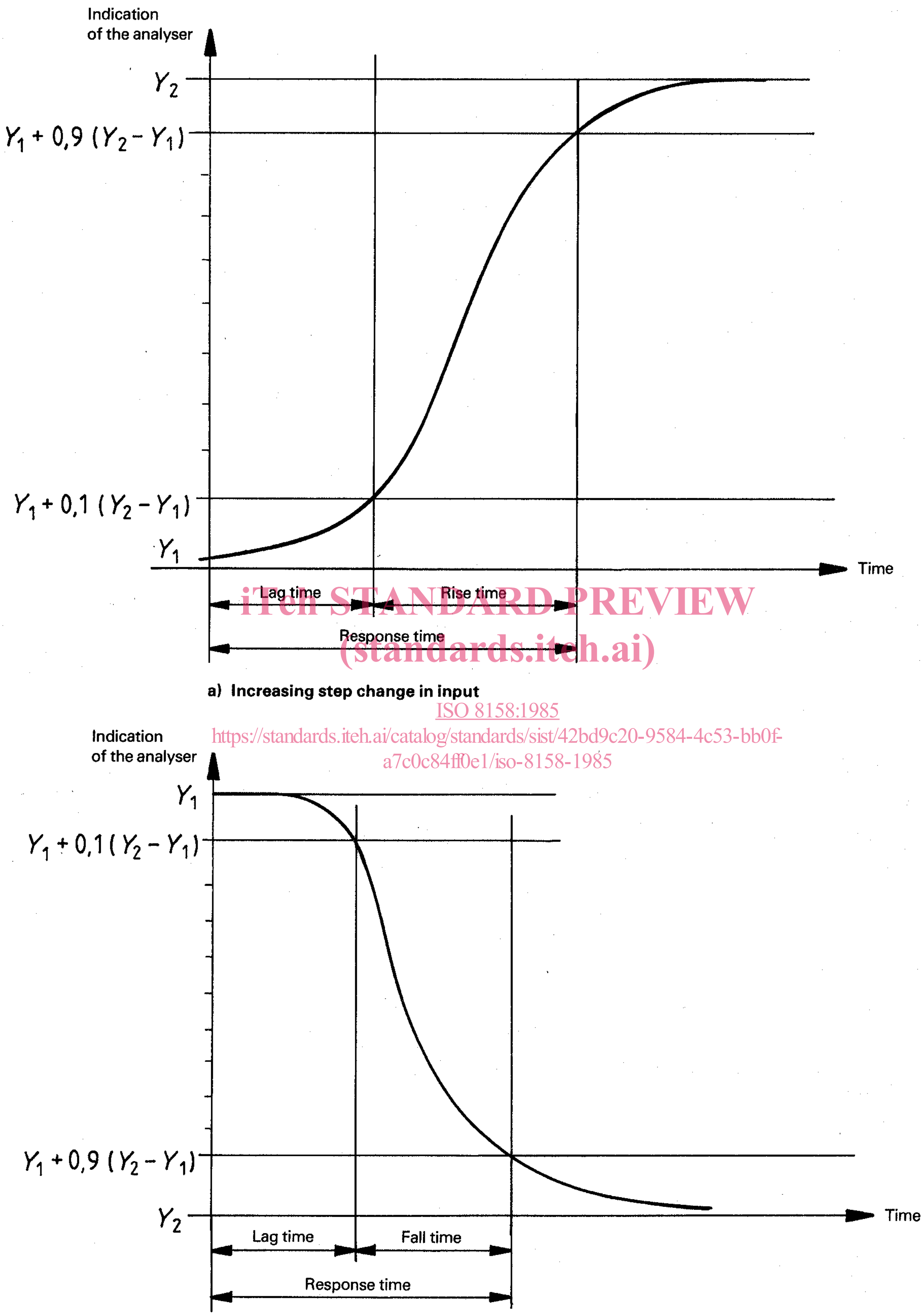
The response time is the time interval from the instant at which the change $C_1 \rightarrow C_2$ occurs to the instant at which the output reading reaches $Y_1 + 0{,}9\,(Y_2 - Y_1)$.

