BRITISH STANDARD

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Guide to

Design of measurement laboratories

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Committees responsible for this British Standard

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British Steel Industry
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Department of Trade and Industry (National Measurement Accreditation Service)
Department of Trade and Industry (National Physical Laboratory)
Department of Trade and Industry (National Weights and Measures Laboratory)
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Contents

Foreword

This British Standard has been prepared under the direction of the Management Systems Sector Board.

It is intended to provide guidance to those who may be involved in the design, construction, supply, purchase and use of laboratories, or modification of an existing laboratory, in which measurements will be carried out. Measurements can be complex, and can involve a wide range of technologies and requirements. Measurements are undertaken across an extremely wide field of applications, under differing environmental conditions, and it is likely that other criteria need to be considered for some laboratories, in addition to those given in this standard. It is, however, not possible within this guide to cover the design requirements for every type of laboratory. More specialized features for some specific types of laboratory are covered in annexes A, B and C. Other publications giving guidance on laboratory design are listed in the bibliography in annex D.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Guide

1 Scope

This British Standard gives guidance on design criteria and considerations for the siting, construction, environment, supply of services and equipping of measurement laboratories, to ensure that measurements undertaken therein are valid and not adversely affected by environmental conditions. Guidance on acceptance tests is also given.

This British Standard does not cover the selection, installation or use of measuring instruments.

2 References

2.1 Normative references

This British Standard incorporates, by dated and undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on page 16. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this British Standard only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications, current at the time of issue of this standard are listed on page 16, but reference should be made to the latest editions.

3 Definitions

For the purposes of this British Standard, the definitions given in BS 5233 : 1986 apply together with the following.

3.1 measurement

The set of operations having the object of determining the value of a quantity.

NOTE. This definition is identical with **2.01** of BS 5233 : 1986.

3.2 measurand

Particular quantity subject to measurement.

Example:

Vapour pressure of a given sample of water at 20 °C.

NOTE 1. The specification of a measurand may require statements about quantities such as time, temperature and pressure.

NOTE 2. This definition is identical with **2.6** of PD 6461 : Part 1 : 1995 (which is identical with the *International vocabulary of basic and general terms in metrology*, ISO 1993).

3.3 influence quantity

A quantity which is not the subject of the measurement but which influences the value of the measurand or the indication of the measuring instrument.

Examples:

Ambient temperature; frequency of an alternating measured voltage.

NOTE. This definition is identical with **2.10** of BS 5233 : 1986.

3.4 measurement laboratory

Place where measurements are carried out under controlled conditions.

3.5 laboratory conditioned atmosphere

Specified operating ranges of temperature and relative humidity within which the atmosphere of a measurement laboratory is controlled.

3.6 reference conditions

Conditions of use prescribed for testing the performance of a measuring instrument or for intercomparison of results of measurements.

NOTE. This definition is similar to **5.07** of BS 5233 : 1986.

3.7 stability

Ability of a measuring instrument to maintain constant its metrological characteristics with time.

NOTE. This definition is similar to **5.16** of BS 5233 : 1986.

4 General considerations and operating conditions

4.1 The laboratory environment can influence the results of certain types of measurement. It may therefore be necessary to control influence quantities to ensure that the desired accuracy of measurements is achieved, and that the results of measurements are within the stated uncertainty. It is also necessary to ensure that the laboratory equipment and processes are not adversely affected by their environment and that the laboratory provides comfortable working conditions for personnel. The detailed construction of a laboratory needs to vary according to its intended purpose and this should be agreed between the purchaser or user of the laboratory and the supplier.

For most measurement laboratories it is essential that the laboratory environment is controlled to maintain stable conditions, particularly over specified periods of time. A single specified standard atmosphere used by all laboratories would be the ideal but, because of the diversity of climates and measurement requirements, this is not possible (see **5.10.3**).

A laboratory, either in a new building or in an existing one, usually requires a specification. The requirements and the tests for acceptance of the completed laboratory should be clearly and fully specified. Where plant to control the laboratory environment is required, its design should take account of the specified laboratory conditions, the construction of the building, the likely external ambient conditions and working conditions within the laboratory. It is essential that the plant designer is provided with all the details of the relevant factors that could affect the laboratory environment.

In practice it is not possible to test the performance of a laboratory under a wide range of external ambient conditions within a short period, as it is necessary to depend upon seasonal variations of the external environment. It is essential that a schedule of tests, to be carried out for accepting the completed laboratory, should be prepared and agreed between the supplier and the purchaser or user, as part of the laboratory specification. Relevant tests should be carried out over a specified and extended period to cover seasonal variations. More detailed recommendations on testing are given in clause **9**.

4.2 The basic criteria for siting, construction or modification, environmental conditions, supply of services and furniture apply to the majority of measurement laboratories.

The following major factors should be considered:

a) the external and the required internal atmospheric conditions;

b) the rate of air change required;

c) the nature, accuracy and uncertainty of the measurements to be undertaken;

d) the ambient noise and vibration;

e) any electromagnetic or radiation effects;

f) health and safety.

It is these factors that mainly dictate the constructional features of the laboratory and the required capacity of any air conditioning plant.

4.3 Other environmental features that need to be considered are illumination (both general and at working positions), operator comfort, air pressure and air pollution.

4.4 Measurement techniques are continually advancing, along with demands for higher accuracies, so when considering a new laboratory the design should allow for future modification to provide flexibility of operations and possibly later expansion and improvements.

4.5 It is recommended that the management of the design of a measurement laboratory should follow the guidance given in BS 7000 : Part 1 : 1989 and that particular regard should be given to section 3 of that standard.

