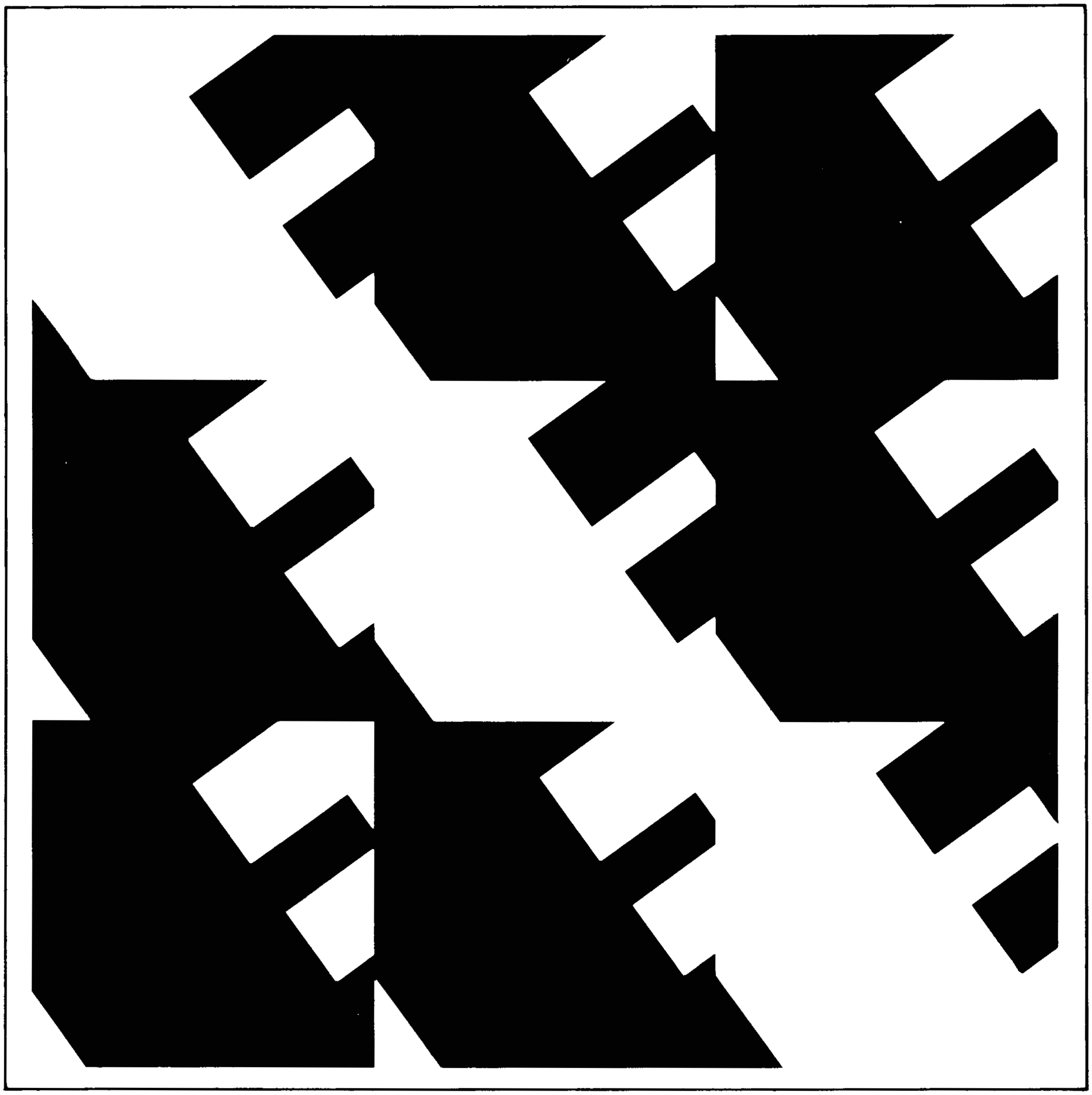
AMERICAN NATIONAL STANDARD

ANSI/IEEE Std 460-1988

IEEE Standard for Electrical Measuring Transducer for Converting AC Electrical Quantities into DC Electrical Quantities



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IEEE Standard for Electrical Measuring Transducer for Converting AC Electrical Quantities into DC Electrical Quantities

Sponsor

Power System Instrumentation and Measurements Committee
of the
IEEE Power Engineering Society

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Foreword

(This Foreword is not a part of ANSI / IEEE Std 460-1988, IEEE Standard for Electrical Measuring Transducer for Converting AC Electrical Quantities into DC Electrical Quantities.)

