

BS 6739:2009



BSI Standards Publication

Code of practice for instrumentation in process control systems: installation design and practice

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Summary of pages

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Foreword

Publishing information

This British Standard is published by BSI and came into effect on 1 January 2009. It was prepared by Technical Committee GEL/65, *Measurement and control*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 6739:1986, which is withdrawn.

Information about this document

This is a full revision of the standard, and introduces the following principal changes:

- existing recommendations brought up to date to reflect changes in workplace practice and technology since 1986;
- new recommendations added to take into account technology introduced since 1986;
- guidance on legislation brought up to date to reflect regulations and directives introduced since 1986.

Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

BSI permits the reproduction of the specimen check sheets in Annex C (Figures C.1 to C.5). This reproduction is only permitted where it is necessary for the user to record findings on the check sheets during each application of the standard.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

NOTE The recommendations given in this British Standard are based on the assumption that all instruments will have been specified and all instrument panels will have been designed.

This British Standard gives recommendations for, and guidance on, the design for the installation of instrumentation of measurement and control systems in the process industry, and the implementation and commissioning of this installation. It is intended to be used as a manual of good practice on the site and also to assist those who design the installation.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

BS 759-1, *Valves, gauges and other safety fittings for application to boilers and to piping installations for and in connection with boilers – Part 1: Specification for valves, mountings and fittings*

BS 1363-1, *13 A plugs, socket-outlets and adaptors – Specification for rewirable and non-rewirable 13 A fused plugs*

BS 3680 (all parts), *Measurement of liquid flow in open channels*

BS 4278, *Specification for eyebolts for lifting purposes*

BS 4727 (all parts), *Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms*

BS 5308 (both parts), *Instrumentation cables*

BS 5499-1, *Graphical symbols and signs – Safety signs, including fire safety signs – Part 1: Specification for geometric shapes, colours and layout*

BS 5839-1, *Fire detection and fire alarm systems for buildings – Part 1: Code of practice for system design, installation, commissioning and maintenance*

BS 6346, *Electric cables – PVC insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V*

BS 6423, *Code of practice for maintenance of electrical switchgear and controlgear for voltages up to and including 1 kV*

BS 7430, *Code of practice for earthing*

BS 7454, *Method for calculation of thermally permissible short-circuit currents, taking into account non-adiabatic heating effects*

BS 7671, *Requirements for electrical installations – IEE Wiring Regulations – Seventeenth edition*

BS 8444-3, *Risk management – Part 3: Guide to risk analysis of technological systems*

BIP 3081, *Legal admissibility collection (BIP 0008 and BIP 0009)*¹⁾

¹⁾ BIP 3081 comprises BIP 0008, *Code of practice for legal admissibility and evidential weight* (in three parts) and BIP 0009, *Code of practice for legal admissibility and evidential weight – Compliance workbook* (in three parts)

PD 5304, *Guidance on safe use of machinery*

PD 5500, *Specification for unfired fusion welded pressure vessels*

BS EN 207, *Personal eye-protection – Filters and eye-protectors against laser radiation (laser eye-protectors)*

BS EN 614-1, *Safety of machinery – Ergonomic design principles – Part 1: Terminology and general principles*

BS EN 1127 (both parts), *Explosive atmospheres – Explosion prevention and protection*

BS EN 10216-1, *Seamless steel tubes for pressure purposes – Technical delivery conditions – Part 1: Non-alloy steel tubes with specified room temperature properties*

BS EN 10217-1, *Welded steel tubes for pressure purposes – Technical delivery conditions – Part 1: Non-alloy steel tubes with specified room temperature properties*

BS EN 10217-7, *Welded steel tubes for pressure purposes – Technical delivery conditions – Part 7: Stainless steel tubes*

BS EN 12449, *Copper and copper alloys – Seamless, round tubes for general purposes*

BS EN 13284-1, *Stationary source emissions – Determination of low range mass concentration of dust – Part 1: Manual gravimetric method*

BS EN 13284-2:2004, *Stationary source emissions – Determination of low range mass concentration of dust – Part 2: Automated measuring systems*

BS EN 13463 (all parts), *Non-electrical equipment for potentially explosive atmospheres*

BS EN 14181:2004, *Stationary source emissions – Quality assurance of automated measuring systems*

BS EN 15259, *Air quality – Measurement of stationary source emissions – Requirements for measurement sections and sites and for the measurement objective, plan and report*

BS EN 15267-3, *Air quality – Certification of automated measuring systems – Part 3: Performance criteria and test procedures for automated measuring systems for monitoring emissions from stationary sources*

BS EN 50173 (all parts), *Information technology – Generic cabling systems*

BS EN 50174 (all parts), *Information technology – Cabling installation*

BS EN 50178, *Electronic equipment for use in power installations*

BS EN 50262, *Cable glands for electrical installations*

BS EN 50288-7, *Multi-element metallic cables used in analogue and digital communication and control – Part 7: Sectional specification for instrumentation and control cables*

