BRITISH STANDARD

BS EN 61115:1994
IEC 1115:1992

Expression of performance of sample handling systems for process analyzers

The European Standard EN 61115:1993 has the status of a British Standard

UDC 621.371.79:543.25

Cooperating organizations

The European Committee for Electrotechnical Standardization (CENELEC), under whose supervision this European Standard was prepared, comprises the national committees of the following countries:

Austria	Italy
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Contents

National foreword

This British Standard has been prepared under the direction of the Industrial-Process Measurement and Control Standards Policy Committee and is the English language version of EN 61115:1993 *Expression of performance of sample handling systems for process analyzers*, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 1115:1992 published by the International Electrotechnical Commission (IEC).

The following print types are used in this standard:

— requirements proper: in roman type;

— *test specifications: in italic type*;

— notes: in smaller roman type.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 22, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61115

October 1993

UDC 621.371.79:543.25

Descriptors: Process analyzers, samples, sample handling, sample handling systems, performance

English version

Expression of performance of sample handling systems for process analyzers

(IEC 1115:1992)

Expression des qualités de fonctionnement des systémes de manipulation d'échantillon pour analyseurs de processus
(CEI 1115:1992)

Angabe zum Betriebsverhalten von Probenhandhabungssystemen für Prozeßanalysengeräte
(IEC 1115:1992)

This European Standard was approved by CENELEC on 1993-09-22. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B-1050 Brussels

Ref. No. EN 61115:1993 E

Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 1115:1992 could be accepted without textual changes, has shown that no common modifications were necessary for the acceptance as European Standard.

The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as EN 61115 on 22 September 1993.

The following dates were fixed:

— latest date of publication of an identical national standard (dop) 1994-10-01

— latest date of withdrawal of conflicting national standards (dow) 1994-10-01

Annexes designated "normative" are part of the body of the standard. Annexes designated "informative" are given only for information. In this standard, Annex A, Annex B, Annex C and Annex ZA are normative and Annex D and Annex E are informative.

Contents

Introduction

Most process or environmental analyzers are designed to work within specified limits of the properties of the sample fluid (e.g. pressure, dew-point) at the sample inlet as well as the outlet [1,2]. Moreover, process analyzers may need auxiliary fluids or other utilities for their correct function.

It is the purpose of a sample handling system to connect one or more process analyzers with one or more source fluids and the environment, so that the requirements of the analyzer are met, and so that it is possible for the analyzer to work properly over an acceptable period of time with an economically justified amount of maintenance work.
(See Annex A for the description of the purpose, functions and properties of sample handling systems.)

Sample handling systems may fulfill the following functions [1]:

- — sample extraction;
- — sample transport;
- — sample conditioning;
- — exhaust stream disposal;
- — supply of utilities;
- — sample stream switching;
- — performance monitoring and control.

Some of the functions can be completely or partly fulfilled by components which are integral parts of an analyzer or which are external to the sample handling system. For the purpose of this standard these components are not considered part of the sample handling system.

The design of a sample handling system depends on the properties of the source fluid, the process analyzer, and the disposal points. Furthermore, the design depends on the properties required for the complete measuring device. Testing a sample handling system is very important. Due to the variety of system configurations and requirements for a system, many different test procedures are applied in practice, but in this standard only the test procedures which are used in most cases are specified. User and manufacturer may agree on additional test procedures, but these are not covered in this standard.

1 Scope and object

1.1 Scope

This International Standard specifies the tests which should be carried out to determine the functional performance of sample handling systems. In addition it specifies the information to be provided by the manufacturers and users of such systems.

It is applicable to:

a) systems handling gaseous or liquid samples for process analyzers used for any ultimate purpose, e.g. process control, emission, ambient air monitoring, etc.;

b) complete systems and system components;

c) power supplies and instrumentation for providing and controlling other utilities necessary for process analyzers or sample handling system components, only in so far as they are a functional part of the system;

d) facilities for maintaining system performance;

e) facilities for maintaining the performance of the process analyzer if these are part of the sample handling system and not the analyzer.

NOTE 1 This standard has been prepared in accordance with the general principles set out in IEC 359.

NOTE 2 Requirements for general principles concerning quantities, units and symbols are given in ISO 1000 and recommendations for the use of their multiples and of certain other units in ISO 31.

1.1.1 *Aspects excluded from scope*

This standard does not cover:

- — general aspects of process analyzers (see IEC 746 for electrochemical analyzers);

  NOTE An IEC standard is in preparation for gas analyzers.
- — electric safety requirements (see IEC 348);
- — safety aspects concerning explosive or toxic hazards;
- — aspects concerning applications where regulations or legal metrology are involved, such as atmospheric pollution. For such aspects more elaborate work going on inside ISO such as ISO 6712 applies;
- — requirements for output signals (see IEC 381-1 and IEC 381-2);
- — influence of environmental conditions (see IEC 68).

1.1.2 *Equipment excluded from scope*

This standard does not apply to:

- — systems for handling solid samples;
- — equipment intended for use in explosive gas atmospheres (see IEC 79-0 to IEC 79-12).

1.2 Object

This standard is intended

- — to specify and to unify the general aspects in the terminology and definitions related to the functional performance of sample handling systems for process analyzers;
- — to specify the tests which, in most cases, should be performed to determine the functional performance of sample handling systems;
- — to specify what information should be available for the manufacturer of sample handling systems. This information may be provided by the user or the manufacturer of process analyzers or by the manufacturer of sample handling system components;
- — to specify what information should be available for the user of sample handling systems.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

2.1 IEC standards

IEC 359:1987, *Expression of the performance of electrical and electronic measuring equipment.*

2.2 ISO standards

ISO 31, *Quantities and units — Parts 0 to 13.*

ISO 1000:1981, *SI units and recommendations for the use of their multiples and certain other units.*

NOTE See Annex E for informative references of ISO and IEC standards.

3 Definitions

3.1 General definitions

(See Annex A and Figure A.1 and Figure A.2 for a description of sample handling systems.)

3.1.1
process analyzer

an analytical instrument connected to a source fluid that automatically provides output signals giving information in relation to a quantity of one or more components present in a fluid mixture or in relation to physical or chemical properties of a fluid which depend on its composition

NOTE For on-line or extractive process analyzers a sample stream is extracted from the source fluid and transported to the analyzer. With an in-line or *in situ* analyzer the measurement is performed within the source fluid.

3.1.2
sample handling system

a system which connects one or more process analyzers with the source fluid, disposal points and utilities

NOTE 1 A sample handling system may extract the required sample stream from one or more source fluids and condition it in order to meet all the input requirements of the process analyzer so that an accurate measurement of the properties under investigation is possible. The system may also ensure the appropriate disposal of exhaust streams and the supply of utilities as necessary. Instrumentation for ensuring the proper function of a sample handling system component or for facilitating maintenance work is considered part of the sample handling system if it is a functional part of it.

NOTE 2 See Annex A and Figure A.1 and Figure A.2 for a description of sample handling systems.