This standard applies to transducers with an electrical input and output for making measurements of alternating electrical quantities. The output, which is in the form of a direct current or voltage, may be used for operating a dc electrical measuring instrument or for other purposes. It does not cover transducers for measuring dc quantities, nonelectrical quantities or those having other than a dc output.

The standard is modeled on the International Electrotechnical Commission (IEC) Publication 688-1 (1980), 1st ed, "Electrical Measuring Transducers for Converting AC Electrical Quantities into DC Electrical Quantities." While the format and much of the text of this IEEE Standard are similar if not identical to the IEC Standard, it is important to note that there are significant differences. These differences are most evident in various tables specifying tolerances and other numerical data.

For those unfamiliar with the language and concepts underlying IEC Standards, it may be advisable to read the definitions of terms used in this IEEE Standard carefully since some of the terms may be unfamiliar or may have slightly different meanings from the commonly accepted engineering terminology. The reader is also referred to IEC Publication 51-1 (1984), "Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories, Part 1: Definitions and General Requirements Common to All Parts," particularly Appendix B1, for the way error is defined and for concepts related to error such as *variations* and *add-on influence error outside reference conditions.* Finally, it should be noted that some of the terms used in this standard are different from those in the IEC Publication 51-1 (1984) due to the fundamental difference between indicating instruments and measuring transducers.

The Accuracy Class Index System of classification used in this standard is based upon IEC Publication 51-1 (1984). Under the Accuracy Class Index System the permitted errors due to varying influence quantities, ambient temperature, voltage, frequency, etc, are specified as a percentage of the Class Index. Thus the Class Index fixes the intrinsic accuracy and the additional errors permissible. Errors are expressed as percent of the fiducial value.

For the unfamiliar with the Accuracy Class Index System, a word of warning is necessary. If a transducer is classified, for example, as Class 1, it does not follow that the error under practical conditions of use will be within 1% of the full output value. It means that the error will not exceed 1% of the *fiducial* value *under specified reference conditions.* If the influence quantities are varied between the limits specified by the nominal ranges of use, an additional error of a specified percentage of the Class Index may be incurred for each influence quantity.

The permissible error of a transducer under working conditions is the sum of the permissible intrinsic error and of the permissible variation due to each of the influence quantities. However, the actual error may be smaller, as not all of the influence quantities are likely to be simultaneously at their most unfavorable values, and some of the variations may cancel one another. It is important that these facts be taken into consideration when specifying transducers for a particular purpose. (The accuracy under working conditions is known as the "Operating Accuracy.")

The working group that developed this standard consisted of the following members:

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IEEE Standard for Electrical Measuring Transducer for Converting AC Electrical Quantities into DC Electrical Quantities

1. Scope and References

1.1 Scope. This standard applies to measuring transducers used for converting ac electrical quantities such as current, voltage, power (active or reactive), power factor, phase angle or frequency to a direct current or voltage. Within the effective range, a change of output is a function of the corresponding change of input that produces it. An auxiliary supply may be needed to power active circuitry.

1.1.1 It applies only to applications where the frequency of the ac input(s) lies between 15 Hz and 1 kHz.

1.1.2 If a measuring transducer is part of a system for the measurement of nonelectrical quantity, this standard may be applied to the ac electrical measuring transducer if the transducer otherwise falls within the scope of this standard.

1.1.3 This standard does not attempt to fix case size of construction, mounting dimensions, terminal arrangements, or specify a guaranteed lifetime.

1.2 References. When the following standards referred to in this document have been superseded by an approved revision, the revision shall apply. This standard shall be used in conjunction with the following publications:

[1] ANSI C39.1-1981. Requirements for Electrical Analog Indicating Instruments.[1]

[2] ANSI C39.5-1974. Safety Requirements for Electrical and Electronic Measuring and Controlling Instrumentation.

[3] ANSI/IEEE C37.90.1-1974, IEEE Guide for Surge Withstand Capability (SWC) Test.

[4] ANSI/IEEE Std 100-1984. IEEE Standard Dictionary of Electrical and Electronics Terms.

[5] IEC Publication 51-1 (1984). Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories, Part 1: Definitions and General Requirements Common to All Parts.[2]

[6] IEC Publication 414 (1973) 1st ed. Safety Requirements for Indicating and Recording Electrical Measuring Instruments and Their Accessories.

[7] IEC Publication 688-1 (1980). Electrical Measuring Transducers for Converting AC Electrical Quantities Into DC Electrical Quantities, Part 1: General Purpose Transducers.

2. Object

This standard is intended to:

(1) Specify the terminology and definitions relating to transducers whose main application is in electrical power engineering.

(2) Unify the test specifications used in evaluating transducer performance.

(3) Specify accuracy classes and also the permissible errors introduced by the various influences for these classes.