1) This term is used according to the definition given in: BIPM, IEC, ISO, OIML. *International Vocabulary of Basic and General Terms in Metrology.* Geneva, ISO (1984):

gauging (of a measuring instrument)

The operation of fixing the position of the gauge marks or scale marks of a measuring instrument (in some cases of certain principal marks only), in relation to the corresponding values of the measurand.

NOTE — "Gauging" should not be confused with "calibration".



a) **Increasing step change in input**

b) **Decreasing step change in input**

Figure 1 — Diagram illustrating response time, lag time and rise time

The lag time is the time interval from the instant at which the change $C_1 \rightarrow C_2$ occurs to the instant at which the output reading reaches $Y_1 + 0{,}1\ (Y_2 - Y_1)$.

The uncertainty of these measurements depends on the stability of the response at the concentrations chosen. Therefore, and in order to calculate the response time better, if necessary, the operator is advised to carry out several determinations in the same operating conditions; the concentrations between which the response time and the lag time are determined shall be noted.

In addition, the operator will carry out other measurements with a small jump in concentration and with as large a jump in concentration as possible within the concentration range which can be measured, and he will also use increasing and decreasing concentrations when it corresponds to the normal working conditions of the analyser.

The aim of these experiments is to find out more about the variations in the response time of the analyser according to the operating conditions. The response time shall always be determined whatever the nature of the response of the analyser (continuous or discontinuous response); lag time and rise time are, on the contrary, generally less important characteristics than the response time and, in the case of discontinuous response type analysers, they may lose their significance. In the case of an appliance with discontinuous response, the response time will depend on the moment at which the instantaneous step concentration occurs at the input to the analyser.

4.1.3 Summary of information to be given

When the response time is used in a document describing the performance characteristics of an analyser or a measuring assembly, at least the following information shall be given:

- sample flow rate;
- values of the initial and final concentrations;
- stability of these concentrations;
- reading frequency of the analyser output signal during the measurement;
- method used to estimate the final value of the analyser output signal;
- number of measurements carried out.

4.2 Drift

4.2.1 Definition

drift: Change of the indications of an analyser, for a given level of concentration over a stated period of time, under reference conditions which remain constant.

It is necessary to distinguish the zero drift which concerns the operation of the instrument with samples of zero or low concentration from the drift considered at one or several levels of concentration.

4.2.2 Principle of the test method

One or more gas mixtures with constant or reproducible concentrations and one gas with zero or low concentration are used. These various gas mixtures, therefore different concentrations, are introduced into the analyser input. The sequence is reproduced periodically (see figure 2). Linear regressions, as a function of time, are made respectively for the indications corresponding to each level of concentration. The slopes of the linear regressions provide an estimation of the drift at each level.

The linear regression is given by the following equation:

$$Y = A + Bt$$

where

Y is the indication (not corrected by the indication obtained with the zero gas) obtained with time t;

$$A = \frac{\Sigma Y - B \Sigma t}{n}$$

$$B = \frac{n \Sigma t Y - (\Sigma t)(\Sigma Y)}{n \Sigma t^2 - (\Sigma t)^2}$$

n is the number of measurements.

There are two different approaches to determine whether the drift is significant

a) By use of the coefficient of linear correlation, r:

$$r = \frac{n \Sigma t Y - (\Sigma t)(\Sigma Y)}{\sqrt{[n \Sigma t^2 - (\Sigma t)^2]\,[n \Sigma Y^2 - (\Sigma Y)^2]}}$$

For n couples (response, time) and for a probability of 95 %, the correlation and therefore the slope are only significant if r is greater than $r_{n95\ \%}$ given by the tables. The drift is therefore estimated by B.

b) By use of the confidence interval

$$s = \sqrt{\frac{\Sigma (Y - At - B)^2}{n - 2}}$$

The drift is expressed by the calculated slope B of the regression line. Whether drift is significant is tested by the slope of the regression line being statistically different from zero.

The 95 % confidence interval of the slope b is given by

$$B - \frac{t_{0,975} \cdot s}{\sqrt{\Sigma t^2 - (\Sigma t)^2/n}} < b < B + \frac{t_{0,975} \cdot s}{\sqrt{\Sigma t^2 - (\Sigma t)^2/n}}$$

If the confidence interval of b does not include the value zero, drift is significant.