NOTE 3 Figure 1 gives a schematic example for the use of terms describing the functions of sample transport and exhaust stream disposal.

3.1.3 Sample extraction

The function of those parts of a sample handling system which extract the required sample stream from the source fluid.

NOTE The sample stream should be extracted in such a way that it is truly representative of the source fluid.

3.1.3.1
source fluid

the source fluid (gas or liquid) from which the sample stream is extracted and of which the composition or properties are to be measured

NOTE 1 The source fluid may flow through a process line or fill a volume. Ambient air may also be the source fluid.

NOTE 2 The source fluid and the sample fluid in the sample line may consist of a combination of the following components:

- — components to be measured;
- — irrelevant components;
- — obstructive components;
- — interfering components.

3.1.3.2
component to be measured

the component or group of components of which a quantity (e.g. concentration) is to be measured by the process analyzer

3.1.3.3
property to be measured

the physical or chemical property which is to be measured by the analyzer and which depends on the composition of the source fluid

3.1.3.4
irrelevant components

the components which are not to be measured and which do not affect the performance of the analyzer or of the sample handling system

3.1.3.5
obstructive components

the components which adversely affect the performance of the analyzer or of sample handling system components

the effect may be:

— physical (e.g. by dirtying windows in optical analyzers), or

— chemical (e.g. by corrosion), or

— by causing unacceptable errors (e.g. bubbles in a liquid sample stream for a photometer).

obstructive components can be solid, liquid or gaseous

3.1.3.6
interfering components

the components which give rise to interference errors in the analyzer

3.1.3.7
sampling point

the point where the sample stream is extracted from the source fluid

NOTE It may be necessary to have a combination of sampling points at the inlet of a sample handling system. The sample streams from different sampling points can be mixed or measured separately.

3.1.4 Sample transport

The function of those parts of a sample handling system which transfer the sample fluid from the sampling point to the inlet of the process analyzer.

3.1.4.1
sample line

the connection from the sampling point(s) to the analyzer inlet in which a stream is allowed to flow

NOTE Filters, coolers, pumps, flowmeters, etc. may be part of the sample line (see Annex A, Figure A.2).

3.1.4.2
sample stream

the fluid stream in the sample line

NOTE 1 Other streams may be branched off the sample stream (e.g. bypass streams) or be injected into it (e.g. dilution streams).

NOTE 2 The composition and the physical state of the fluid in the sample line shall be allowed to change only in a predictable way.

NOTE 3 The properties of the conditioned sample stream at the inlet of an analyzer have to meet the requirements of the analyzer.

3.1.4.3
bypass stream

a fluid stream which is branched off the sample stream

NOTE 1 It is frequently the purpose of bypass streams to reduce the delay time of the sample handling system.

NOTE 2 The term "bypass stream" is also used for process lines. So the sample stream may be extracted from a bypass stream of a process stream.

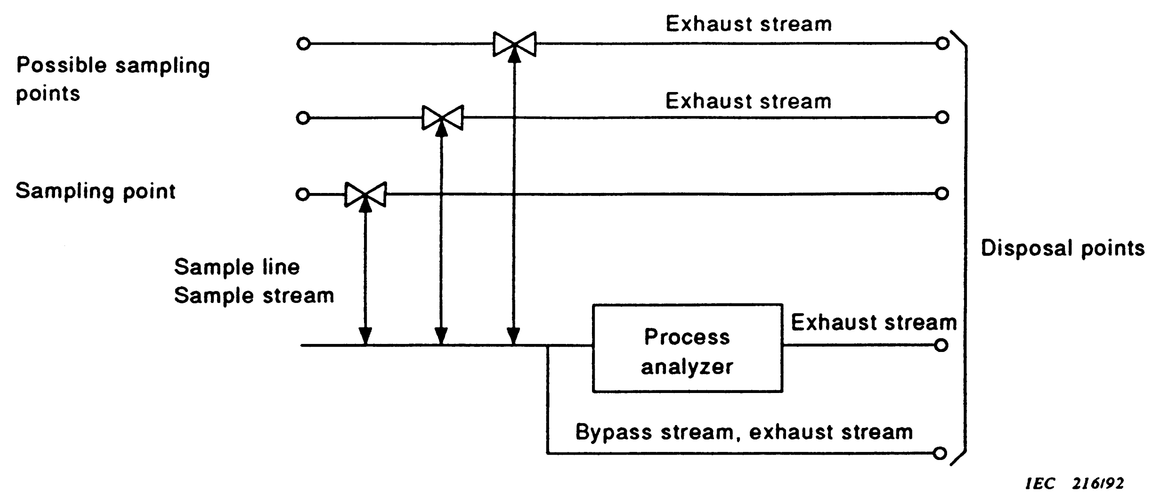

Figure 1 — Schematic example for the use of terms describing the functions of sample transport and exhaust stream disposal

3.1.5 Sample conditioning

The function of those parts of a sample handling system which change the physical and/or chemical properties of the sample stream to suit the process analyzer without changing the composition unless this is done in a predictable way.

NOTE 1 In sample conditioning the sample stream is treated in a predictable way whereby obstructive and interfering components are removed or converted as far as necessary.

NOTE 2 The requirements the sample conditioning has to meet depend on the physical and chemical properties of the source fluid as well as on the admissible inlet conditions of the process analyzer.

3.1.5.1
conditioned sample fluid

the sample fluid suitably conditioned for the analysis

3.1.6 Exhaust stream disposal

The function of those parts of a sample handling system which connect the outlet of the process analyzer or another point in the sample handling system with a disposal point.

NOTE 1 This function should be so realized that the requirements for the analyzer outlet or for other points in the sample handling system are met as well as those for the disposal point.

NOTE 2 The instrumentation for exhaust stream disposal depends very much on the physical state (liquid or gaseous) of the exhaust stream. One sample handling system may give rise to exhaust streams of different physical states.

3.1.6.1
disposal point

the point at which exhaust streams leave the complete system

NOTE A disposal point can be in the open air, the inlet to a process line or volume, or the inlet to a disposal system external to the sample handling system.

3.1.6.2
exhaust stream

a fluid stream from the process analyzer outlet or from another point in the sample handling system to a disposal point

3.1.7 Supply of utilities

The function of those parts of a sample handling system which supply the process analyzer or components of the sample handling system with utilities (e.g. pressurized air, water for cooling, steam for heating, test fluids for calibration, electric power).

3.1.7.1
calibration fluid (test fluid)

a fluid with known quantities or properties to be measured

3.1.8
sample stream switching

the function of those parts of a sample handling system which sequentially connect the process analyzer automatically or manually to different sampling points

NOTE The electronics or pneumatics which control valves used for sample stream switching are considered part of the sample stream switching if they are a functional part of the sample handling system.

3.1.9
performance monitoring and control

the function of those parts of a sample handling system by which the performance of the system or the process analyzer can be checked, maintained or re-established either automatically or manually

NOTE 1 Sample handling system components as well as analyzers may include elements which serve the performance monitoring and control.