[1] ANSI/IEEE publications can be obtained from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, or from the Service Center, The Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

[2] IEC publications are available in the US from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018, USA. The IEC publications are also available from International Electrotechnical Commission, 3, rue de Varembé, Case postale 131, 1211-Geneve 20, Switzerland/Suisse.

3. Definitions

For the purposes of this standard, the following definitions apply in addition to those in ANSI/IEEE Std 100-1987 [4][3].

In this standard, the term *transducer* is restricted to transducers which convert alternating electrical measured quantities into direct current or voltage.

3.1 General Terms

3.1.1 Electrical Measuring Transducer (Hereinafter Designated *Transducer*). A device for converting an ac electrical quantity into a direct current or voltage for measurement purposes.

3.1.2 Auxiliary Supply. An alternating current or direct current electrical supply other than that producing the measured quantity which is necessary for the correct operation of the transducer.

3.1.3 Auxiliary Circuit. A circuit which is usually energized by an auxiliary supply.

NOTE: The auxiliary circuit is sometimes energized by the measured quantity.

3.1.4 Transducer with Offset Zero (Live Zero). A transducer which gives a predetermined output other than zero when the measured quantity is zero.

3.1.5 Transducer with Suppressed Zero. A transducer for which zero output corresponds to an input quantity greater than zero.

3.1.6 Distortion Factor. The ratio of the rms value of the harmonic content to the rms value of the nonsinusoidal quantity.

3.1.7 Output Load. The total resistance of the circuits and apparatus connected externally across the output terminal of the transducer.

3.1.8 Ripple Content of the Output. With steady-state input conditions, the peak-to-peak value of the fluctuating component of the output expressed as a percentage of the output span.

3.1.9 Output Power. The power available at the transducer output terminals.

3.1.10 Output Current (Voltage). The current (voltage) produced by the transducer which is an analog function of the measured quantity.

3.1.11 Output Compliance (For Current Outputs). The maximum voltage drop that can be maintained on the output and have the unit retain its specified accuracy.

3.1.12 Reversible Output Current (Voltage). An output current (voltage) which reverses polarity in response to a change of sign or direction in the measured quantity. Also referred to as bipolar current (voltage).

3.1.13 Measuring Element of a Transducer. A unit or module of a transducer which converts an electrical input quantity into a signal capable of being combined with the signals from similar elements in the same transducer so that the transducer output corresponds to a function of the individual input quantities.

3.1.14 Single-Element Transducer. A transducer having one measuring element.

3.1.1.5 Multi-Element Transducer. A transducer having two or more measuring elements.

3.1.16 Multi-Section Transducer. A transducer having two or more independent measuring circuits for one or more functions.

3.1.17 Response Time. The time from the instant of application of an input step until the output reaches and remains at its final steady value to within 1% of the final value of the output.

3.1.18 Burden. Load imposed by the transducer on the measured circuit.

3.2 Terms Relating to the Description of Transducers According to the Measured Quantity

3.2.1 Voltage Transducer. A transducer used for the measurement of alternating voltage.

3.2.2 Current Transducer. A transducer used for the measurement of alternating current.

3.2.3 Active Power (Watt) Transducer. A transducer used for the measurement of active electric power.

3.2.4 Reactive Power (Var) Transducer. A transducer used for the measurement of reactive electric power.

3.2.5 Frequency Transducer. A transducer used for the measurement of the frequency of an alternating electrical quantity.

3.2.6 Phase Angle Transducer. A transducer used for the measurement of the phase angle between two alternating electrical quantities having the same frequency.

3.2.7 Power Factor Transducer. A transducer used for the measurement of the power factor of an ac circuit.

[3] Numbers in brackets correspond to those of the references in 1.2 of this standard.

3.3 Terms Relating to the Description of Transducers According to the Output Load

3.3.1 Fixed Output Load Transducer. A transducer which complies with this standard only when the output load is at its nominal value, within specified limits.

3.3.2 Variable Output Load Transducer. A transducer which complies with this standard when the output load has any value within a specified range.

3.4 Terms Relating to Input and Output Values

3.4.1 Nominal Value. A value, or one of the values, indicating the intended use of a transducer.

3.4.2 Output Span. The algebraic difference between the upper and lower values of the output range.

3.4.3 Input Span. The algebraic difference between the upper and lower values of the input range.

3.4.4 Fiducial Value. A value to which reference is made in order to specify the accuracy of a transducer. The fiducial value is the span except for transducers having a symmetrical reversible input and output. In this case, the fiducial value is half the span.

3.4.5 Circuit Insulation Voltage (Nominal Circuit Voltage). The highest circuit voltage to ground at which a circuit of a transducer may be used. This determines the maximum permitted test voltage.