5 Selection of site and design criteria

5.1 General

The site for a laboratory should be chosen with considerable care, paying particular attention to the nature and accuracy of the measurements to be undertaken and any local conditions that could affect the constructional and operational aspects. The factors given in **5.2** to **5.12** should be considered during the planning and design stages since they could affect the operational performance of the laboratory. These criteria are not universally applicable however, and for specialized laboratories more exacting environmental controls, and additional features and services may need to be incorporated.

Additional considerations for some specific types of laboratories are covered in annexes A, B and C as follows:

a) annex A: electrical measurement laboratories;

b) annex B: mechanical measurement laboratories;

c) annex C: mass measurement laboratories.

5.2 Noise and vibration

Measurements and the laboratory personnel can be adversely affected by ambient noise and vibration from the laboratory building and from adjacent buildings, machinery, nearby roads carrying heavy vehicles, railways and other local industrial activities.

Ideally, the site for the laboratory should be free from such influences, particularly in the case of laboratories making acoustic, optical and mass measurements. If noise and vibration are likely to affect the measurement results, a survey of the site should be carried out to establish both the levels and frequencies of the ambient noise and vibration. If excessive noise and/or vibration are found, consideration should be given to a more suitable location for the laboratory.

Where the vibration level is tolerable, but would be likely to affect the measurement results adversely, the incorporation of damping features and devices within the laboratory structure should be considered. If the vibration level is likely to affect only a few equipments, it may be acceptable to provide such equipments with individual anti-vibration mounts.

Sources of noise and vibration such as air conditioning plant and power transformers should be installed, as far as practicable, so that the levels of noise and vibration that they generate are minimized.

5.3 Acoustics

The ambient noise within the laboratory should not exceed 50 dBA, with equipment operating but without personnel present.

5.4 Building location and access

The on-site roads should be of adequate size and strength to provide easy access for the equipment being delivered to the laboratory. When necessary the building should be located so that it has good connections to a major roadway and rail system. Where large or heavy equipment needs to be handled, an outside area and lifting facilities may be required for loading and unloading vehicles. Adjacent parking for a mobile measurement laboratory may also be needed.

5.5 Building aspect

The building aspect of the laboratory, e.g. north facing, should be considered to reduce influences such as sunlight. A considerable amount of heat transmission occurs through external windows. If a laboratory without windows is unacceptable, to reduce heat gains from solar radiation in the summer, windows should be fitted only in north facing walls, where practicable.

5.6 Glazing

External glazed areas should be kept to a minimum and the fitting of skylights for natural lighting is not recommended for the reasons given in **5.5**. Where windows have to be installed they should be multiply-glazed units and fitted with blinds or shades to reduce direct sunlight. Solar control film applied to windows can be beneficial. Internal partitions and doors should be single or multiply-glazed depending on the operation and measurement tasks of the laboratory, and should include sight windows for the safety of personnel, where appropriate.

5.7 Internal layout

The internal layout and size of the laboratory should provide adequate space for equipment and surrounding working areas, particularly where the items to be measured are large or heavy. Separate enclosures may have to be constructed within the main laboratory where there are requirements for operating under different environmental conditions, or with closer environmental tolerances. Sufficient space should be allowed when designing access points and corridors to allow for safe passage of personnel and easy movement of equipment. Variations in floor level within the laboratory should be avoided.

A ground floor location provides a solid foundation. For some types of measurement a laboratory sited below ground level can be beneficial in reducing the effects of adverse environmental conditions on the site.

The relative positions of, and adequate space for, support functions such as storage, records and administrative offices should be arranged, where possible, to provide easy access to the laboratory. Space should be allowed for the storage of measuring instruments, standards and other equipment and materials when not in use.

Adequate writing areas for recording results should be provided where needed, and should normally be next to the measuring equipment. However, for some measurements, such as the accurate determination of mass, the writing area should not be at the measuring point. Adequate space should be provided for the secure storage of documentation, preferably outside the laboratory but with easy access to it.

5.8 Building structure

5.8.1 *General*

The type, size and thermal effectiveness of materials and insulation to be used for the construction of the external and internal walls, floors, ceilings and roof should be considered with respect to the operating conditions specified and the planned life of the laboratory. Where the laboratory temperature needs to be very closely controlled, additional insulation may be required in the construction. Consideration should also be given to any additional load-bearing requirements for floors to support heavy equipment, and the provision of walls or other supports for the installation of an overhead crane.

To facilitate maintenance and routine cleaning, careful consideration should be given to the choice of materials to be used in the building.

5.8.2 *Use of an existing building*

If a laboratory is to be constructed within an existing building, the nature and use of adjoining areas that could affect the construction and operation of the laboratory should be taken into account.

5.8.3 *Floors*

Floors should be of sufficient strength to support the equipment being installed and any localized areas required for higher than normal floor loadings should be clearly specified. Surfaces should be suitable for expected use and amounts of traffic. Special requirements such as electrical conductive or insulating properties, protection against solvent spillage and non-slip finishes should also be detailed. The routing and outlet positions of the required services need to be considered, for example the type of ducting, channels and the possible need for false flooring, to allow for their installation and servicing (see also **5.8.4**).

5.8.4 *Ceilings*

The height of the ceilings is a factor in determining the volume of the measurement laboratory and therefore the volume of air to be conditioned. Requirements for ceilings higher than those specified in normal office building standards should be considered where large laboratory equipment or lifting facilities need to be installed.

The possible need for false ceiling sections to accommodate services should be considered (see also **5.8.3**).

