

Glossary of

Terms used in air gauging with notes on the technique

Confirmed
January 2010

Co-operating organizations

The Instrument Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

- British Clock and Watch Manufacturers' Association
- British Electrical and Allied Manufacturers' Association*
- British Industrial Measuring and Control Apparatus Manufacturers' Association*
- British Nautical Instrument Trade Association
- British Railways Board
- British Scientific Instrument Research Association*
- British Steel Industry*
- Council of British Manufacturers of Petroleum Equipment*
- Electrical Research Association
- Electricity Council, the Central Electricity Generating Board and the Area Boards in England and Wales
- Electronic Engineering Association
- Engineering Equipment Users' Association*
- Gauge and Tool Makers' Association*
- Institution of Chemical Engineers*
- Institution of Electrical Engineers*
- Institution of Heating and Ventilating Engineers
- Institution of Mechanical Engineers
- Institution of Production Engineers
- Ministry of Defence, Air Force Department*
- Ministry of Defence, Army Department*
- National Coal Board
- National Physical Laboratory (Ministry of Technology)*
- Oil Companies Materials Association*
- Scientific Instrument Manufacturers' Association*
- Water Resources Board
- Water-tube Boilermakers' Association*

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this standard:

- Institute of Measurement and Control
- Institution of Gas Engineers
- Ministry of Defence, Navy Department
- Individual Manufacturer

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Foreword

This standard makes reference to the following British Standard:

BS 308, *Engineering drawing practice — Part 3: Geometrical tolerancing using ISO symbols*¹⁾.

This British Standard has been prepared under the authority of the Instrument Industry Standards Committee and is based upon a glossary drawn up by a group of British manufacturers of air gauging systems.

Since its introduction some thirty years ago the use of the air gauging method of dimensional measurement has grown enormously in Great Britain. Not surprisingly, the terminology relating to the method has become confused; terms have been invented without regard to their etymology and often with no thought as to their relationship to similar or corresponding terms in other technologies. This glossary aims at removing this confusion.

During its preparation, the following objectives were kept in mind:

- i) to rationalize the terminology by choosing suitable terms which manufacturers would agree to use, and thus eliminate the present confusion arising from the use of different terms by different manufacturers;
- ii) to provide users, and potential users, of air gauging equipment with an unambiguous means for communicating their requirements to manufacturers;
- iii) to furnish for this particular technology a terminology which finds general acceptance and becomes, in due course, the recognized terminology in the literature and in discussions of the air gauging method.

In the introduction to the glossary the principles of air gauging are briefly described and examples are given of the application of the method to the measurement of dimensions and the inspection of form; some notes are included on the operating pressures used. Section 1 of the glossary defines the general terms relating to the air gauging technique, whilst Section 2 deals specifically with the air gauge unit, that part of the air gauging system which contains the indicating unit and the controls. In Section 3, the measuring heads for dimensional measurement are detailed, and the related terms and their definitions are given, whilst Section 4, in conjunction with Appendix A, provides corresponding information for measuring heads employed in the inspection of form and position. Appendix B covers applications of air gauging not included in Section 3, Section 4 and Appendix A.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 30, 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.

¹⁾ In course of preparation.

General introduction

If the tube A which terminates in the jet J (Figure 1) is connected to a source of compressed air held at constant pressure, air will flow through the jet to atmosphere at a constant rate. If now the surface S is moved toward the jet the escape of air will be impeded and the flow will begin to decrease. Continued advancement of the surface will steadily reduce the flow until finally, with the surface in contact with the whole area of the jet, the flow ceases. This simple device is thus a displacement-flow transducer which permits detection of the movement of the surface normal to the jet by observing the change in air flow.