3.4.6 Maximum Permissible Values of Input Current and Voltage. Values of input current and voltage assigned by the manufacturer as those which the transducer will withstand indefinitely without damage.

3.4.7 Limiting Value of the Output Current (Voltage). The upper limit of output current (voltage) which will not, by design, be exceeded under rated or specified overload conditions.

3.4.8 Effective Range. That part of the span where the performance is intended to comply with the requirements of this standard.

3.4.9 Rated Output. The intended value of the output corresponding to the rated input.

3.4.10 Rated Input. The nominal value of the input quantity measured or specified by the manufacturer.

3.5 Terms Relating to Influence Quantities and Reference Conditions

3.5.1 Influence Quantity. A quantity (other than the measured quantity) which can cause unwanted variation in the output of a transducer.

3.5.2 Reference Conditions. A set of values assigned to the influence quantities used for determining the intrinsic accuracy of the transducer.

3.5.3 Reference Values. A specified single value of an influence quantity at which (within the tolerances stated in Section 4) the transducer is intended to comply with the requirements concerning intrinsic errors.

3.5.4 Reference Range. A specified range of values of an influence quantity within which the transducer is intended to comply with the requirements concerning intrinsic errors.

3.5.5 Nominal Range of Use. A specified range of values which it is intended that an influence quantity can assume without the output of the transducer changing by amounts in excess of those specified in Table 1.

3.6 Terms Relating to Errors and Variations

3.6.1 Error. The observed value of the output minus the true[4] (ideal) value of the output.

3.6.2 Error Expressed as a Percentage of the Fiducial Value. One hundred times the ratio of the error to the fiducial value.

3.6.3 Intrinsic Error. The error determined when the transducer is under reference conditions.

3.6.4 Variation Due to an Influence Quantity. The difference between the two output values for the same value of the measured quantity when an influence quantity assumes successively two different specified values.

3.6.5 Variation Due to an Influence Quantity Expressed as a Percentage of the Fiducial Value. One hundred times the ratio of the variation due to an influence quantity to the fiducial value.

3.7 Terms Relating to Accuracy and Class Index

3.7.1 Accuracy. The accuracy of the transducer is the sum of the intrinsic error and the variations due to influence quantities.

3.7.2 Accuracy Class. A group of transducers which comply with the requirements of this

[4] True value means theoretically expected or ideal value of the output. This is used in the same sense as in the definition of error per ANSI/IEEE Std 100-1984 [4].

Table 1
Limits of the Nominal Range of Use and Permissible Variations*

Influence Quantity		Limits of nominal range of use unless otherwise marked	Class Index 0.1	0.25	0.5	1	1.5	2.5
			Permissible influence error expressed as a percent of the class index***					
Ambient temperature		23 ± 40 °C	400	300	200	100	100	100
Frequency: (1) All transducers with phase shift		Nominal ± 1%	1000	500	250	125	100	50
(2) All other transducers		Nominal ± 10%	100	100	100	100	100	100
Voltage (externally powered)**		Nominal ± 20%	50	50	50	50	50	50
Current: active power (watt transducers) and reactive power (var transducers)		0–120%	50	50	50	50	50	50
Current: for phase angle and power factor transducers		20% to 120% of nominal	100	100	100	100	100	100
Power factor: (cos φ) for active power transducers (watt transducers)		See 5.2.4 1 ≥ cos φ ≥ 0	100	100	100	100	100	100
Reactive power factor: (sin φ) for reactive power transducers (var transducers)		See 5.2.4 1 ≥ sin φ ≥ 0	100	100	100	100	100	100
Output load Fixed output load transducers		Range to be assigned by manufacturer	50	50	50	50	50	50
Output load Variable output load transducers		10% to 100% of rated value	30	30	30	30	30	30
Auxiliary supply**	Voltage	Rated ± 10%	25	25	25	50	50	50
	Frequency different from measured variable	Rated ± 5%	25	25	25	25	25	25

* In 5.3.2, 5.4, 5.5, 5.6, and 5.7, also have influence error that must be taken into account.
** When the auxiliary supply is obtained from the measured quantity, the additional influence of the auxiliary supply should be added to the voltage influence.
*** For example permissible ambient temperature influence error for a 0.5 class index transducer is ± (0.5 × 200%)/100 = ± 1.0% of fiducial value.

standard and whose accuracy can be designated by the same number.

3.7.3 Class Index. The number which designates the accuracy class; that is, the intrinsic accuracy.

NOTE: (Influence Quantities), the permissible variation is also related to the class index, but by varying percentages. Throughout this standard the phrase "x% of the class index" denotes: "x% of the limits of error relating to the class index." (See Table 1, note 3.)