5.9 Entrances

Requirements for ensuring that access is limited to authorized personnel only should be considered at the design stage. The main entrance and internal doors should be of sufficient size to allow the passage and handling of equipment without hazard and, where required, also access for vehicular traffic. Additional requirements such as air-lock door arrangements to maintain temperature stability should be clearly specified. Where doors are likely to be in frequent use, their effect on the stability of the environmental conditions should be considered. Interlocked doors may be necessary for the closest control of the environmental conditions. Treated mats (tacky mats) should be provided at entrances to remove dirt from shoes.

5.10 Air conditioning

5.10.1 *General*

The necessity for air conditioning plant depends on the nature of the measurements to be undertaken, but sometimes normal office environment standards are sufficient. Depending on the laboratory location and other factors, the plant may need to provide either heating or cooling, or both, for conditioning the air. Where accurate measurements are required, the laboratory environmental conditions should be specified for the following:

a) the nominal operating temperature, its tolerance and maximum permissible rate of change;

b) the range of relative humidity;

c) the number of air changes per hour and the proportion of fresh air;

d) the required air speed in the working areas consistent with the measurements being carried out and with comfortable working conditions;

The likely maximum and minimum external temperatures should also be taken into account.

Certain areas of the laboratory may need to operate under more stringent conditions, for example areas for the measurement of high grade standards, and this should be allowed for at the design stage.

NOTE. Further guidance on air conditioning is given in BS 5720.

5.10.2 *Positioning and operation of plant*

The positioning of the air conditioning plant should be carefully chosen to give optimum operation by keeping the volume of air in the system to a minimum and the routing of ducting as simple and short as possible. The adverse effects of noise and vibration from the plant also need to be taken into account. The system needs to provide uniform conditions throughout the laboratory and therefore a sufficient number of air delivery points and control sensors should be provided. The sensors should be correctly positioned throughout the laboratory to ensure acceptable times for response to changes in the conditions of the atmosphere and for their correction. The fresh air inlet for the plant should be positioned to avoid the possible intake of contaminated air. Information on the positioning of fume cupboard outlets is given in **5.11.6.**

Consideration should be given to the flow of air throughout the laboratory, so as to remove any excess heat from the measuring equipment and maintain it at a desired temperature, while providing adequate comfort for personnel. The system should have sufficient devices for the proper recording and monitoring of the environmental conditions, the displays for which should be sited so as to be easily read and, if necessary, calibrated. The installation of a data link for centralized display of the information, or a data logger with computer facilities, may be preferable, depending on the size and complexity of the installation.

5.10.3 *Laboratory conditioned atmosphere*

The ideal would be for a single standard atmosphere to be used for all laboratories where the temperature and relative humidity are controlled at the same values. A single standard is not possible because of the diversity of climates and the difficulty of establishing tables of values for those measurements and conditions obtained previously. Therefore, as a compromise it is advisable to limit the range of conditions used to one of the three recognized standard atmospheres given in table 1, as appropriate for the particular laboratory.

5.10.4 *Temperature*

Most dimensional calibration laboratories normally operate at 20 °C, whereas electrical calibration laboratories normally operate at 20 °C or 23 °C. A temperature of 23 °C is operationally more economical to maintain than 20 °C which could require a greater amount of cooling plant. The choice between 20 °C and 23 °C needs to be based on operational requirements. It is recommended that the laboratory atmosphere should be continuously controlled to maintain a stable temperature at all times, and thus maintain the measuring equipment at the same temperature as the surrounding air.

A stable temperature is important in many measurement processes, particularly for high accuracy measurements. The permissible rate of change of temperature may need to be specified. Generally, the temperature should not vary by more that the specified tolerance over the working day and not vary by more than half the tolerance over any one hour period (for example: for a tolerance of ±2 °C, the variation should not exceed 2 °C during each working day nor 1 °C during any one hour period). For the highest accuracy measurements, the permissible hourly rate of change may need to be less.

Table 1. Laboratory conditioned atmospheres

Atmosphere	Temperature			Relative humidity	
	Nominal value °C	Close tolerance °C	Normal tolerance °C	Close tolerance %	Normal tolerance %
A	20	± 1	± 2	53 to 57	50 to 60
B	23	± 1	± 2	48 to 52	45 to 55
C[1)]	27	± 1	± 2	63 to 67	60 to 70

[1)]These conditions may be required for laboratories in certain regions of the world.

NOTE 1. These temperature and relative humidity conditions are adequate to meet the majority of measurement requirements in most laboratories. Where high accuracy measurements are to be made, the temperature tolerances may need to be closer than those shown.

NOTE 2. The relative humidity may need to be lower or higher than those stated for certain types of measurement.

NOTE 3. Further guidance on temperature and relative humidity conditions for some specific types of measurement laboratories are given in **A.1**, **B.2** and **C.2**.

5.10.5 *Relative humidity*

Whether the relative humidity of the laboratory atmosphere needs to be controlled depends on the nature of the measurements to be undertaken. Where humidity is likely to affect adversely the measurement processes, equipment or personnel, it may be necessary to install plant to control the humidity level. This normally would be part of the air conditioning plant but could be a separate unit for specialized needs. Conditions should be specified for the nominal humidity and its permissible variations and whether the laboratory conditions have to be continuously controlled. Factors that need to be considered are the effects of humidity on measurement processes, damage to equipment by surface corrosion, and a suitable level for personnel to operate in without discomfort. Where requirements dictate extreme moisture conditions (either high or low moisture levels) for preconditioning or as part of the measurement process, provisions for a separate enclosure may need to be included. Further information on the control of humidity, to avoid possible corrosion of equipment, is given in **B.2**.

