INTERNATIONAL

RECOMMENDATION

OIML R 70

Edition 1985 (E)

Determination of intrinsic and hysteresis errors of gas analysers

Détermination des erreurs de base et d'hystérésis des analyseurs de gaz

OIML R 70 Edition 1985 (E)

ORGANISATION INTERNATIONALE
DE MÉTROLOGIE LÉGALE

INTERNATIONAL ORGANIZATION
OF LEGAL METROLOGY

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This publication – reference OIML R 70 (E), edition 1985 – which is under the responsibility of TC 17/SC 6 *Gas analysis*, was sanctionned by the International Conference of Legal Metrology in 1984.

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DETERMINATION
of INTRINSIC and HYSTERESIS ERRORS
# of GAS ANALYSERS

1. Introduction

This Recommendation specifies a method and the means for the determination of intrinsic and hysteresis errors of gas analysers intended for the measurement of concentrations of component gases in gas samples, during their verification.

Other methods are accepted provided that they give similar results during the determination of the metrological characteristics of gas analysers.

This Recommendation also covers the measuring systems which contain not only the gas analysers but also sample preparation equipment and data processing units which are part of the gas analyser.

A complete description of the evaluation of gas analysers may be found in the International Standard ISO 8158-1985 « Evaluation of the performance characteristics of gas analysers ».

2. Parameters to be checked

	Parameter to be checked	Reference
1.	Markings and designations	point 5.1
2.	Completeness of the instrument, external appearance	5.2
3.	Intrinsic error	5.3.1 and 5.3.2 and 5.3.3 and 5.3.4 and 5.3.5 and 5.3.6
4.	Systematic component of the intrinsic error	
5.	Standard deviation of the random component of the intrinsic error	
6.	Hysteresis error of the output signal	

Table 1

Note : only those of the parameters numbered 3 to 6, which are included in the certificate of the gas analyser being verified, shall be checked. Other parameters characterising the condition of the gas analyser, such as vacuum tightness, electrical insulation resistance, etc., can be added to the list of parameters to be checked, if necessary.

3. Reference conditions during verification

3.1. In general, the ambient temperature shall be between 18 arid 25 °C. The temperature shall be maintained at a known value within ± 1 °C, and/or be measured with an error not exceeding ± 0,2 °C. When checking at a temperature other than specified, the effect of the ambient temperature upon the parameter being checked shall be taken into account.

3.2. The atmospheric pressure measurement error shall not exceed ± 0.2 kPa. At atmospheric pressures which differ from the calibration pressure, appropriate corrections shall be made to the result of the measurement.

3.3. The relative humidity of ambient air shall be between 30 and 80 %.

3.4. The voltage of the electric power supply shall not vary from its rated value by more than 1 %. In some cases, the relevant national regulations may fix other values.

4. Means

4.1. The means to be used for determining the intrinsic error, its systematic component, the standard deviation of the random component of the intrinsic error and the hysteresis error may be classified as follows :

a) certified reference gases : gas mixtures and pure gases supplied under pressure in cylinders,

b) devices for setting up the flow of the calibration gas, of which the concentration of an individual component is predetermined : electrolysers, zero gas cleaners, mixing pumps, capillary mixers, etc. ; the combined error due to these devices shall not exceed 25 % of the intrinsic error of the gas analyser being verified,

c) working standard gas analysers, of which the indications are compared with those of the gas analyser being verified, by feeding the same gas sample into the inlet ports of the two devices involved.

The metrological characteristics of standard instruments shall be specified in their certificates ; the certificates for reference gas mixtures supplied under pressure in cylinders shall comply with the International Standard ISO 6141-1984 « Gas analysis-Calibration gas mixtures. Certificate of mixture preparation ».

4.2. The composition of the calibration gas used for the verification of a gas analyser shall be the same as that of the gas mixtures used for the initial calibration of the gas analyser.

The concentrations of the components to be measured and the permissible variations shall comply with the values given in Table 2.

Calibration gas No.	Concentration of the component to be measured, at check point, in % of the measuring range
1	5 ± 5
2	30 ± 5
3	50 ± 5
4	70 ± 5
5	95 ± 5

Table 2

The concentrations of the component to be measured in the gas mixtures used for checking the intrinsic error or its systematic component shall be known with an accuracy better than 20 to 40 % of the specified value for the parameter being checked.

4.3. When measuring the output signals of transducers, use shall be made of secondary devices for which the fiducial error does not exceed 25 % of the maximum permissible fiducial intrinsic error (or the maximum permissible systematic component of the intrinsic error) for the transducer being verified.

5. Procedure

5.1. Check the following markings and designations :

a) manufacturer's trade mark,
b) designation of the gas analyser,
c) serial number,
d) year of manufacture,
e) rated values of current, voltage and frequency of the electric power supply, or nominal pressure for gas analysers with pneumatic operation,
f) chemical symbol or name of the component gas to be measured,
g) symbol of the unit of the quantity to be measured,
h) measuring ranges and limits of the output signal.

5.2. Check :

a) the certificate including the list of specified characteristics,
b) the components and assembly of the gas analyser.