3.7.4 Intrinsic Accuracy (Percent). One hundred times the ratio of limits of intrinsic error and the fiducial value.

3.7.5 Operating Accuracy. The accuracy under a range of influence conditions typical of actual installed conditions. These conditions have to be designated by the manufacturer.

4. Permissible Intrinsic Errors and Reference Conditions

4.1 Preferred Class Indexes for Transducers. The preferred class indexes are given in Table 2. The relationship is provided between the limits of intrinsic error, expressed as a percentage of the fiducial value, and the class index.

Table 2
Limits of Intrinsic Errors

Class Index	0.1	0.25	0.5	1	1.5	2.5
Limit of Error	±0.1%	±0.25%	±0.5%	±1%	±1.5%	±2.5%

4.2 Limits of Intrinsic Error. When the trans-

Table 3
Reference Conditions of the Influence Quantities and Tolerances for Testing Purposes

Influence quantity	Reference conditions unless otherwise marked		Tolerance permitted for testing purposes applicable to a single reference value*
Ambient temperature	23 °C		Classes- 0.1 to 0.5: ±1 °C Classes- 1.0 to 2.5: ±2 °C
Position	Any		
Frequency of the measured quantity	Nonfrequency-sensitive transducers	Nominal value	±2% times class index
	Frequency-sensitive transducers (for example, employing phase shifters)	Nominal value	±0.1% times class index
Waveform of the measured quantity	Sinusoidal		Distortion factor not exceeding the class index expressed as a percentage
Output load (fixed)	Rated load		±10% times class index
Output load (variable)	Mean value of the rated range		±10% of mean value
Auxiliary supply	Rated values		Voltage or current: +1% Frequency: ±2%
External magnetic flux density	Total absence		Value of flux density of terrestrial magnetic field
Humidity	50% Relative humidity		30% to 70% Relative humidity

* When a reference range is marked, no tolerance is allowed.

Table 4
Reference Conditions Relative to the Measured Quantity

Measured Quantity	Reference Conditions		
	Voltage	Current	Power Factor Active or Reactive
Active power (See note)	Nominal Voltage ±2%	Any current up to the nominal current or up to the upper limit of the reference range, if any.	Active power factor $\cos \phi = 0.8$ lag to 1 to 0.8 lead
Reactive power (See note)	Nominal voltage ±2%	Any current up to the nominal current or up to the upper limit of the reference range, if any.	Reactive power factor $\sin \phi = 0.8$ lag to 1 to 0.8 lead
Phase angle and power factor	Nominal voltage ±2%	Any current within the reference range. If not otherwise marked, the reference range is 40% to 100% of nominal current.	—
Frequency	Nominal voltage ±2% or any voltage within the reference range	—	—

NOTE: If polyphase testing is performed, each of the phase or line voltages of the system shall not differ by more than 1% from the average of all three line-to-line or line-to-neutral voltage. Each of the currents in the phases shall not differ by more than 1% from their average. The phase angle between each phase current and its corresponding phase-to-neutral voltage shall not differ from those of the other phases by more than 2°.

ducer is under the reference conditions given in Tables 3 and 4, the error at any point within the span shall not exceed the limits of the intrinsic error, expressed as a percentage of the fiducial value, given in Table 2.

Tabulated corrections, if any, supplied with the transducer shall not be applied in determining the errors.

4.3 Conditions Under Which Intrinsic Errors Shall be Determined

4.3.1 Prior to preconditioning and before determination of the intrinsic errors, connections shall be made in accordance with the manufacturer's instructions. The transducer shall be at the reference temperature (see Table 3).

4.3.2 The transducer shall be left in the circuit under the conditions specified in Table 5.

4.3.3 After the specified preconditioning, transducers having adjustments available to the user shall be adjusted in accordance with the manufacturer's instructions.

4.3.4 The reference conditions relative to each of the influence quantities are given in Table 3. The reference conditions relative to the measured quantity are given in Table 4.

4.4 Long Term Stability. The change in the output over a specified period of time expressed as a percentage of rated output, with the input variables and influence quantities maintained within rated values. During this long-term stability test, the transducer shall operate continuously at about 80% of the rated output. The tests at the start and the end of the period shall be made at the reference conditions.

5. Permissible Limits of Variations Due to Change in Influence Quantities

5.1 Permissible Variations. When the transducer is under the reference conditions given in Tables 3 and 4 and a single influence quantity is varied in accordance with 5.2, the resultant variation expressed as a percentage of the fiducial value, when determined in accordance with 5.2.2 shall not exceed:

(1) The values shown for the influence quantities listed in Table 1

(2) The limits stated in 5.3.2, 5.4, 5.5, 5.6, and 5.7 for the other influence quantities

5.2 Conditions Under Which the Variations Shall be Determined

5.2.1 The variations shall be determined for each influence quantity. During each test, all other influence quantities shall be maintained at their reference conditions.