5.10.6 *Heat and moisture gains and losses*

Heat and moisture gains and losses are affected by the external environment and by internal sources such as lighting, equipment and personnel. This needs to be taken into account in the specification of the air conditioning plant. The thermal effect of some types of lighting may require that lights be kept on permanently where very stable temperatures are required. The proximity of the laboratory to other heat generating sources such as boiler plant or industrial processes should be avoided where possible. Central heating, steam and hot water piping should not be taken through the laboratory. If this cannot be avoided pipes should be well lagged and the unavoidable heat gain allowed for in the specification of the air conditioning plant.

5.10.7 *Operational load*

The design of the air conditioning plant should take account of the types of activity to be carried out, the equipment needed for the laboratory, the fresh air supply, the heat loss or gain through the fabric of the laboratory, lighting, air extraction, fume cupboards and the projected number of laboratory personnel. The equipment and furniture should be positioned so as to be unlikely to cause major interference to the flow of air. Further guidance on the operational load on air conditioning plant is given in **3.2.4** and **3.2.5** of BS 5720 : 1979.

5.10.8 *Air cleanliness*

Acceptable levels of air cleanliness may need to be specified for some laboratories, either in terms of conformity to standard conditions, or in terms of a permissible range and frequency distribution of dust particle sizes. Air pollutants and corrosive chemicals can affect the equipment, the measurement process and the personnel in both the short and the long term. Appropriate requirements should be specified in accordance with BS 5295 : Part 0 : 1989, BS 5295 : Part 1 : 1989, and BS 5295 : Part 2 : 1989. All surfaces within the laboratory likely to produce dust should be sealed with a non-peeling finish.

NOTE. Guidance on air filters for use in air conditioning and general ventilation is given in BS EN 779 : 1992.

5.10.9 *Air change rates*

The acceptable minimum volume of fresh air intake per minute, its source, and the number of air changes per hour should be specified, as should whether the air pressure is to be maintained above, equal to, or below the external atmospheric pressure. Measurement areas should normally be held at a small positive pressure above the external ambient pressure, so as to reduce the ingress of pollutants. Where there is negligible contamination or heat gain, the minimum number of air changes per hour should be five, of which 10 % of the air intake should be fresh air. Further guidance on mechanical ventilation and air conditioning in buildings is given in BS 5720 : 1979.

5.10.10 ***Air speed***

In addition to the requirements arising from the recommendations given in **5.10.8** and **5.10.9**, the maximum air speed in the working area should not adversely affect any measurement process or the comfort of personnel. Where heat dissipation from equipment is important, the air velocity around the equipment should be as high as is practicable.

5.10.11 ***Plant shut-down and start-up***

If a shut-down of the air conditioning plant is not acceptable, it may be necessary for a stand-by plant to be installed to ensure continuous operation in the event of a failure or during maintenance. If the atmosphere in the laboratory is not to be permanently controlled, the time to reach normal operating conditions from start-up, and the permissible overshoot tolerances of the controlled conditions during both start-up and shut-down, may need to be specified.

5.11 Services

5.11.1 ***General***

Details of the electrical, gas, compressed air and water supplies, drainage, telephones and any other special services required for the operation of the laboratory should be considered. Accessibility for modifications and maintenance also needs to be considered. This could require the installation of false flooring or ceiling sections (see also **5.8.3** and **5.8.4**).

5.11.2 ***Electrical supplies***

Electrical supplies of differing capacity, stability, waveform purity, maintainability and flexibility may be needed according to the requirements for a particular laboratory. Radiated and conducted electrical interference need to be considered as they can affect both measurement processes and computerized control systems. The wiring of electrical supplies should be arranged to minimize such interference. The electrical installation should conform to BS 7671 : 1992.

To minimize the effect of unwanted magnetic fields, attention should be paid to the presence of ferromagnetic materials and the location of field-producing transformers and wiring.

Normally a laboratory requires all or some of the following supplies.

a) *Single and three phase power supplies at normal mains voltage and frequency.* These normally comprise socket outlets for the single phase supply and an adequate current rating per phase for the three phase four wire supply.

b) *Single and three phase heavy duty power supplies at normal mains voltage and frequency.* These should have an adequate rating for both single phase and each phase of a three phase supply.

c) *Single and three phase supplies at other than mains voltage and frequency.*

d) *Direct current supply at 24/28 V.* The earthing of this supply needs to be considered.

e) *Uninterruptible power supplies (UPSs).* These may be needed for certain electrical standards and measurement systems, and are particularly important for computers, to ensure that the supply is not interrupted at any time or only with due notice.

NOTE 1. The fast response time of modern UPSs allows such rapid switching from normal operation to standby operation that the loading of equipment is virtually unaffected. Such supplies can be permanently in circuit so that in the event of a power failure they can provide substitute power for a stated period. The application, for example maintaining a heater or a system in operation, should determine the type of UPS selected.

f) *Conditioned power supplies.* These can range from supplies with a simple regulator to those with a full line conditioner which not only regulates but filters and eliminates fast rising pulses. Such supplies may be needed for particular applications. The need for a conditioned power supply is dependent on the electrical purity, the stability and regulation of the electrical supply, and the susceptibility of the measuring equipment and device under test to mains regulation, waveform purity and line-borne interference.

NOTE 2. Full conditioning is normally required only where very low levels of electrical signals are being measured or for automated systems where transients (electrical disturbances which rise and fall slowly) can cause problems with computerized control and/or data gathering.

The laboratory requirements need to be fully determined to ensure the design and installation of the most effective system, and to allow for possible future modifications.

Information on the principles involved in the design and construction of earth monitoring, earth proving and insulation monitoring devices, and requirements for their safe use and application are given in BS 4444 : 1989.