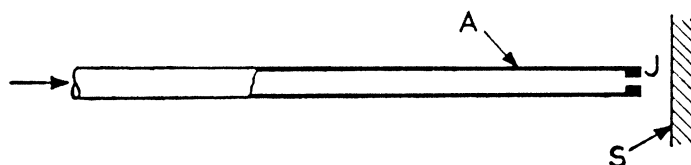


Figure 1 — Displacement-flow transducer

In Figure 2, a regulator R maintains the incoming air supply at a constant pressure and a variable-area flowmeter F measures the flow of air through the jet. The float responds to the changes in flow, rising as the flow increases and falling as it decreases. The flowmeter can be graduated in units of length to give a scale which can be used to measure the displacement of the surface S normal to the jet.

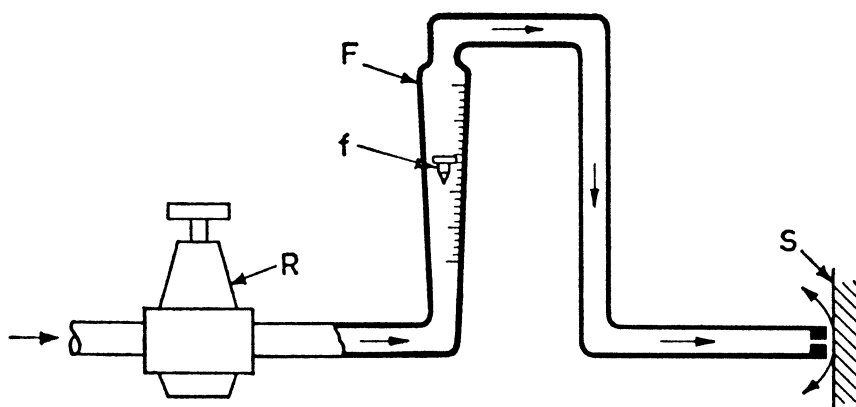


Figure 2 — Displacement flow-transducer with flowmeter

It is not, however, essential to measure directly the changes in air flow: these changes can be converted into changes in air pressure by the method shown in Figure 3. A restriction O, called the control orifice, is introduced between the regulator and the jet, and the air pressure between this restriction and the jet is measured by a suitable pressure indicator G. The indicator (shown in Figure 3 in simple diagrammatic form) will register a lower pressure when the air flow through the jet increases, a higher pressure when it decreases; as before, the scale of the indicator can be graduated in units of length and used for gauging. The arrangement shown in Figure 3 is thus a displacement-pressure transducer.

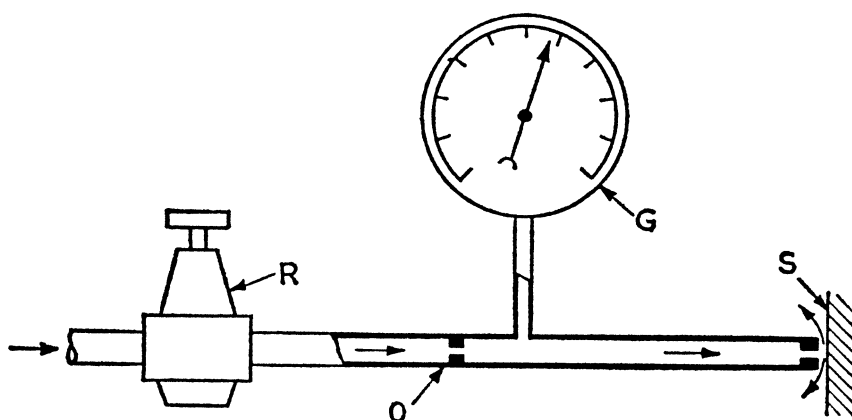


Figure 3 — Displacement-pressure transducer

These then are the basic ideas of air gauging. Their simplicity will be appreciated, but what is important is that they can be used to build robust measuring instruments of extremely high accuracy and stability for use in precision engineering. Their magnification, that is the ratio of the movement of the indicator index, e.g. the float in Figure 2 or the pointer in Figure 3, to the movement of the surface which produces it, can be relatively low, say, 1 000, or very high, say, 100 000. Magnifications of 10 000 and 20 000 are common and permit accurate inspection of closely-toleranced components; the true sizes of the components are obtained and errors of form and position can be investigated. The air gauging system thus offers substantial advantages over inspection by limit gauging and furthermore can, when required, be used for selective assembly of mating components. The actual gauging element, the jet in Figure 2 and Figure 3, can be separated from the indicator (flowmeter or pressure indicator) by suitable hose connexion, so that remote reading can be readily arranged.