5.2.2 The determination of the variations associated with the influence quantities listed in Table 1 and 5.4, 5.5, and 5.6 shall be made at *a minimum of two points* between the lower and upper nominal values of the output.

For watt and var transducers, the above test values shall be obtained by retaining the voltage and power factor at their reference conditions and *varying the value of the current.*

5.2.3 The variation is assessed as follows:

5.2.3.1 When a reference value is assigned to the transducer, the influence quantity may be varied between that value and any value within the limits of the nominal range of use as given in Table 1.

Table 5
Preconditioning

Test Conditions	Values
Voltage*	Nominal**
Current	Nominal
Frequency	Nominal
Minimum time between connection into circuit and start of determination of errors.	At least 30 min. A longer time, but preferably not exceeding 60 min, may be agreed upon between the manufacturer and the user.

* Including any auxiliary supply.
** Rated value for an auxiliary supply.

5.2.3.2 When a reference range and a nominal range of use are assigned to the transducer, the influence quantity is varied between each of the limits of the reference range of use adjacent to the chosen limit of the reference range.

5.2.4 For transducers with reversible output current (voltage), variations shall be determined for each output polarity separately.

5.2.5 Where internal connections preclude application of the specified test(s), the transducer error shall be determined by other appropriate methods (see 5.4, 5.5, and 5.6).

5.3 Variation Due to Continuous Load

5.3.1 All transducers shall comply with the requirements appropriate to their accuracy class when they are continuously loaded at their nominal current or nominal voltage under the reference conditions given in Tables 3 and 4.

5.3.2 The effect of self heating shall be determined as follows:

Transducers shall be at ambient temperature and shall have been disconnected for not less than 4 h. They shall then be energized under reference conditions and the error in the output determined between 1 min and 3 min and between 30 min and 35 min after being energized, operation being continuous at about the same value of the measured quantity. The difference between the two errors shall not exceed 50% of the class index.

5.4 Variation Due to Unbalanced Currents on the Performance of Polyphase Active Power and Reactive Power Transducers. The variation due to unbalanced currents shall not exceed 100% of the class index.

The variation, expressed as a percentage of the fiducial value, shall be determined in the following manner:

(1) The transducer shall be maintained at the reference conditions specified in Tables 3 and 4.

(2) The currents shall be balanced and adjusted so that the output is approximately in the middle of the span or, if zero output is within the span, halfway between zero and the upper nominal value of the output.

(3) The output shall be noted.

(4) One current circuit is disconnected, the voltage being maintained balanced and symmetrical, and the other currents adjusted, while being maintained equal, so as to maintain the initial value of the active or reactive power input.

(5) The new output is then noted. The difference between the two outputs is the variation.

These requirements are not applicable to single-element transducers used to measure polyphase quantities.

5.5 Variation Due to Distorted Waveform of the Input Quantity(ies). When relevant, the variation due to distorted waveform of the input quantity(ies) is to be agreed between the manufacturer and the user.

5.6 Influence of Interaction Between the Measuring Circuits of Polyphase Active Power and Reactive Power Transducers. The effect of interaction between the measuring circuits of polyphase active-power and reactive-power transducers shall be determined under reference conditions as specified in 5.6.1.

5.6.1 The voltage input of one measuring circuit alone shall be energized at nominal voltage. The current input of each of the other measuring circuits shall be energized in turn at nominal current. The maximum departure from the output corresponding to zero measured quantity input shall be noted while the phase angle between the voltage and current is changed through 360°.

Where the auxiliary supply is derived from one of the voltage inputs, this circuit shall be chosen as the circuit to which the voltage is applied.

5.6.2 The maximum value of the departure of the output from the value for zero measured quantity input shall not exceed 50% of the class index.

5.7 Variation Due to External Magnetic Field

5.7.1 For transducers marked with symbol 2 mT, the total current in the test equipment described in 5.7.4 is chosen so that, in the absence of the transducer under test, a magnetic flux density is produced having a value of 2 mT. Under these conditions, the variation shall not exceed 100% of the class index.

5.7.2 When the transducer is not marked with any symbol, the total current in the test equipment described in 5.7.4 is chosen so that, in the absence of the transducer under test, a magnetic flux density is produced having a value of 0.5 mT. Under these conditions, the variation shall not exceed 25% of the class index.