5.11.3 ***Lighting***

The type of lighting required can vary from general illumination to high intensity local lighting in the working areas. The generally accepted lighting level for normal measurement work is between 500 lux and 1000 lux. The effectiveness of any lighting system depends on the general shape, colour and decoration of the laboratory and the materials comprising the surfaces in the laboratory, and these should be considered at the planning stage. Fluorescent lighting should be considered for general illumination because of its evenness and low heat dissipation and because fluorescent tubes are available in various colour tints which is important for reducing eye strain, especially where there is no natural ambient daylight.

5.11.4 *Water and drainage*

The installation of a water supply, for direct use or for topping up indirect systems, and sink facilities may be required for some laboratories. Where water is to be used in the measurement process or for the dilution of reagents, the purity of the water may need to be specified and appropriate water treatment equipment installed. Water for laboratory use is specified in BS 3978 : 1987.

If water is used in a laboratory, consideration should be given to the necessary drainage. If the discharged water is uncontaminated, disposal can be to the site drainage system.

NOTE. In the case of contaminated water, attention is drawn to national and local regulations covering disposal.

5.11.5 *Gas and air*

The installation of supplies of natural gas, compressed air, and other gases may be required depending on the nature of the laboratory.

5.11.6 *Fume cupboards*

If hazardous substances are used during the measurement process, the handling of these substances needs to be carried out in an environment where noxious fumes can be extracted without danger to people. This can be achieved by the installation of fume cupboards. Appropriate requirements for fume cupboards should be specified in accordance with BS 7258 : Part 1 : 1990, BS 7258 : Part 2 : 1990 and BS 7258 : Part 3 : 1990.

5.12 Computer and communication facilities

Most laboratories require computer and communication facilities. The requirements should be fully specified at the design stage to ensure that adequate provision for communication networks is installed. The system should not only meet the initial requirements but have potential for expansion and modification in the future. Laboratories should also have a communication network between internal and external areas, particularly for safety where personnel could be working in isolation. BS 7083 provides recommendations for the accommodation and operating environment of computer equipment.

NOTE. Sufficient trunking should be fitted to contain all the various communication media lines, ensuring that precautions are taken where interference and cross-talk are likely to occur.

6 Furniture

The type of furniture required and its location generally depends on the type of laboratory. The following factors should be considered to ensure that the furniture is suitable, practical and ergonomically arranged.

a) Materials of which furniture is constructed should be compatible with the nature of the measurements so as not to adversely affect the results; for example ferromagnetic furniture should not be used where measurement of inductance is carried out.

b) Strength and stability of furniture, after installation, should be adequate for the heaviest equipment expected to be placed on it.

c) Each bench should be of adequate size to accommodate the largest equipment expected to be placed on it and to provide sufficient working space around the equipment.

d) Where measuring equipment is particularly sensitive to movement, the installation of seismic blocks, granite tables or air-bed platforms may be necessary.

e) Heights of working surfaces should provide comfortable working conditions for personnel and permit easy movement of equipment.

f) Eye level shelving should be used for mounting indicators and displays.

g) Chairs should be comfortable, stable and moveable, and where appropriate the height should be adjustable.

h) Storage systems should be appropriate for their intended use, for example for safe and proper storage of ancillary equipment, documentation and computer media.

i) Particular attention should be paid to the needs of certain specialist areas, such as laboratories undertaking the measurement of reactance, where not only the furniture needs to be non-ferromagnetic but also any ancillary equipment such as oil or air baths.

j) The correct storage of computer media to prevent data corruption by strong magnetic fields, dirt, heat and water is most important. The furniture required depends on the media to be stored. The provision of additional storage furniture for the retention of back-up copies, at a site remote from the computer operational area, is also recommended.

NOTE 1. BS 3202 provides further information on laboratory furniture and fittings.

NOTE 2. See **A.6** for guidance on laboratories where electrostatic sensitive devices and equipment are handled.

7 Receipt and dispatch areas

Where possible the receipt and dispatch areas should be located conveniently with respect to all the other laboratory related functions. To provide an efficient service, they should have direct access for vehicular traffic where required. They should be equipped with adequate lifting facilities, particularly if equipment is likely to be heavy or large, and should have sufficient space for loading and unloading of equipment. The need for areas for on-receipt inspection, and packaging of equipment before dispatch, also should be considered. (See also **5.4**.)

8 Safety

NOTE. Attention is drawn to statutory regulations regarding health and safety.

Installation of the following should be considered:

a) central or individual residual current circuit breakers for electrical equipment;

b) emergency stop buttons for complex or hazardous equipment and processes;

c) audio or visual alarm and monitoring systems (e.g. closed circuit television), particularly for enclosed chambers where personnel may be required to work alone;

d) interlock devices for hazardous facilities or processes, such as high voltage equipment;

e) separate preparation areas having suitable extraction hoods and, where necessary, exhaust ducting to a suitable treatment plant or to the outside, where this is permissible. Precautions should be taken to ensure that the exhausted substances, for example fumes from cleaning agents or process baths, are not recirculated back into the air conditioning system and do not create a nuisance. (See also **5.11.6**.);

f) automatic fire detection and alarm systems, smoke detectors, gas discharge systems and appropriate fire extinguishers;

NOTE 1. Care should be taken that these are positioned correctly.

g) facilities for the retention of hazardous liquids (e.g. cleaning baths) in the event of rupture of the container;

h) depending upon the level of risk involved, shielding against electric, electromagnetic, radiation and acoustic effects;

i) emergency lighting.

NOTE 2. This list is not necessarily exhaustive.