The open jet of Figure 2 or Figure 3, which never makes contact with the work being gauged and which may, therefore, be described as a non-contact gauging element, is suitable for many applications of air gauging. For others, e.g. when measuring components which have a relatively rough surface finish or porous surfaces, it is better to use a contact gauging element.

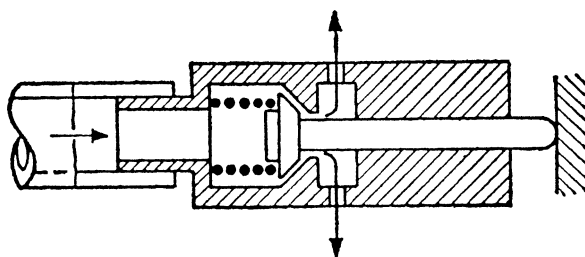


Figure 4 — Contact gauging element

This may take one of several forms, but the principle is shown in Figure 4. The contact gauging element provides a stylus which is in contact with the work being gauged and it will be seen how movement of the stylus changes the flow of air.

An air gauging system comprises essentially an air gauge unit and a measuring head. The air gauge unit contains the means to display the measured sizes, or to generate signals based upon them, and certain other elements depending on its type; in particular, when the variable measured is pressure, it will contain the control orifice. The measuring head may contain a single gauging element, either contact or non-contact, or two or more such elements. The form of the measuring head and the number of gauging elements used will depend upon the type of measurement (length or thickness, internal diameter, external diameter, straightness, squareness, etc.) to be made.

The air supply for the air gauging system will usually be drawn from the factory's compressed air line but, if necessary, a suitable local compressor may be employed. The air gauging system must be operated at a constant pressure; this is readily done by using a pressure regulator, which is usually provided in the air gauge unit. It is essential that the supply pressure is significantly greater than the operating pressure and the manufacturer's directions should be observed. Systems using flow measurement normally operate at 0.7 bar.²⁾ The operating pressures in systems using pressure measurement range up to 4.1 bar and it is convenient to classify these systems as low, medium and high by subdivision as follows:

Operating pressure	Classification
Not greater than 0.3 bar	low
Greater than 0.3 bar but less than 1 bar	medium
1 bar and above	high

It is important that the air supplied to the air gauge unit is clean and dry and, in particular, free from oil mist. Filters should be regularly drained and periodically cleaned; attention to this point will ensure trouble-free service for a long time; but neglect will inevitably lead to a breakdown.

The air gauging principle shown in Figure 2 and Figure 3 furnishes a means for comparing the sizes of like objects; in other words an air gauging system is a comparator and, as with all other comparators, requires standardization before it can give true size. Suitable setting standards are therefore required for use with the system and are employed, in conjunction with simple controls, for datum setting and for fixing the magnification. In some cases, it is convenient to fix the magnification by using master setting jets which are substituted for the measuring head.

However precise the instrument used in measuring, it cannot give the correct answer if a poor inspection technique is employed. Change of temperature alters the size of components being measured; difference of form between standard and component, or errors of form in the component, may lead to false results, and so on. The need to use sound techniques is common to all methods of measurement; it is not to be neglected when the air gauging method is employed.

Some of the more direct applications of air gauging are illustrated in the simple line drawings of Figure 5 and Figure 6, in which the gauging element is represented by an arrow head thus .

²⁾ 1 bar = 10⁵ N/m².