Carry out an external inspection of the gas analyser in order to detect cracks, dents, corroded surfaces and contamination (dust, oil, etc.). In the case of missing components or faults impeding normal operation of the gas analyser, stop the verification and apply the rejection mark.

5.3. Determine the intrinsic error, the systematic component of the intrinsic error, the standard deviation of the random component of the intrinsic error and the hysteresis error as follows.

5.3.1. Carry out all the actions necessary to prepare the gas analyser for operation according to the user's instructions.

5.3.2. Introduce the calibration gases into the gas analyser according to the following sequence, in each series of tests :

— for gas analysers with regular scales or linear transformation functions :

Nos. 1, 3, 5, 3, 1, 5

— for gas analysers with non-regular scales or non-linear transformation functions :

Nos. 1, 2, 4, 5, 4, 2, 1, 5.

The number of series of tests, n, shall be equal to :

at least 1, when checking the intrinsic error,

at least 5, when checking the systematic component of the intrinsic error and the standard deviation of the random component of the intrinsic error.

Enter in the verification report the known concentration (A_o) of the measured component of the calibration gases, and the corresponding indications (A_i) of the gas analyser being verified.

5.3.3. Determine the intrinsic error of the gas analyser, at each point of the measuring range at which the check is being carried out, using the formula :

$$\Delta_i = A_i - A_0 \quad (1)$$

Check whether the following inequality is satisfied (for i = 1, 2) :

$$\left| \Delta_i \right| \leq \Delta_p \quad (2)$$

where Δ_p is the maximum permissible intrinsic error.

Note : when the parameters to be checked are specified as fiducial values, their estimates calculated from the results of observations shall be presented in the same form.

5.3.4. Determine the systematic component of the intrinsic error, at each point of the measuring range at which the check is being carried out, using the formula :

$$\Delta_s = \frac{\sum_{i=1}^{2n} A_i}{2n} - A_o \quad (3)$$

Check whether the following inequality is satisfied :

$$\left| \Delta_s \right| \leq \Delta_{sp} \quad (4)$$

where Δ_{sp} is the maximum permissible systematic component of the intrinsic error.

5.3.5. Estimate the standard deviation of the random component of the intrinsic error :

— at the check points corresponding to the calibration gases Nos. 1 and 5, using the formula :

$$\sigma(\Delta) = \sqrt{\frac{\sum_{i=1}^{2n} \left(A_i - \frac{\sum_{i=1}^{2n} A_i}{2n} \right)^2}{2n-1}} \quad (5)$$

— at the check points corresponding to the calibration gases Nos. 2, 3 and 4, using the formula :

$$\sigma(\Delta) = \sqrt{\frac{\sum_{-i=1}^{n} \left(A_{-i} - \frac{\sum_{-i=1}^{n} A_{-i}}{n} \right)^2 + \sum_{+i=1}^{n} \left(A_{+i} - \frac{\sum_{+i=1}^{n} A_{+i}}{n} \right)^2}{2n-1}} \quad (6)$$

where A_{+i} and A_{-i} are the indications of the gas analyser for increasing and decreasing values of the concentration of the component respectively.

Check whether the following inequality is satisfied :

$$\sigma(\Delta) \leq \sigma_p(\Delta) \quad (7)$$

where $\sigma_p(\Delta)$ is the maximum permissible standard deviation of the random component of the intrinsic error.

5.3.6. Estimate the hysteresis error of the output signal at the check points corresponding to gases Nos. 2, 3 and 4, using the formula :

$$H = \frac{1}{n} \left| \sum_{-i=1}^{n} A_{-i} - \sum_{+i=1}^{n} A_{+i} \right| \quad (8)$$

Check whether the following inequality is satisfied :

$$H \leq Hp \quad (9)$$

where Hp is the maximum permissible hysteresis error.

6. Presentation of results

6.1. Fill in the verification report (see Appendix).

6.2. Issue a certificate for the gas analyser after completion of the verification and apply a stamp, if appropriate.

APPENDIX

EXAMPLE OF VERIFICATION REPORT

Name of institution .....

Verification report of gas analyser, type ..... serial No. .....

Manufacturer .....

Date of putting into service .....

Measured component .....

Measuring range .....

Verification date .....

Measuring means used for verification

No.	Type	Number of

TEST RESULTS

Ambient temperature ..... °C
Atmospheric pressure ..... kPa
Relative humidity ..... %

No. of calibration gas	Concentration of the component in the calibration gas, A_o	Measured concentration of the component using the gas analyser being verified, A_i									
		1st series		2^{nd} series		3 rd series		4^{th} series		5^{th} series	
1 2 3 4 5											

Values of parameters at check points

	1	2	3	4	5
Δ					
Δ_s					
σ (Δ)					
H	**XXX**				**XXX**

VERIFICATION RESULTS

a) Markings and designations .....

b) Completeness of instrument, external appearance .....

c) Intrinsic error .....

d) Systematic component of the intrinsic error .....

e) Standard deviation of the intrinsic error .....

f) Hysteresis error .....

Signature of the Verification Officer :

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