NOTE 2 Equipment which serves the maintainability of the sample handling system or of the analyzer (e.g. valves for draining off condensate or facilities for re-calibration) are considered part of the performance monitoring and control (see example in Figure A.2 of Annex A).

NOTE 3 Equipment in which signals from measuring instruments or sensors or any sample handling system components are processed for maintenance or reliability reasons and which are an integral part of the sample handling system are considered part of the performance monitoring and control.

3.1.10 Sample handling system component

Any device which is used for performing the functions of a sample handling system.

3.1.10.1
filter

a device which removes solid particles and/or liquid droplets from a fluid stream

NOTE Filtering may be done mechanically, by coalescing or with electric precipitators.

3.1.10.2
separator

a device in which one phase is separated from another

3.1.10.3
absorber

a device which separates components from a fluid stream by sorption, ion exchange or chemical reaction

3.1.10.4
converter

a device in which the chemical constitution of one or more components in a stream is changed

NOTE A converter may convert an obstructive or interfering component into an irrelevant one or a component to be measured into a measurable one.

3.1.10.5
scrubber

a device in which a gaseous stream is passed through a liquid for washing out solids or droplets or gaseous components

3.1.10.6
cooler (heater)

a device in which one or more sample streams are cooled (heated)

3.1.10.7
pump

a device for actively transferring fluids

3.1.10.8
phase exchanger

a device in which a component or group of components to be measured and present in a fluid of one physical state is at least partly transferred into a fluid of a different physical state

NOTE A device for transferring a component or group of components from a liquid into a gas stream is frequently called a stripper.

3.1.10.9
vaporizer

a device for totally converting a liquid into a gas

3.1.10.10
sampling probe

a device to be inserted into a process stream or volume for the purpose of extracting a sample stream

NOTE A sampling probe may comprise parts for sample conditioning (e.g. a filter).

3.1.11 Performance

The degree to which the intended functions of a sample handling system or of a sample handling system component are accomplished.

3.1.11.1
performance characteristic

one of the quantities assigned to a sample handling system or a sample handling system component in order to define by values, tolerances, ranges, etc. the performance of the system or component

3.1.12
influence quantity

any quantity, generally external to a sample handling system or sample handling system component which may affect the performance of the system or component (Examples: ambient temperature, ambient pressure, corrosive atmosphere.)

3.1.13
specified range, specified value

the range (value) of a quantity to be measured, observed, supplied or set where a sample handling system or system component works within the limits of performance characteristics as stated by the manufacturer

3.2 Terms related to conditions of operation, transportation and storage

3.2.1 Specified operating conditions

The whole of

- — effective ranges and values of performance characteristics;
- — specified ranges of use;
- — specified ranges and values for source fluid conditions at the sampling point(s) (see **4.1.1**);
- — specified ranges and values for exhaust stream conditions at the disposal point(s) (see **4.1.2**) and
- — specified ranges and values for utilities (see **4.1.3**)

within which the sample handling system is specified.

3.2.1.1
specified range of use (refer to Annex B)

the range of values for an influence quantity within which the sample handling system or system component works within the limits of performance characteristics as stated by the manufacturer

3.2.2
reference conditions (refer to Annex B)

a set of values with tolerances or restricted ranges of influence quantities specified for making comparison tests

3.2.3
limit conditions of operation (refer to Annex B)

the whole of the ranges of values for influence quantities and performance characteristics (beyond the specified ranges of use and effective ranges respectively) within which the apparatus can function without resulting in damage or degradation of performance when it is afterwards operated under rated operating conditions

3.2.4
limit conditions of storage and transport (refer to Annex B)

all the conditions of temperature, humidity, air pressure, vibration, shock, etc. within which an apparatus may be stored or transported in an inoperative condition, without causing damage or degradation of performance when the apparatus is afterwards operated under specified operating conditions

3.3 Terms related to the specification of the performance of sample handling systems and sample handling system components

Tests shall be performed with the sample handling system or the sample handling system component ready for use, after start-up time (if necessary) and after performing adjustments according to the manufacturer's instructions.

3.3.1 Time constants (see Figure 2)

For test procedures see **4.5.1**.

3.3.1.1
delay time (T_{10})

the time interval from the instant a step change occurs in the concentration or property to be measured at the inlet, to the instant when the change in the analyzer inlet passes and remains beyond 10 % of its steady-state difference, with the sample flow kept at its specified value

NOTE In sample handling systems the delay time frequently depends on the time needed to transport the sample from the sampling point to the analyzer inlet. This sample transport time can be determined with an analyzer with small time constants together with suitable test fluid.

3.3.1.2
rise (fall) time (T_r, T_f)

the time interval within which the concentration or property to be measured passes from 10 % to (and remains beyond) 90 % of its steady-state difference at the analyzer inlet after a step increase (decrease) in the concentration or property to be measured at the inlet, with the sample flow kept at its specified value

3.3.1.3
90 % time (T_{90})