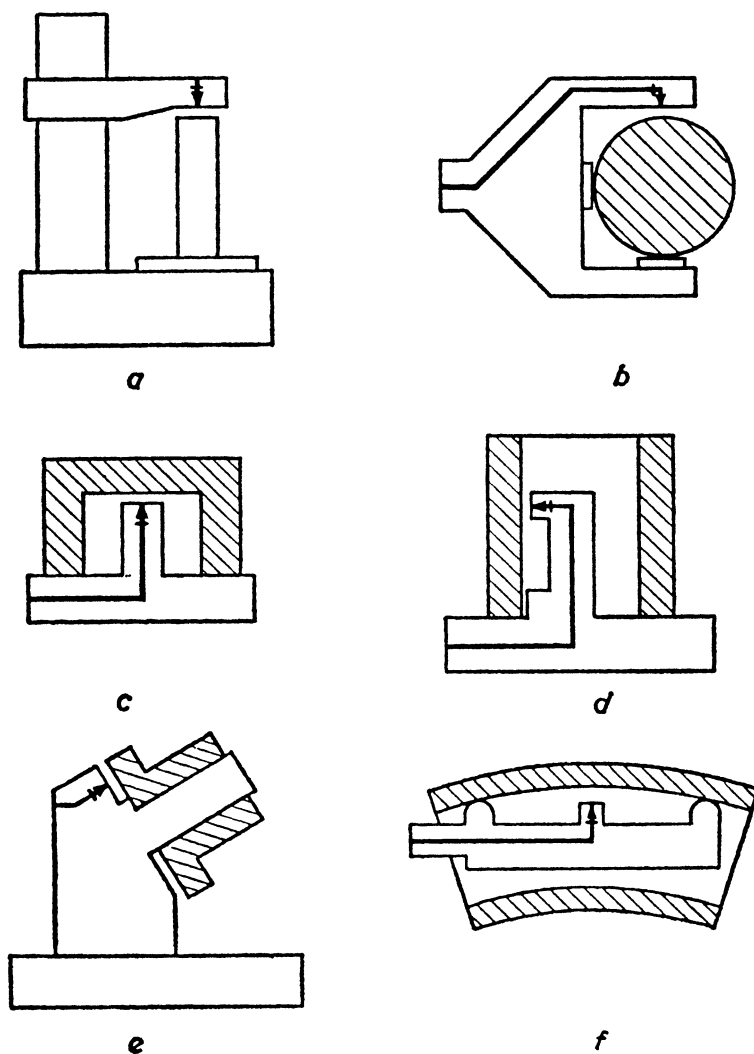


Figure 5 — Examples of air gauging applications

In the examples of Figure 5, a single gauging element is used; the measurement of length or thickness is depicted at *a*, that of diameter at *b* and depth at *c*; checking for squareness is shown at *d* and *e* and for straightness at *f*.