5.7.3 The field shall be produced by a current of the same frequency as that which energizes the input measuring circuit. The field shall be such as to have the most unfavorable combination of phase and orientation. The values of ac fields are expressed as rms values.

5.7.4 The transducer is placed in the center of a coil of 1 m mean diameter, of square cross section, and of radial thickness small compared with the diameter; and passing such a current as will produce, at the center of the coil, in the absence of the transducer under test, the magnetic flux density specified in 5.7.1 or 5.7.2.

Any transducer having an external dimension exceeding 250 mm shall be tested in a coil of mean diameter not less than four times the maximum dimension of the transducer, the resulting excitation being maintained at the values specified in 5.7.1 or 5.7.2.

400 A turns in the specified coil will produce a flux density of 0.5 mT at its center in the absence of the transducer under test.

By agreement between the manufacturer and the user, other devices which produce an adequate homogeneous magnetic field in the absence of the transducer under test are also permissible.

6. Nominal Values for Transducers

6.1 Input Values. The nominal values of voltage, current, frequency, and auxiliary supply shall be agreed between the manufacturer and the user.

6.2 Output Values. Output and load values are given in 6.2.1, 6.2.2, and 6.2.3.

6.2.1 For transducers having a current output:

0 – 0.5 mA	– 1.0 —— 0 —— + 1.0 mA
0 – 1.0 mA	– 2.5 —— 0 —— + 2.5 mA
0 – 5.0 mA	– 5.0 —— 0 —— + 5.0 mA
0 – 10 mA	– 10 —— 0 —— + 10 mA
0 – 20 mA	
4 – 20 mA	

6.2.2 For transducers having a voltage output:

0 —— + 10 mV
0 —— + 50 mV
0 —— + 100 mV
0 —— + 1 V
0 —— + 5 V
0 —— + 10 V
– 1 —— 0 —— + 1 V
– 5 —— 0 —— + 5 V
–10 —— 0 —— + 10 V

6.2.3 For transducers having a current output, the rated output load shall have one of the following values:

100 Ω	3000 Ω
500 Ω	8000 Ω
600 Ω	10 000 Ω
1000 Ω	
1500 Ω	
2000 Ω	

6.2.4 For transducers having a voltage output, the rated output load shall be agreed between the manufacturer and the user.

6.2.5 The manufacturer shall state the limiting value of the output voltage occurring under any conditions of output load and input. This voltage shall not exceed:

(1) 60 V dc, or

(2) 24.8 V dc interrupted at a 10–200 Hz rate.

7. General Requirements for Transducers

7.1 Ripple Content. Unless otherwise agreed between the manufacturer and the user, the peak-to-peak ripple content in the output shall not exceed 2% of the output span.

NOTE: Special requirements may apply in the output of a transducer to be used in conjunction with a data-handling system having a short acquisition time.

7.2 Response Time. The response time is to be stated by the manufacturer.

7.2.1 Before determining the response time, the auxiliary circuit shall be energized for at least the preconditioning time unless it is energized from one of the measuring input quantities and is not separately accessible.

7.2.2 Methods of test for frequency transducers and suppressed zero transducers shall be agreed between the manufacturer and the user.

7.3 Permissible Excessive Inputs. After completion of the test described in 7.3.1 and 7.3.2 and after having regained equilibrium with the reference value of the ambient temperature, transducers shall comply with the requirements appropriate to their class index other than those for continuous excessive inputs.

7.3.1 Continuous Excessive Input. The inputs of all measuring and auxiliary circuits of the transducer shall simultaneously be subjected to 120% of:

(1) The upper nominal value(s), or

(2) The upper limit of the reference range(s), or

(3) The upper limit of the nominal range(s) of use, whichever is the greatest, or

(4) The value(s) assigned by the manufacturer.

Whichever value is chosen, it shall be applied for a period of 2 h, all influence quantities being maintained at their reference values.

Where relevant, the power factor shall have its nominal value.

7.3.2 Excessive Inputs of Short Duration. The tests shall be made under reference conditions. The excessive inputs of short duration which shall be applied to transducers are specified in Table 6. The test circuit shall be substantially nonreactive. Where more than one test is specified, the tests shall be carried out in the order specified in Table 6.

7.4 Limiting Value of the Output. When the measured quantity is not between its lower and upper nominal values, the transducer shall not, under any conditions within the manufacturer's maximum ratings (for example, overcurrent or undervoltage) produce an output having a value between its lower and upper nominal values.

7.5 Temperature Limits of Operation. Unless otherwise marked, transducers shall withstand continuous operation when the ambient temperature is within the range of −17 °C to +63 °C.

7.6 Voltage Tests, Insulation Tests, and Other Safety Requirements. The requirements for the voltage test and other safety requirements in ANSI C39.5-1974 [2], apply to transducers covered by this standard.