the sum of the delay time and the rise or fall time, whichever is larger

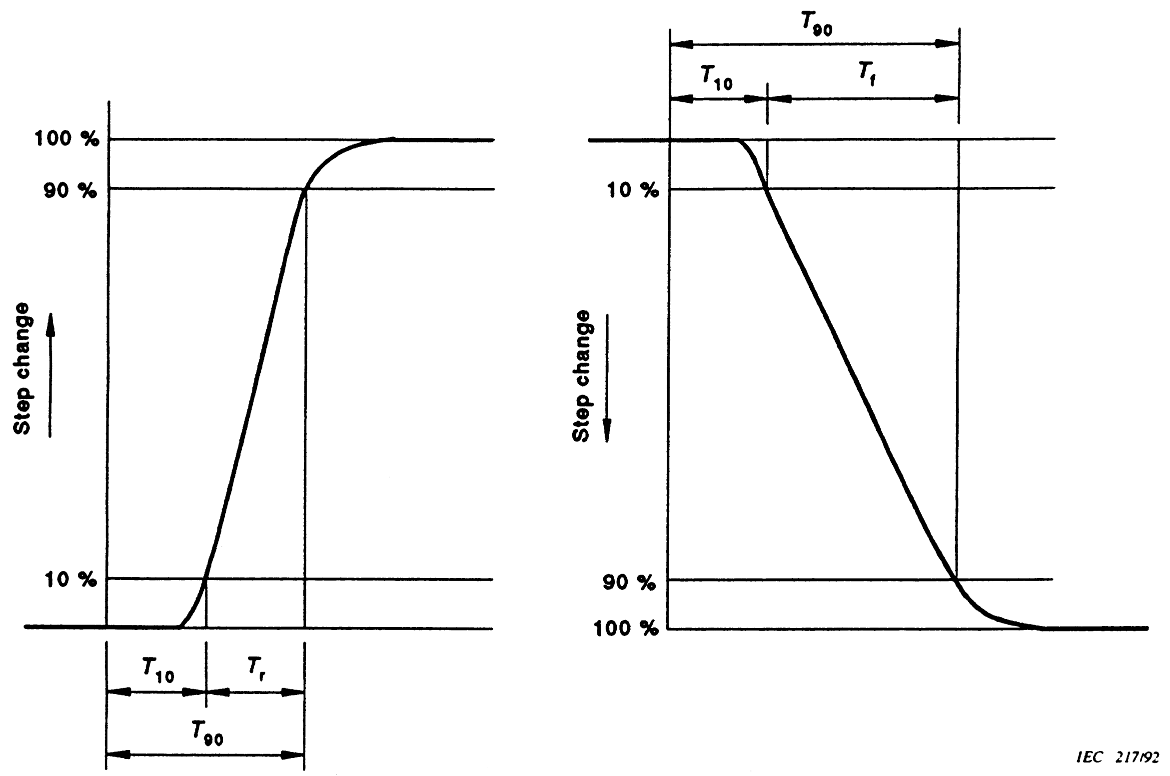

Figure 2 — Time constants and relation between T_{10}, T_r (T_f) and T_{90}

3.3.1.4
cycle time

for sample handling systems equipped with devices for automatic sample stream switching, the cycle time is the time between two consecutive starts of the sampling period on the sample stream from the same sampling point

NOTE 1 The cycle time is not necessarily identical for all sampling points.

NOTE 2 If the time between two consecutive starts on any sample is less than the 90 % time of that part of the system between switching valve and process analyzer, special precautions are necessary for the interpretation of the output signal of the analyzer.

for sample handling systems with discontinuously working sample extraction, sample transport or sample conditioning, the cycle time is the time between two consecutive starts of these operations

3.3.1.5
time constants of sample handling systems with automatic sample stream switching (see **4.5.2**)

for sample handling systems with automatic sample stream switching, the time constants for sampling on one sample stream depend on:

- the time constants of the system between sampling point and switching valve, and
- the time constants of the system between switching valve and process analyzer.

additionally these constants depend on the time-lag between the occurrence of a concentration change at the sampling point and the start of the sampling period on the sample stream from that sampling point

3.3.1.6
start-up time

the time interval between switching on the power and other utilities, and the beginning of the sample handling system or system component working within the stated limits of performance characteristics

3.3.2
leak rate (see **4.5.3**)

the amount of unwanted fluid which enters (e.g. ambient air) or leaves the sample handling system or system component per time unit with the system or component within its specified range of operating pressure

3.3.3
maintenance requirements (see **4.5.4**)

the work which foreseeably has to be done to maintain the specified operating conditions of a sample handling system or system component. This may also include the re-calibration procedure

3.3.4
status signal

externally available binary signal which describes the status of a sample handling system component or of a sampling system

3.3.5 Special performance characteristics

NOTE In sample conditioning the composition of the sample fluid may change, and the changes may affect the measurement [1, 2, 4, 5, 6]. Their effect may be corrected by calculation or by compensation by appropriate calibration procedures, but errors specific for sample handling systems can remain. Exclusively absolute errors are dealt with in the following.

3.3.5.1
volume effect (enrichment effect)

the effect on the concentration to be measured which results from removing components from the sample stream so that the concentration of the components to be measured is increased in the conditioned sample fluid

NOTE 1 A typical example for increasing the concentration of the component to be measured is the removal of vapours for dry analysis.

NOTE 2 The volume effect depends on the concentration of the components to be removed in the source fluid and in the conditioned sample fluid (if the removal is not complete). If these concentrations are known the volume effect can be calculated [6] using the formula:

$$C_m = \left(\frac{1 - C_r}{1 - C'_r}\right) \times C'_m \qquad (1)$$

where

C_m is the concentration of the component to be measured in the source fluid,

C'_m is the concentration to be measured in the conditioned sample fluid (measured by the process analyzer),

C_r is the concentration of the components to be removed in the source fluid, and

C'_r is the concentration of these components remaining in the conditioned sample fluid,

where by the concentrations are given as volume fractions.

If necessary the correction for the volume effect can be based on estimates for the mean concentrations of C_r and C'_r

3.3.5.2
volume error (enrichment error)

the difference between the concentration measured by the process analyzer in the conditioned sample fluid [possibly corrected by using formula (1)] and the concentration to be measured at the sampling point which results from removing components not to be measured

NOTE If the concentration to be measured in the conditioned sample fluid is corrected by means of mean concentrations of C_r and C'_r the remaining volume error depends on their variation.

3.3.5.3
dilution effect

the effect on the concentration or property to be measured which results from injecting a dilution stream consisting of inert components into the sample stream

NOTE The dilution effect for concentrations can be calculated using the formula:

$$C_m = \left(1 + \frac{Q_i}{Q_s}\right) \times C'_m \qquad (2)$$

where

C_m is the concentration to be measured before injection,

C'_m is the concentration to be measured after injection,

Q_s is the sample stream flow before injection, and

Q_i is the flow of the injected dilution stream,

whereby the concentrations are given as volume fractions.

The dilution effect can be compensated by calibrating the sample handling system and the process analyzer with test fluids which are introduced upstream of the injection instead of the sample stream and with the same flow.

3.3.5.4
dilution error

the difference between the corrected [by calculation using formula (2) or compensation] concentration or property to be measured by the process analyzer in the conditioned sample fluid and the concentration or property to be measured at the sampling point, which results from flow variations in the sample or dilution flow

NOTE If the specified ranges of flow of the sample and dilution stream are known the error by dilution can be calculated using formula (2).

3.3.5.5
composition error

the difference between the concentration to be measured in the conditioned sample fluid and at the sampling point, which arises from sorption, or dissolution, or permeation, or reactions of the components to be measured within the sample stream

NOTE The composition error should be determined when the sample handling system and the process analyzer working in their specified ranges of use. The analyzer is calibrated, and then at the sampling point a test fluid is introduced that is similar to the source fluid but in which the concentration of the component to be measured is in a typical range and known. The composition error is the difference between the concentration known and that found by the process analyzer.

3.3.5.6
converter efficiency (see **4.5.5**)

the ratio of the actual concentration of the particular molecule produced by the converter to the theoretical maximum concentration of that molecule

NOTE The converter efficiency is characterized by the conversion factor in the equation:

$$C^*_m = \alpha \cdot k \cdot C_m \qquad (3)$$

where

C^*_m is the concentration of the component produced by conversion at the converter outlet, if this component is not present at the converter inlet,

C_m is the concentration of the component to be converted at the inlet of the converter,

α is the conversion factor ($\alpha = 1$, if the conversion is complete), and

k is the stoichiometric ratio resulting from the conversion reaction,

whereby the concentrations are given as volume fractions.

3.3.5.7
converter capacity (see **4.5.5**)

the amount of components to be converted which a converter is able to convert

usual dimension: concentration · time

3.3.5.8
conversion error

the difference between the corrected [by calculation using formula (3) or compensation] concentration of the produced component at the converter outlet and the concentration of the component to be converted at the converter inlet, if the component to be produced by conversion is not present at the converter inlet

3.3.5.9
phase exchanger efficiency (see **4.5.6**)

the ratio of the concentration of the component to be measured in the inlet fluid to the phase exchanger to the concentration of the same component in the outlet fluid

NOTE 1 The phase exchanger efficiency is characterized by the transition factor in the equation:

$$C'_m = \beta \cdot C_m \qquad (4)$$

where

C'_m is the concentration of the component to be measured in the fluid into which this component is transferred,

C_m is the concentration to be measured in the fluid from which this component is to be transferred, and

β is the transition factor,

whereby the concentrations are given as volume fractions.