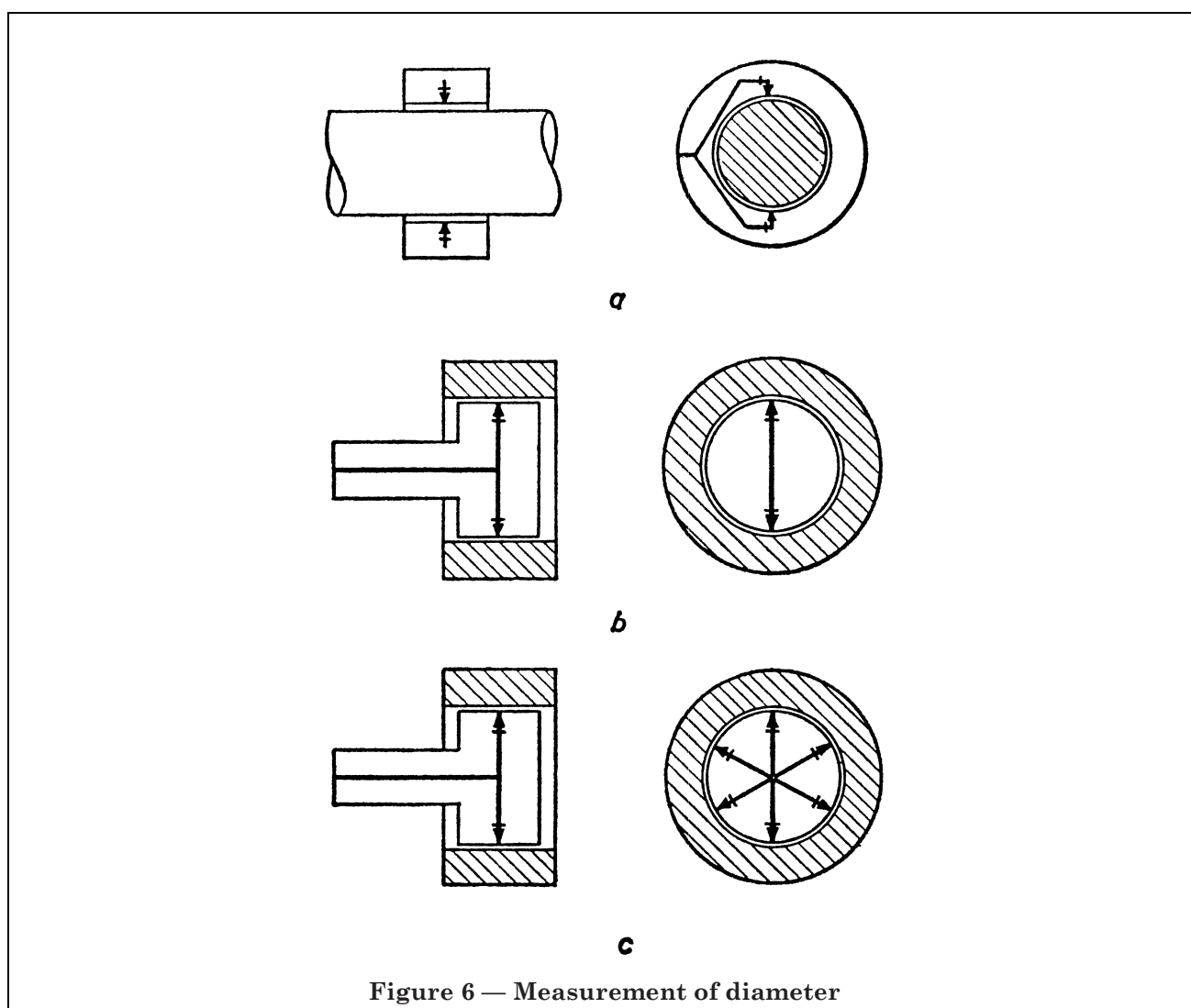


Figure 6 — Measurement of diameter

In the examples in Figure 6, two or more gauging elements are used for measuring diameter, the last example showing how several gauging elements can be disposed so as to measure average diameter.

Since it is the purpose of Figure 5 and Figure 6 to show as clearly as possible how the air gauging method is applied, the illustrations have been confined to simple applications. One of the outstanding features of the method is its extreme flexibility and, in consequence, its very wide field of application. It is particularly valuable for the simultaneous inspection of several dimensions, and can be conveniently employed on the machine tool to give measurement during production. Signal retainers and signal inverters can readily be incorporated in some systems; measurements can be recorded or converted into electrical signals for automatic control. All these techniques are straightforward and in everyday use.

For further information on the theoretical aspects of air gauging reference should be made to "Notes on Applied Science No. 34" — "Principles of Pneumatic Gauging" by J. C. Evans and I. G. Morgan — published by H.M.S.O. (1964).