8. Additional Electrical and Mechanical Requirements

8.1 Limits of the Effective Range. When the limits of the effective range do not coincide with the lower and upper nominal limits in the output, the limits of the effective range shall be marked (see 9.1).

8.2 Limiting Conditions for Storage and Transport. Unless otherwise stated by the manufacturer, transducers shall be capable of withstanding, without damage, exposure to temperatures within the range −40 °C to +70 °C. After returning to the reference condition, they shall meet the requirements of this standard.

The manufacturer shall specify any additional limiting condition required to ensure the integrity of the transducer.

Table 6
Excessive Input Tests of Short Duration

Measured quantity*	Current factor	Voltage factor	Number of applications	Duration of each application of excessive input (s)	Interval between successive applications
Current	2	—	10	10	10 s
	10	—	5	3	5 min
	50	—	1	1	1 h
Voltage and frequency	—	1.5	10	10	10 s
Power (active, reactive)	1	1.5	10	10	10 s
Power factor	2	1	10	10	10 s
and	10	1	5	3	5 min
phase angle	50	1	1	1	1 h

* The current and voltage for these tests are the products of the factors given in the Table and
(1) the upper nominal value, or
(2) the upper limit of the reference range, or
(3) the upper limit of the nominal range of use, if any, whichever is the greatest, or
(4) the value assigned by the manufacturer.

8.3 Sealing. When the transducer is sealed to prevent unauthorized adjustment to the internal circuit and to the components within the case, access shall not be possible without destroying the seal.

9. Markings and Symbols for Transducers

9.1 Markings and Symbols on the Case. Transducers shall bear, on (or visible through) one of the external surfaces of the case, the markings listed below. The markings shall be legible and indelible.

(1) Manufacturer's name or mark

(2) Manufacturer's type designation

(3) Serial number or date code

(4) Nature of the measured quantity and the number of circuits

(5) Lower and upper nominal values of the measured quantity

(6) Range of values of the output current (voltage) and output load within which specified operation is obtained

(7) limits of the effective range if appropriate (see 8.1)

(8) Value(s) of the auxiliary supply, if relevant

(9) Identification of terminals

9.1.1 If the markings and symbols are on an easily removable part, such as a cover, the removable part shall have a serial number which shall also be marked on the body of the transducer.

9.2 Markings Relating to the Reference Conditions and Nominal Ranges of Use for Transducers

9.2.1 The reference values or reference ranges corresponding to each influence quantity shall be marked, if different from those given in Tables 3 and 4. These markings shall be made on the transducer or in a document supplied with it. If given in a document supplied with the transducer, the transducer shall be marked with the document identification number.

9.2.2 The nominal range of use shall be marked, if different from that given in Table 1.

9.2.3 Burdens for current and voltage inputs and for auxiliary supply where applicable shall be specified in a document supplied with the transducer.

9.3 Identification of Connections and Terminals. If so required for the correct use of the transducer, a diagram or table of connections shall be supplied and the terminals shall be clearly marked to show the proper method of connection.

Grounding terminals shall be marked using the symbol:

Appendixes

(These Appendixes are not a part of ANSI/IEEE Std 460-1988, IEEE Standard for Electrical Measuring Transducer for Converting AC Electrical Quantities into DC Electrical Quantities, but are included for information only.)

Appendix A
Surge Withstand Capability Test

A1. General. The development of transducers employing transistors and integrated circuits has made necessary the formulation of a surge withstand capability test. The surge voltage waveform shall be the same as specified in the relay SWC test identified as ANSI/IEEE C37.90.1-1974 [3]. Devices for generating the required waveform are now available as a complete test unit. The test is a design test for the transducers and does not require that each production unit be tested.

Appendix B
Nomenclature and Definitions

B1. General. In addition to the previously given definitions that are also contained in the related IEC Publication 688-1, (1980) [7], the following terms are also used in transducer practice.

B2. Input Current Circuits. An input circuit to which is applied either a voltage or current which is a measure of primary current.

B3. Input Voltage Circuit. An input circuit to which is applied either a voltage or a current which is a measure of primary voltage.

B4. Output Circuit. The circuit supplying the signal representative of the quantity being measured.

B5. Power Supply Circuit. Refer to the definition of auxiliary circuit, 3.1.3 of this standard.

B6. Common Mode Voltage. The voltage common to all conductors of a group as measured between that group at a given location and an arbitrary reference (usually earth).

B7. Transverse (Differential) Mode Voltage. The voltage at a given location between two conductors of a group.

B8. Design Test. Tests made by the manufacturer to obtain data for design or application, or to obtain information on the performance of each type of device.