NOTE 2 The transition factor β depends on the solubility of the component to be transferred in the primary fluid, on the temperature, on the flow rates and on the construction of the flow exchanger.

3.3.5.10
phase exchanger error

the difference between the corrected [by calculation using formula (4) or compensation] concentration in the sample stream outlet and the concentration of the component to be measured in the fluid at the sample stream inlet of the phase exchanger

4 Procedures for statements

In the following a list of statements is given which may be important for the manufacturer of sample handling systems or for their user. Due to the structure of sample handling systems (see Figure A.1 of Annex A) the manufacturer of sample handling systems needs statements to be provided by the user (**4.1**), by the manufacturer of the process analyzer (**4.2**), and by the manufacturer of sample handling system components (**4.3**). The user will need statements specifying the performance of the sample handling system which are to be provided by the manufacturer of the system (**4.4**).

The choice of statements necessary depends on the specific case. The following may be used as a check-list from which the useful statements can be selected. The statements which are usually of primary interest, and necessary in most cases, are marked by an asterisk (*).

If more practical, minimum, normal and maximum values may be stated instead of ranges. Abnormal situations shall also be taken into account.

NOTE The specified ranges of use, the reference conditions and the limit conditions of operation, storage and transport for all influence quantities, shall be stated and selected only from one of the groups listed in Annex B.
Any exceptions to the values given there shall be explicitly and clearly stated by the manufacturer with an indication that they are exceptions.

4.1 Statements concerning the requirements for a sample handling system (user)

4.1.1 ***Statements concerning the source fluid conditions at the sampling point (user)***

The following statements shall be provided by the user as far as possible and for each sampling point:

* range of temperature;

* range of pressure;

* physical state(s);

* ranges of concentration of all components;

— specification of the process line at the sampling point;

— concentration and size data of particulates and/or droplets;

— density and viscosity of a liquid source fluid and if needed of a gaseous source at one or more temperatures;

— pH value of a liquid source fluid;

— ranges of velocity, flow and direction of the source fluid stream;

— dew-point, bubble-point, flash-point and/or melting-point;

— saturation temperature for solutes present in high concentration;

— critical properties of the source fluid such as corrosiveness, possible polymerization reactions, other chemical reactions leading to a change of composition, etc.

4.1.2 ***Statements concerning the conditions at the disposal points (user and manufacturer of sample handling system)***

The following statements shall be agreed upon between manufacturer and user for each disposal point:

* range of pressure (return pressure);

— range of temperature;

— admissible maximum concentration of hazardous components;

— maximum flow of exhaust stream.

4.1.3 ***Statements concerning the location (user)***

The following statements shall be provided by the user in order to specify under what environmental conditions the sample handling system has to work. If necessary special statements shall be given for the different areas in which the parts of the sample handling system will be located:

* range of ambient temperature;

* available utilities (specification of power supplies; pressure, temperature and quality of auxiliary fluids);

* distance between sampling point and analyzer;

* distance between analyzer and disposal points.

— range of ambient pressure;

— height difference between sampling point and analyzer (for liquid sample streams);

* area classification;

— corrosiveness of the atmosphere.

4.2 Statements concerning the requirements for a sample handling system (manufacturer of process analyzer)

The following statements shall be provided by the manufacturer of the process analyzer in order to specify the requirements a sample handling system has to meet for the analyzer.

4.2.1 ***Process analyzer inlet for the sample stream***

* range of temperature of the sample stream;

* range of flow of the sample stream;

* interference error of interfering components present in the source fluid;

* admissible maximum concentration of obstructive components present in the source fluid;

* admissible dew-point;

— range of pressure;
— admissible range of density;
— admissible range of viscosity.

4.2.2 *Process analyzer outlet of exhaust stream*

* range of pressure;
* range of flow;
— range of temperature.

4.2.3 *Process analyzer inlet for utilities*

* range of pressure of auxiliary fluids;
* range of flow of auxiliary fluids;
* requirements concerning the quality of auxiliary fluids;
— range of temperature of auxiliary fluids;
* specification of power supply and consumption of electric energy.

4.3 Statements concerning sample handling system components (manufacturer of sample handling system components)

The following statements shall be provided by the manufacturer of sample handling system components in order to specify the properties of the components so that their applicability can be judged. This information is necessary for the manufacturer of sample handling systems whereas it is not necessary for the user of the complete system. It shall be made available to the user on request.

* a list of all materials which come into contact with the sample fluid;
* effective internal volume;
* range of pressure of the sample fluid;
* range of temperature of the sample fluid;
* range of sample fluid flow;
* pressure drop at specified flow rate of sample fluid;
* performance characteristics (see **3.3** and **4.5** for possibly applicable performance characteristics);
* requirements for environmental conditions;
— limit conditions of operation;
— limit conditions of storage and transport;
— requirements for utilities;
— specification of status signals together with their meaning and possible causes;
— instructions for installation (e.g. of sampling probes).

4.4 Statements concerning sample handling systems (manufacturer of sample handling systems)

The following statements shall be provided by the manufacturer of sample handling systems in order to specify the properties of the sample handling system:

* ranges of pressure of auxiliary fluids;
* ranges of temperature of auxiliary fluids;
* quality requirements for auxiliary fluids;
* consumption of auxiliary fluids;
* ranges of power supply;
* consumption of electric energy;
* environmental conditions for the sample handling system or parts of it;
* performance characteristics (see **3.3** and **4.5** for possibly applicable performance characteristics);
* output signals (e.g. in sample handling systems with automatic sample stream switching);
— limit conditions of operation;
— limit conditions of storage and transport;
— specification of status signals together with their meaning and possible causes;
— instructions for installation;
— operating instructions.

4.5 Statements on special performance characteristics

4.5.1 ***Verification of time constants of a measuring system for process analysis*** (see **3.3.1** and Annex C)

Verification of the time constants of the complete measuring system for process analysis comprising a sample handling system and a process analyzer shall be carried out. One suggested method is given in Annex C.

4.5.2 ***Time constants of sample handling systems with automatic sample stream switching*** (see **3.3.1.5**)

The 90 % time of measuring systems with automatic sample stream switching shall be stated for the best and worst cases.

4.5.3 ***Leak rate*** (see **3.3.2**)

The leak rate of a system or component shall be determined.

NOTE Because of the wide range of materials which could be sampled, no single method is available.

4.5.4 ***Maintenance requirements*** (see **3.3.3**)

Maintenance requirements normally depend to a large extent on the conditions under which a sample handling system or system component has to work.