1 General

No.	Term	Definition
1001	air gauging PNEUMATIC GAUGING, <i>deprecated</i>	A precise measuring technique, using air drawn from a compressed air supply, which can be employed to measure size, or to check form or position. NOTE The technique can be based on the determination of air flow or alternatively the determination of air pressure. In either case, the measured sizes are displayed on indicators; in the latter they may alternatively or simultaneously be recorded, converted into audible or visual signals, or into signals for automatic operations, e.g. inspection, grading, control of size.
1002	air gauging system	Measuring equipment employing air gauging based on the determination of flow or pressure and comprising an air gauge unit and one or more measuring heads as detailed in Section 2 and Sections 3, 4 and 5 respectively. The air gauging system may be designed for measuring one variable only, or for the simultaneous measurement of two or more independent variables.
1003	air gauging (flow) system	An air gauging system based upon the determination of flow.
1004	air gauging (pressure) system	An air gauging system based upon the determination of pressure.
1005	air gauge unit	That part of the air gauging system which displays the measured sizes or provides visual or audible signals or converts the measurements into signals for automatic operations. For details see Section 2.
1006	measuring head	That part of the air gauging system which contains the gauging element(s) and which is presented to the work, or vice versa. For details see Sections 3 and 4.
1007	gauging element	The element in the measuring head which detects dimensional change and provides the response which enables the air gauging system to measure that change. The gauging element may be an open jet or a contact gauging element, and the measuring head may have one, two or more elements depending on its type. For details see Sections 3 and 4.
1008	open jet	A gauging element in the form of a jet of circular or rectangular section which does not contact the work being measured. The parameters of a jet are its internal and external diameters, when the section is circular; the external and internal length and breadth when the section is rectangular.
1009	land width	The terminating wall thickness of an open jet.
1010	jet recession	The amount by which an open jet is recessed behind the outer surface of the measuring head. NOTE Recession fulfils two objectives: 1) It protects the jet from mechanical damage, 2) it maintains the essential minimum distance between the jet and the work being measured.
1011	jet guard	A protective device to prevent mechanical damage to an open jet when the design of the measuring head does not permit the jet to be recessed.
1012	contact gauging element	A gauging element fitted with a stylus which contacts the work being measured. See, for example, Figure 4.
1013	matched gauging elements	Gauging elements which have matched pneumatic characteristics so that they may be used in combination in a single measuring circuit.

No.	Term	Definition
1014	asymmetry error	The error which may arise when the work being measured is asymmetrically disposed between gauging elements which are combined in one measuring circuit. This error is reduced to negligible proportions by correct design of the measuring head and the stipulation of its measuring range.
1015	air escape duct	An air passage, e.g. a groove or hole, which provides an easy final escape to atmosphere of air which has emerged from a gauging element.
1016	control orifice control jet	The restriction used in air gauging (pressure) systems. In association with the gauging elements, the control orifice determines the magnification of the system.
1017	supply pressure	The pressure of the supply from which the air gauging system draws its air.
1018	air filter	A device for cleaning the air supply to the air gauging system and which, ideally, removes all liquid and solid particles.
1019	inlet restrictor	A fixed inlet orifice used in some air gauging (pressure) systems upstream of the pressure regulator to limit the quantity of air supplied to the system.
1020	economiser orifice	The fixed orifice in the measuring head in some air gauging (flow) systems which limits the maximum air flow when the measuring head is disengaged from the work.
1021	operating pressure	The constant pressure at which the air gauging system is operated.
1022	operating pressure indicator	A pressure measuring instrument which registers the operating pressure and which is usually fitted to the air gauge unit.
1023	pressure regulator	A device which keeps the operating pressure constant irrespective of pressure changes in the supply line and of changes of air flow in the air gauging system itself.
1024	intermediate pressure BACK PRESSURE, <i>deprecated</i>	In air gauging (pressure) systems, the pressure between the control orifice and the measuring head.
1025	simple pressure measurement	Measurement of the intermediate pressure in relation to the ambient atmospheric pressure or to the operating pressure as datum. NOTE This term and terms 1026 and 1027 serve to distinguish between the different methods currently used in air gauging (pressure) systems for measuring the intermediate pressure.
1026	differential pressure measurement	Measurement of the intermediate pressure in relation to a pre-set fixed pressure obtained from a branch circuit having the same operating pressure as the measuring circuit. This fixed pressure is adjusted to be approximately equal to the intermediate pressure at the mid-point of the measuring range.
1027	null-balance pressure measurement	Measurement of the intermediate pressure by a self-balancing system which brings the pressure in a secondary chamber to equality with the pressure being measured by means of a pressure regulating mechanism fitted with an appropriate indicating device.
1028	datum setting control	The control which enables the indicator reading to be set to a datum, e.g. zero. NOTE This control will normally be used in association with a setting standard or a master setting jet.