9 Acceptance tests

The specification for the laboratory should include a schedule of acceptance tests, agreed between the supplier and the purchaser/user, that are to be used for the acceptance by the purchaser/user of the completed laboratory. The supplier should carry out these acceptance tests which, if possible, should be repeated under different external ambient conditions, to demonstrate that the completed laboratory conforms to the specification. Performance should be checked under working conditions. This should take account of normal heat inputs due to the lighting, electrical and other heat generating equipment, and personnel. The extent and period of the testing should be sufficient to establish the stability and rate of change of conditions over a given time, taking into account seasonal and external conditions. When applicable, this should include a check that normal operating conditions are fully restored within a stated period following an interruption.

NOTE. During the commissioning of the completed laboratory, the temperature and humidity profiles of the laboratory should be fully assessed. If structural modifications or major equipment changes are made, the temperature and humidity assessment should be repeated.

Annexes

Annex A (normative)

Additional considerations for electrical measurement laboratories

A.1 Environment

The main requirements for electrical measurement laboratories are for the control and monitoring of the temperature and humidity.

Where equipments with critical temperature coefficients are measured, the temperature and relative humidity conditions generally required are 20 °C ± 1 °C and 50 % r.h. to 60 % r.h. or 23 °C ± 1 °C and 45 % r.h. to 55 % r.h.

For measurements where the temperature coefficients are not so critical, the temperature tolerance can be increased to ± 2 °C.

Where the temperature needs to be controlled to finer limits, the use of isothermal oil or air baths is recommended.

For the measurement of high resistance and high voltage, the relative humidity should not exceed 45 % r.h. to avoid leakage paths and high voltage tracking.

A.2 Vibration

Vibration should be kept to a minimum, to prevent instability of measurement or damage to measurement standards, and should not exceed 0.005 *g* up to frequencies of 400 Hz for laboratories measuring reference standards.

A.3 Electrical supplies

The basic requirement is for a single phase power supply with sufficient socket outlets to meet all the equipment needs.

There is usually a need for at least one outlet of 100 A capacity to cater for more powerful equipment or for situations where equipments are run in parallel, such as several calibrators used to produce a 1000 A supply.

A three phase four wire supply of adequate current rating is normally required to operate specialist equipment.

If other supplies such as 60 Hz, 400 Hz and direct current are needed, they should be specified. If the need is only occasional, then the use of bench-top static or rotary converters is the most cost effective method. Continual use would require the installation of the correct capacity plant. The noise from rotary plant can be a nuisance, consideration should therefore be given to siting this plant remotely.

Laboratories making highly accurate measurements may require some form of conditioning to the mains supplies to prevent sources of random errors in the measurements. The waveform of a mains supply can be distorted by loads being switched, such as digital and commutation equipment. For example a computer terminal, when switched on, can generate a spike (a sharp, short duration electrical disturbance) of more than 100 V on to the supply. The use of filters, regulators or isolation transformers can improve the purity of the supply. Where the measurement uncertainty would be significantly affected by an increased random error contribution, full line conditioning to provide the necessary characteristics for load regulation, short term stability (10 min), harmonic reduction and impulse suppression is recommended.

Dependent on the specific needs, the laboratory could have designated outlets as raw, regulated and conditioned mains supply.

If equipments require a continuous supply, to maintain reference temperatures or to ensure permanent operation, there is a need for a maintained supply. For measurement systems where the maintenance of temperature is the criterion, mains failure changeover systems can be used if a break in supply, not exceeding a few seconds, is unlikely to cause problems. A back-up supply also can be used and can be any suitable system, either rotary or static, that has sufficient capacity to last the longest unsupervised interval, normally not exceeding 72 h.

Systems that are continuous in operation such as automated measurement equipment, computing facilities, and off-air frequency standards require an uninterruptible power supply. This ensures that the system is not without power for even the shortest interval and, therefore, the risk of data loss or mis-operation is avoided. However, the equipment is likely to be heavy and the running cost per watt high and it should be reserved for the systems where, upon failure, loss of operational integrity would be expensive in terms of lost traceability or lost data.

A.4 Electrical earthing

Electrical laboratories may require a separate earth system to ensure that an effective earth is achieved. The use of a buried grid or mat is the standard practice. The depth at which the grid or mat needs to be buried depends on the soil resistivity and this should be determined by measurement in accordance with the recommendation given in BS 4444 : 1989 using the methods described in BS 7671 : 1992.

A.5 Screening

Careful consideration should be given to the need for screened rooms although with the more effective screening found on modern receivers and sources of electromagnetic radiation, the necessity is now diminished. Screened rooms are required in areas that are subject to transmitted radio frequency interference that is of sufficient strength to cause instability in electrical equipment. The use of appropriate filters should be considered in situations where interference is conducted.

A.6 Static electricity

Certain electronic devices, integrated circuits and assemblies are susceptible to damage or malfunctioning when subjected to electrostatic discharges (ESDs) or electric fields arising from initially static electrical charges.

It is recommended that laboratories intended for the measurement of electronic devices, integrated circuits and assemblies should conform to the appropriate sections (sections 3 and 4) of BS EN 100015-1 : 1992. When designing such laboratories electrostatic discharge protected areas (EPAs) should conform to BS EN 100015-1 : 1992 including the following requirements:

a) signs for EPAs;

b) marking of earth bonding points, earth grounding points and ESD earth facilities;

c) configuration of EPAs;

d) control boundaries;

e) basic material requirements for use within the controlled boundaries of all forms of EPAs (including working surfaces and floor coverings);

f) ionization;

g) humidity (above 20 % r.h.).

When such laboratories also include clean room areas and/or high voltage environments, their EPAs should also conform to the appropriate additional requirements of sections 3 and 4 of BS EN 100015-3 : 1994 and/or BS EN 100015-4 : 1994, respectively.