The manufacturer shall supply the user with the information necessary to estimate the maintenance requirements. The information should include, but is not limited to:

— a description of the work which foreseeably has to be carried out to maintain the operating conditions of the sample handling system or system components;

— the frequency with which this work or parts of it have to be repeated;

— the material (spare parts, reagents, etc.) which are consumed for this work;

— a list of recommended spare parts.

4.5.5 ***Efficiency and capacity of converters*** (see **3.3.5.6** and **3.3.5.7**)

The ranges of converter efficiency and converter capacity shall be stated by the manufacturer for the specified ranges of use (e.g. flow, concentration of the component to be converted, etc.) and if necessary, together with the maximum concentration of the component to be converted.

NOTE The effect of the conversion efficiency on the measurements of the process analyzer can be compensated by calibrating the sample handling system and the process analyzer with test fluids containing the component to be converted, which are introduced upstream of the converter instead of the sample stream.

4.5.6 ***Phase exchanger efficiency*** (see **3.3.5.9**)

If the phase exchanger efficiency is not compensated in the calibration procedure, it should be stated for each component to be transferred, for the fluids used and for the specified range of use (especially flows and temperature).

NOTE The effect of the phase exchanger efficiency on the measurement results of the process analyzer can be compensated by calibrating the sample handling system and process analyzer with test fluids which are introduced upstream of the phase exchanger.

Annex A (normative) Purpose, functions and properties of sample handling systems

A complete measuring device for process analysis consists of at least one process analyzer and a peripheral system called the sample handling system in which the process analyzer is embedded.

In Figure A.1, the requirements of the process analyzer for the properties of the sample fluid at its inlet are characterized by a set of quantities and ranges [Z_i]. The set [Z_0] characterizes its requirements for the outlet, and the set [Z_a] those at the inlet for auxiliary fluids.

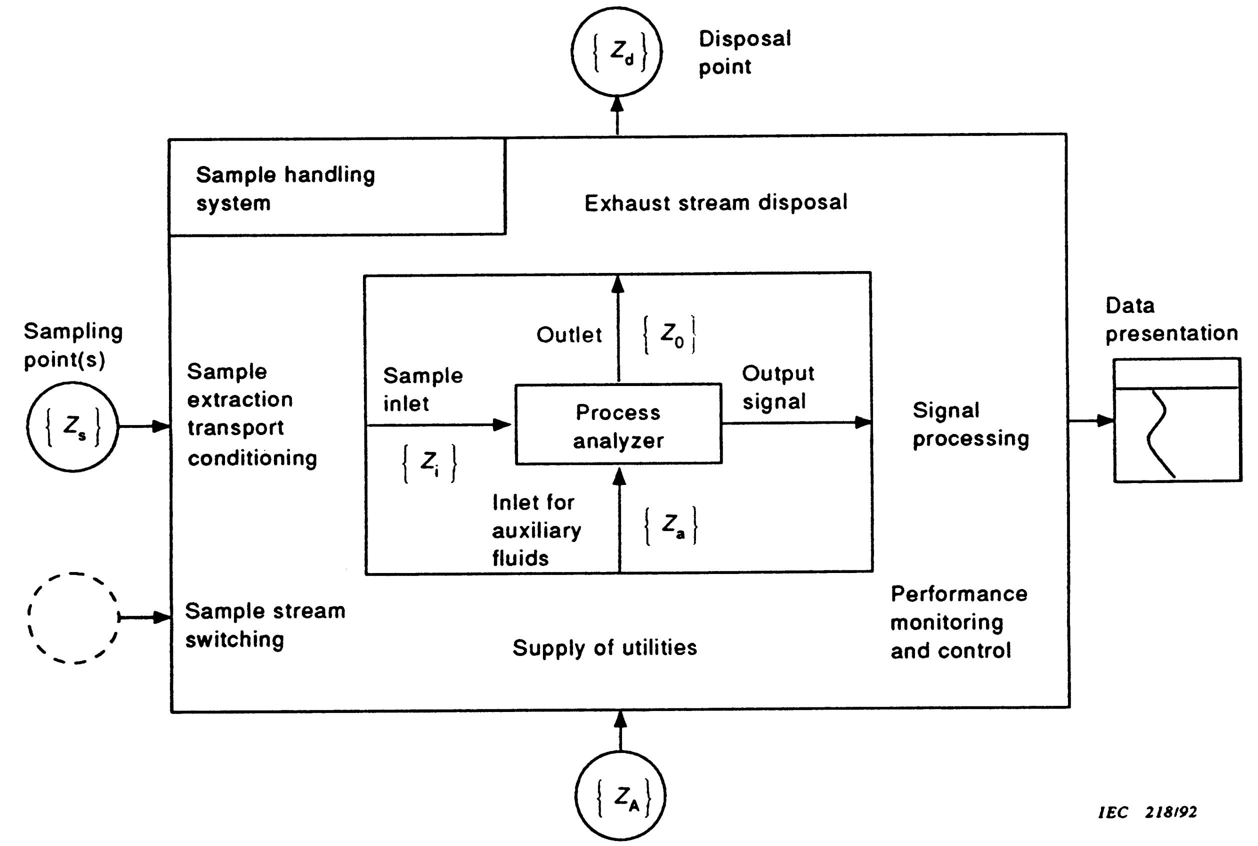

Figure A.1 — Schematic outline of a complete measuring system for process analysis consisting of a process analyzer and a sample handling system [6]

(Possible basic functions:

- — sample extraction;
- — sample transport;
- — sample conditioning;
- — sample stream switching;
- — supply of utilities;
- — exhaust stream disposal.

Additional function:

- — performance monitoring and control.

Properties:

- — response time;
- — errors;
- — reliability;
- — investment and maintenance expense.)

The process analyzer with its specified requirements has to be connected to the sampling points and the environment by means of a sample handling system. The properties of the source fluid at the sampling points are quantified by the set [Z_s], auxiliary fluids and power supplies are provided for the system with the properties [Z_A], and the possible conditions at the disposal point are described by the set [Z_d].

The tasks of a sample handling system can be the following:

— to change the properties [Z_s] of the sample stream at the sampling point so that the requirements [Z_i] of the process analyzer for its inlet are met;

— to change the properties [Z_A] of the utilities provided so that the requirements of the process analyzer [Z_a] and, if necessary, of sample handling system components are met, and

— to connect the process analyzer outlet with the point of disposal so that the respective requirements [Z_0] and [Z_d] are met.

A sample handling system may perform the following basic functions:

— sample extraction;

— sample transport;

— sample conditioning;

— exhaust stream disposal;

— supply of utilities;

— sample stream switching.

To obtain a sufficient reliability and to keep the maintenance expense to an economically justified level, it is normally necessary to realize the additional function:

— performance monitoring and control.

The possibilities of instrumentation for this function are manifold. They range from equipping the system with simple measuring instruments (e.g. flowmeter, manometer) and valves for rinsing with test fluids to the automation of the performance monitoring and control by means of status sensors and complex electronics. These may also be able to perform routine maintenance work (e.g. calibrations) automatically and to give externally available failure reports for improving the reliability.