A.7 Services

The services required depend on the tasks being undertaken but there is normally a need for some or all of the following:

a) dry compressed air;

b) vacuum supply;

c) carbon dioxide;

d) liquid nitrogen;

e) dry nitrogen;

f) natural gas;

g) water and drainage facilities;

h) ice making and crushing facility;

i) computer communications;

j) telephone communications;

k) electrical supply at standard frequency and voltage.

NOTE. This list is not necessarily exhaustive.

A.8 Safety

NOTE. Attention is drawn to national and local regulations regarding safety precautions.

Particular areas of risk in electrical laboratories are as follows:

a) exposed conductors carrying greater than 50 V a.c. or 70 V d.c.;

b) exposed conductors carrying currents in excess of 50 A;

c) radio frequency or microwave signal leakage;

d) laser operating systems;

e) oil bath systems requiring fume extraction.

Additionally, all mains energized electrical equipment should be supplied via residual current circuit breakers (RCCBs) of appropriate rating. It is essential that RCCBs should be accessible for regular testing.

Annex B (normative)
Additional considerations for mechanical measurement laboratories

B.1 Building

Requirements for reinforced foundations, special piling, heavy duty flooring, gantries and vibration isolators should all be considered. The building and access dimensions should allow for the installation of the larger and more specialized measurement equipment.

B.2 Environment

The main requirements for mechanical laboratories are the control and monitoring of the temperature and humidity.

The relative humidity should be controlled at 45 % r.h. to 55 % r.h. to minimize the possible corrosion of unprotected steel parts of the laboratory equipment and to restrict the growth of rust to a primary film (i.e. a film that can be removed by routine cleaning procedures). At 65 % r.h. the growth of a secondary film of rust (which can cause extensive and possibly irreparable damage) occurs on steel and this is accelerated by gaseous and dust contaminants until rust is clearly visible.

For the measurement of standards, the temperature should be controlled at 20 °C ± 0.5 °C, to minimize the effect of the differential expansion of materials. The rate of change of temperature should not exceed 0.1 °C/h.

For lower accuracy calibration work and general measurement the temperature tolerance can be increased to ± 1 °C, and for large components and laboratories having a large volume it may be necessary to relax the tolerance to ± 2 °C. However, the control of the humidity level should still be held at 45 % r.h. to 55 % r.h. and the rate of change of temperature should not exceed 2 °C/day and 1 °C/h.

B.3 Vibration

Vibration should be kept to a minimum, particularly for accurate measurements of dimensions, force, pressure or vacuum, optical properties and acceleration. The tolerable level of ambient vibration that would not degrade such measurements needs to be considered. Where the level of vibration is found to be unacceptable, installation of vibration isolators is necessary. The following levels are a guide to the tolerable ambient vibration permissible for a laboratory carrying out the above types of measurement to the highest accuracy:

a) continuous vibration:

0.001 *g* for frequencies > 100 Hz,

0.25 µm displacement for frequencies < 100 Hz;

b) intermittent vibration: 0.01 *g*.

B.4 Environmental cleanliness

The degree of environmental cleanliness required depends on the nature of the measurements to be undertaken.

NOTE. See table 2 of BS 5295 : Part 1 : 1989. Classes J or K are likely to be suitable for most applications.

B.5 Electrical supplies

The laboratories should have a single phase power supply with sufficient socket outlets to meet all the equipment needs. Heavy duty single phase and three phase four wire mains supplies may also be required for some equipment.

Consideration should be given to the need for any regulated or conditioned supplies to operate electronic equipment or computers.

The elimination of transient electrical disturbances is important where digital equipment is used, particularly where automated systems are operated. Where continuous measurement systems are used the installation of a standby or uninterruptible power supply to ensure that a continuous supply is maintained should be considered.

B.6 Services

The services required depend on the task being undertaken but there is normally a need for some or all of the following:

a) dry compressed air;

b) vacuum supply;

c) carbon dioxide;

d) liquid nitrogen;

e) dry nitrogen;

f) natural gas;

g) water (tap, distilled and de-ionized) and drainage facilities;

h) ice making and crushing facilities;

i) computer communications;

j) telephone communications.

B.7 Preconditioning area

An area for preconditioning items before measurement, either within the laboratory or an adjacent area conditioned to the same level as the laboratory, may be required so that they stabilize to the temperature of the laboratory.

B.8 Safety

NOTE. Attention is drawn to national and local regulations regarding safety precautions.

Particular areas of risk in mechanical laboratories are as follows:

a) the movement of heavy components or measurement equipment;

b) laser operating systems;

c) high pressure pneumatic or hydraulic systems;

d) ancillary electrical systems.

Additionally, all mains energized electrical equipment should be supplied via a residual current circuit breaker (RCCB) of adequate rating. It is essential that the RCCBs should be accessible for regular testing.

Annex C (normative)

Additional considerations for mass measurement laboratories

NOTE. Guidance is also given in NAMAS Publications NIS 0416 and NIS 6 (references [1] and [2]).

C.1 Location

The site for a mass measurement laboratory should be chosen with considerable care with regard to meeting certain environmental conditions. It is essential that the location is free from vibration and shock, and sources of electrical interference and that the atmosphere is appropriately clean.

Ideally the laboratory should be at ground or basement level to provide a solid foundation.

A mass measurement laboratory should not be used for other measurement activities in order to avoid sources of vibration and thermal disturbances, or air pollution contaminating the weight surfaces, for example from a hydraulic deadweight tester.

If these important environmental conditions are not met, it is unlikely that any accurate weighing machine will function to its designed performance.