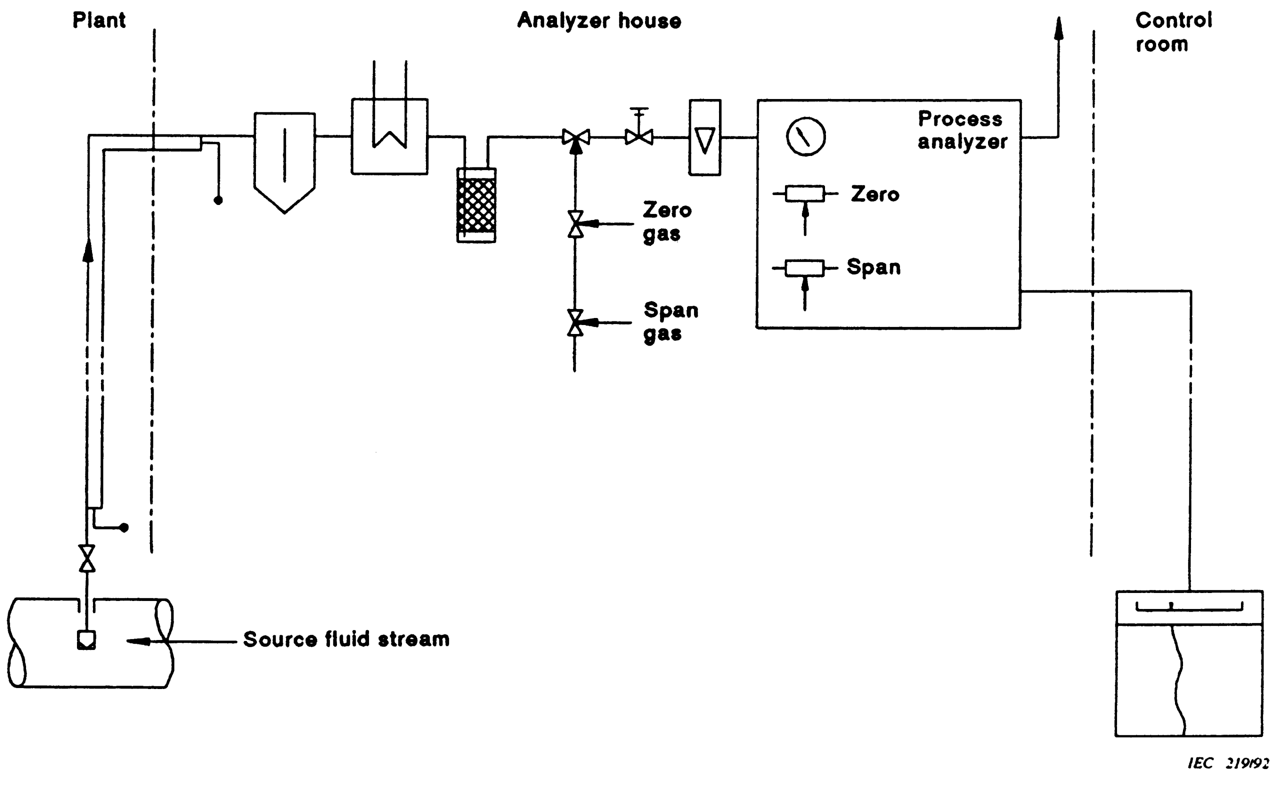

Figure A.2 — Simple example for a complete measuring system for process analysis

Not all of the basic functions have to be realized in all cases. “Sample stream switching”, is comparatively seldom necessary, and for in-line or *in situ* analyzers the functions “sample extraction”, “sample transport” and “sample conditioning” need not be performed, whereas the function “supply of utilities” may nevertheless be needed. For some portable and battery driven analyzers (e.g. for workplace hygiene measurements) a sample handling system is not necessary.

A simple example for a complete measuring system is shown in Figure A.2. It is assumed that the pressure at the sampling point is high enough for transferring the sample stream through the sample handling system and the analyzer to the disposal point in the open air. The functions “sample stream switching” and “supply of utilities” are not utilized in this example.

The following table contains the sample handling system components of the example together with their respective functions.

Table A.1 — Functions of sample handling system components

Components	Functions				
	Sample			Exhaust stream disposal	Performance monitoring and control
	Extraction	Transport	Conditioning		
Sampling probe — with in-line filter	×	×	×		
Valve		×			×
Heated sample line		×			
Filter (coalescer)		×	×		
Cooler		×	×		
Absorber		×	×		
Valves for calibration gases					×
Needle valve		×	×		×
Flowmeter		×			×
Exhaust line				×	

The process analyzer comprises components (indicators, potentiometers for re-calibration) which also serve the function “performance monitoring and control”.

It is the purpose of a complete measuring system to provide information about chemical or physical properties of the source fluid. The sample stream carries the information from the sampling point to the analyzer which transforms it into a signal. Errors may not only arise within the process analyzer but also in the sample handling system, if the properties of the sample stream are changed in an uncontrolled way so that it loses an unknown part of information to be acquired [1, 2, 4, 5]. If the functions “sample extraction”, “sample transport”, and above all “sample conditioning” are performed, errors are possible and have to be taken into account which are specific for sample handling systems (e.g. composition error, volume error, dilution error, etc.).

For the properties of a complete measuring system important demands can arise with emphasis depending on the particular case. The most important properties are:

- — time constants;
- — errors;
- — reliability (operational availability);
- — investment expense;
- — maintenance expense.

Other important properties (e.g. safety characteristics) are not dealt with in this standard. The properties of a complete system depend on the process analyzer as well as on the construction of the sample handling system.

A sample handling system has to be constructed so that the demands concerning its properties are met as far as possible. With many measuring systems for process analysis it is the sample handling system rather than the process analyzer that is more frequently the source of poor performance or breakdown. The objectives of maintenance should be that the accuracy and availability are continuously and reliably achieved.

Annex B (normative)
Operating groups and limit ranges of operation, storage and transport

The operating ranges of influence quantities are divided into five operating groups, according to the severity of the environment, as shown in Table B.1.

Of the many possible influence quantities only a few are important in the environments in which most sample handling systems and process analyzers are used.

These quantities are referred to as primary influence quantities. Limit values or operating ranges for primary influence quantities according to operating groups are given or described in Table B.2.

Table B.1 — Operating groups

Operating group	Operating conditions
A	The environment existing in standard laboratories, under suitable conditions for calibration and measurements to resolve disputes. NOTE The ranges for influence quantities may be chosen to be reference ranges or nominal ranges of use as given in other IEC publications.
B	The environment existing indoors under conditions which are normally found in laboratories and light industry, and where equipment will be handled carefully.
C	The environment existing under conditions which are normally found in heavy industry.
D	An uncontrolled environment in which the equipment may be subjected to rough handling.
E	Special environmental requirements relating to unusual fields of use. NOTE For this group the details will be subject of special agreement between manufacturer and user.

Table B.2 — Primary influence quantities according to operating groups

Primary influence quantity	Limit values of ranges					
	Reference value or range	Operating range				
	All operating groups	Operating group A Standard laboratories	Operating group B General laboratories and light industry	Operating group C Heavy industry	Operating group D Uncontrolled environment	Operating group E Special duty
1. Ambient temperature (notes 1 and 2)	20 °C, 23 °C or 27 °C ± 1 °C	As stated in IEC publication relevant to equipment (for example, Nominal Range of Use) or as agreed between manufacturer and user	+ 5 °C to + 40 °C	– 10 °C to + 55 °C	– 25 °C to + 70 °C	As agreed between manufacturer and user
2. Relative humidity	40 % to 60 %		30 % to 70 %	10 % to 90 %	5 % to 95 %	
3a. Supply voltage	Rated value ± 1 %		Rated value ± 5 %	Rated value ± 10 %	Rated value ± 15 %	
3b. Attitude	Any stated attitude ± 1° in any direction		Any stated attitude ± 5° in any direction	Any stated attitude ± 5° in any direction	Any stated attitude ± 30° in any direction	

NOTE 1 These temperatures are taken from IEC 160. The reference temperature relating to a particular equipment must be explicitly stated. If a reference range for temperature is stated, it shall include at least one of these temperatures.

NOTE 2 The tolerance is as shown unless a smaller tolerance is stated in a relevant IEC publication.

Table B.3 — Limit ranges for operation, storage and transport

Operating group	Limit range of operation (note 1)	Limit range of storage and transport (note 2)
Group A	Equal to operating range, unless otherwise stated in the relevant IEC publication	As agreed between manufacturer and user, unless otherwise stated in the relevant IEC publication
Groups B, C, D	Equal to operating range	Primary influence quantities: • Temperature: – 40 °C to + 70 °C • Relative humidity: 5 % to 95 % Secondary influence quantities: • as agreed between manufacturer and user
Group E	As agreed between manufacturer and user	As agreed between manufacturer and user

NOTE 1 The limit range of operation applies to all stated influence quantities.
NOTE 2 The limit range of storage and transport applies only to those stated influence quantities which affect the equipment when it is not operating. For instance, supply voltage is not applicable.

Annex C (normative) Verification of time constants of a measuring system for process analysis

To determine the time constants of a complete measuring system for process analysis comprising a sample handling system and a process analyzer, the following procedure can be performed:

While the process analyzer output is recorded the sampling point is flushed with a test fluid until a constant reading of the analyzer is obtained. Then the sampling point is flushed with a test fluid of a composition that will give rise to an analyzer signal change between 65 % and 95 % of full scale. The values for the time constants are determined from the time elapsed since the start of inserting the latter test fluid.

If either appropriate test fluids are not available, or introducing test fluids at the sampling point is not possible, the following procedure [3] can be performed for a system which is attached to a source fluid of a nearly constant composition which gives rise to an analyzer signal of between 50 % and 95 % of full scale.

The sample handling system and the analyzer are completely backflushed with a fluid that is similar to the source fluid but which will not give rise to an analyzer signal greater than 10 % of full scale. Then backflushing is stopped and, with the analyzer and sample handling system working at their specified operating conditions, the analyzer signal is recorded.

The delay time and the rise time are determined by evaluating the recorded analyzer signal.

Alternative test methods may be agreed upon by the manufacturer and the user.

Annex D (informative) Index of definitions

Annex E (informative) Bibliography

E.1 Documents

[1] E.A. Houser: Principle of sample handling and sampling systems design for process analyzers. Instrument Society of America, Pittsburgh, Pa., 1972.

[2] Manual on Installation of Refinery Instruments and Control Systems, RP 550, Part II — Process Stream Analyzers, 4th edition, February 1985, American Petroleum Institute, Washington D.C.

[3] D.S. Bartran: Testing the response of on-line analyzers. Chemical Engineering, March 9 (1981), 115/116.

[4] VDI/VDE — Richtlinie 3516, Blatt 1: Gasanalytische Betriebsmesseinrichtungen und -anlagen (Process analytical equipment for gases). VDI-Verlag, Düsseldorf, 1978.

[5] VDI/VDE — Richtlinie 3516, Blatt 2: Flüssigkeitsanalytische Betriebsmesseinrichtungen und -anlagen (Process analytical equipment for liquids). VDI-Verlag, Düsseldorf, 1981.

[6] E.D. Gilles, E. Nicklaus, M. Polke: Sensortechnik in der chemischen Industrie — Status und Trend (Sensor Technology in the Chemical Industries — Status and Trend.) Chemie-Ingenieur-Technik 58 (1986) Nr 7.

E.2 IEC Standards

IEC 68-1:1988, *Environmental testing, Part 1: General and guidance.*

IEC 79, *Electrical apparatus for explosive gas atmospheres — Parts 0:1983 to 12:1978.*

IEC 160:1963, *Standard atmospheric conditions for test purposes.*

IEC 348:1978, *Safety requirements for electronic measuring apparatus.*

IEC 381-1:1982, *Analogue signals for process control systems — Part 1: Direct current signals.*

IEC 381-2:1978, *Analogue signals for process control systems — Part 2: Direct voltage signals.*

IEC 746-1:1982, *Expression of performance of electrochemical analyzers — Part 1: General.*

IEC 746-2:1982, *Expression of performance of electrochemical analyzers — Part 2: pH value.*

IEC 746-3:1985, *Expression of performance of electrochemical analyzers — Part 3: Electrolyric conductivity.*

E.3 ISO Standard

ISO 6712:1982, *Gas analysis — Sampling and transfer equipment for gases supplying an analytical unit.*

Annex ZA (normative) Other international publications quoted in this standard with the references of the relevant European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

NOTE When the international publication has been modified by CENELEC common modifications, indicated by (mod), the relevant EN/HD applies.

IEC publication	Date	Title	EN/HD	Date
359	1987	*Expression of the performance of electrical and electronic measuring equipment*	—	—

Other publications:

ISO 31	*Quantities and units — Parts 0 to 13*
ISO 1000:1981	*SI units and recommendations for the use of their multiples and certain other units*

National annex NA (informative) Committees responsible

The United Kingdom participation in the preparation of this European Standard was entrusted by the Industrial-Process Measurement and Control Standards Policy Committee (PCL/-) to Technical Committee PCL/1 upon which the following bodies were represented:

British Coal Corporation
British Gas plc
Electrical Contractors Association
Electricity Association
Energy Industries Council
Engineering Equipment and Materials Users' Association
GAMBICA (BEAMA Ltd.)
Health and Safety Executive
Institution of Gas Engineers
British Telecommunications plc
Department of Trade and Industry (Gas and Oil Measurement Branch)

The following bodies were also represented in the drafting of the standard, through subcommittees:

Department of Trade and Industry (National Physical Laboratory)

National annex NB (informative) Cross-references

Publication referred to	Corresponding British Standard
IEC 359:1987	BS 4889:1990 *Method for specifying the performance of electrical and electronic measuring equipment*
ISO 31	BS 5775 *Specification for quantities, units and symbols*

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