C.2 Environment

The stability of the laboratory temperature is more important than the nominal operating temperature, usually 20 °C. Rapid temperature changes cause drift in the results, and can even alter the sensitivity of the weighing machines. The laboratory temperature should therefore not be unduly affected by changes of the external ambient conditions.

Temperature gradients and draughts should be avoided in the working area. See **C.3** for guidance on minimizing the causes of temperature gradients and draughts and their effects.

Rapid changes in temperature should be avoided; the rate of change should not exceed 0.5 °C over the working day where high accuracy (1 part per million) weighing is undertaken. For lower accuracy weighing, the rate of change of temperature is less critical and these requirements may be relaxed.

It is recommended that the laboratory atmosphere is continuously controlled to maintain a stable temperature at all times, and thus maintain the weighing machines at the same temperature as the surrounding air. For high accuracy weighing, the laboratory lighting should be left on continuously to avoid variation of its thermal output. Portable lighting should not be used, even if not directed at a weighing machine, owing to the machine being affected by localized heating. Fluorescent lighting is suitable for weighing areas.

Heat from personnel can be troublesome in closely controlled environments, particularly with high accuracy balances.

A relative humidity of 40 % r.h. to 50 % r.h. is suitable as this permits a simple environmental control, sufficient to minimize electrostatic effects and possible corrosion of equipment (from moisture condensing from the atmosphere).

C.3 Air movement and pressure changes

Air currents and pressure changes can adversely affect the performance of weighing machines. It is important that the speed of air movement around weighing machines is minimal and that air currents are not directed on to the balances. Where an existing building that already has air conditioning installed is to be used for a mass measurement laboratory, the air velocity needs to be the minimum necessary to achieve the specified temperature throughout the laboratory.

The construction of separate weighing enclosures or draught shields may be necessary. Some balances are supplied in a fully enclosed housing, or are available with optional draught shields.

C.4 Vibration

Vibration adversely affects all types of weighing machine to a certain extent. Severe vibration can damage delicate parts, such as knife-edges, and cause blurring of the optical scale. The use of anti-vibration mounts is not an acceptable practice to isolate weighing machines from vibration effects. External sources of vibration should be avoided by selecting a location away from roads carrying heavy vehicles, railways and industrial activities.

C.5 Electrical interference

Electronic balances can be adversely affected and subject to error from electrical interference, both radiated and conducted. Electrical mains interference can be minimized by using a plug with an integral electrical filter.

Electrostatic charges can cause problems of attraction between the object being weighed and the parts of the balance. This effect can produce a considerable weighing error that might not be detected. Glass and other substances readily become electrostatically charged when wiped, particularly when the relative humidity is less than 40 % r.h. The use of plastics, in covers and curtains for draught shields, should be avoided for this reason.

NOTE. A static eliminator, such as polonium^{210}, can be effectively used to reduce the effects of electrostatic charge when using microbalances for weighing glassware or fine powders.

C.6 Environmental cleanliness

A clean air environment is essential for the best performance of weighing machines.

Moving parts such as levers, knife-edges and bearings are particularly sensitive to small quantities of dust, which cause wear and errors in weighing.

For high accuracy weighing, the environmental cleanliness should conform to class J as given in table 2 of BS 5295 : Part 1 : 1989. For lower accuracy levels the conditions may be relaxed to a less stringent class of environmental cleanliness.

C.7 Supports for weighing machines

Weighing machines need to be placed on a stable and level surface. The top should be stone (polished granite is ideal), at least 40 mm thick, and supported by solid brick piers on a concrete floor. A wooden floor or a suspended floor is not suitable. The support should not be attached to or be in contact with the walls of the building. Ideally the brick piers should go through the floor to the foundations without contact with the floor. A mastic or similar seal should be used to fill the gap. This minimizes vibrations caused by the movements of laboratory personnel.

Steel, even in reinforced concrete, should not be used in the construction of the supporting surface because of its magnetic properties.

Ideally a separate support should be provided for each weighing machine.

C.8 Furniture

The general requirements for furniture are as outlined in clause **6** but steel furniture should not be used because of its magnetic properties. Working surfaces should be of suitable material and finish, so as to be easily cleaned and to prevent weights from being scratched or contaminated.

Ideally there should be a minimum of furniture, with clerical work and computer printing taking place in adjoining offices, to reduce dust and disturbance.

Annex D (informative)

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List of references (see clause 2)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 4444 : 1989	*Guide to electrical earth monitoring and protective conductor proving*
BS 5233 : 1986	*Glossary of terms used in metrology (incorporating BS 2643)*
BS 5295 :	*Environmental cleanliness in enclosed spaces*
BS 5295 : Part 0 : 1989	*General introduction, terms and definitions for clean rooms and clean air devices*
BS 5295 : Part 1 : 1989	*Specification for clean rooms and clean air devices*
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BS 7000 :	*Design management systems*
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BS 7258 :	*Laboratory fume cupboards*
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BS 7671 : 1992	*Requirements for electrical installations. IEE Wiring Regulations. Sixteenth edition*
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BS EN 100015-3 : 1994	*Requirements for clean room areas*
BS EN 100015-4 : 1994	*Requirements for high voltage environments*

Informative references

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BS 3202 :	*Laboratory furniture and fittings*
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ISO publications

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO) Geneva. (All publications are available from Customer Services, BSI.)

International vocabulary of basic and general terms in metrology, 1993

Other references

[1] NAMAS Publication NIS 0416 : 1990 *Guidance on weighing in NAMAS accredited laboratories*[1)]

[2] NAMAS Publication NIS 6 : 1992 *The calibration of weights and weighing machines*[1)]

[1)]Available from NAMAS Executive, National Physical Laboratory, Teddington, Middlesex TW11 0LW

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