BS EN 60079 (all parts), *Electrical apparatus for explosive gas atmospheres*

BS EN 60204-1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

BS EN 60205, *Calculation of the effective parameters of magnetic piece parts*

- BS EN 60309 (all parts), *Plugs, socket-outlets and couplers for industrial purposes*
- BS EN 60529, *Specification for degrees of protection provided by enclosures (IP code)*
- BS EN 60584 (all parts), *Thermocouples*
- BS EN 60751, *Industrial platinum resistance thermometer sensors*
- BS EN 60801-2, *Electromagnetic compatibility for industrial-process measurement and control equipment – Part 2: Electrostatic discharge requirements*
- BS EN 60825 (all parts), *Safety of laser products*
- BS EN 60950 (all parts), *Information technology equipment – Safety*
- BS EN 61010 (all parts), *Safety requirements for electrical equipment for measurement, control, and laboratory use*
- BS EN 61131-2, *Programmable controllers – Part 2: Equipment requirements and tests*
- BS EN 61241 (all parts), *Electrical apparatus for use in the presence of combustible dust*
- BS EN 61285, *Industrial-process control – Safety of analyser houses*
- BS EN 61326 (all parts), *Electrical equipment for measurement, control and laboratory use – EMC requirements*
- BS EN 61386-1, *Conduit systems for cable management – Part 1: General requirements*
- BS EN 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*
- BS EN 61511 (all parts), *Functional safety – Safety instrumented systems for the process industry sector*
- BS EN 61800-5-1, *Adjustable speed electrical power drive systems – Safety requirements – Part 5-1: Electrical, thermal and energy*
- BS EN 62061, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*
- BS EN 62262, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*
- BS EN ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods*
- BS EN ISO 4126-1, *Safety devices for protection against excessive pressure – Part 1: Safety valves*
- BS EN ISO 5167 (all parts), *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full*
- BS EN ISO 11064 (all parts), *Ergonomic design of control centres*
- BS EN ISO 11252, *Lasers and laser-related equipment – Laser device – Minimum requirements for documentation*
- BS EN ISO 13406, *Ergonomic requirements for work with visual display based on flat panels*
- BS ISO 9096, *Stationary source emissions – Manual determination of mass concentration of particulate matter*

BS ISO 10155, *Stationary source emissions – Automated monitoring of mass concentrations of particles – Performance characteristics, test methods and specifications*

BS ISO 10396, *Stationary source emissions – Sampling for the automated determination of gas emission concentrations for permanently-installed monitoring systems*

BS ISO 14164, *Stationary source emissions – Determination of the volume flowrate of gas streams in ducts – Automated method*

BS ISO 15489-1, *Information and documentation – Records management – Part 1: General*

BS ISO/IEC 27001, *Information technology – Security techniques – Information security management systems – Requirements*

BS IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test – Basic EMC publication*

BS IEC 61513, *Nuclear power plants – Instrumentation and control for systems important to safety – General requirements for systems*

DD CEN/TS 15675, *Air quality – Measurement of stationary source emissions – Application of EN ISO/IEC 17025:2005 to periodic measurements*

DD CLC/TS 61643-12, *Low-voltage surge protective devices – Surge protective devices connected to low-voltage power systems – Part 12: Selection and application principles*

DD CLC/TS 61643-22, *Low-voltage surge protective devices – Surge protective devices connected to telecommunications and signalling networks – Part 22: Selection and application principles*

PD CLC/TR 50404, *Electrostatics – Code of practice for the avoidance of hazards due to static electricity*

PD IEC/TR 60825-14, *Safety of laser products – Part 14: A user's guide*

ISO/IEC 24702, *Information technology – Generic cabling – Industrial premises*

IEC 61784-5, *Digital data communication for measurement and control – Part 5: Installation profiles for communication networks in industrial control systems*

IEC 61918, *Digital data communications for measurement and control – Profiles covering installation practice for fieldbus communications media within and between the Automation Island*

Other publications

INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION. Guidelines on limits of exposure to ultraviolet radiation of wavelengths between 180 nm and 400 nm (incoherent optical radiation). *Health physics*, 2004, Volume 87 (2), pp. 171–186.²⁾

INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION. Revision of the guidelines on limits of exposure to laser radiation of wavelengths between 400 nm and 1.4 µm. *Health physics*, 2000, Volume 79 (4), pp. 431–440.²⁾

²⁾ Available for downloading from <http://www.icnirp.de/Publications.htm>

INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION. Guidelines on limits of exposure to broad-band incoherent optical radiation (0.38 to 3 μm). *Health physics*, 1997, Volume 73 (3): pp. 539–554.²⁾

INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION. Guidelines on UV radiation exposure limits. *Health physics*, 1996, 71 (6): p. 978.²⁾

INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION. Guidelines on limits of exposure to laser radiation of wavelengths between 180 nm and 1 mm. *Health physics*, 1996, Volume 71 (5): pp. 804–819.²⁾

INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION. Proposed change to the IRPA 1985 guidelines on limits of exposure to ultraviolet radiation. *Health physics*, 1989, Volume 56 (6): pp. 971–972.²⁾

INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION. Guidelines on limits of exposure to ultraviolet radiation of wavelengths between 180 nm and 400 nm (incoherent optical radiation). *Health physics*, 1985, Volume 49 (2): pp. 331–340.²⁾

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS 4727 and the following apply.

3.1.1 actuator

mechanism for changing a signal into a corresponding movement

3.1.2 atmospheric contamination

presence in the environment of undesirable gases, vapours or dusts that might be harmful to equipment or personnel working in that environment

3.1.3 authorized person

person authorized by management in writing to carry out certain duties and tasks on their behalf, on the understanding that the correct and appropriate procedures will be followed and standing instructions will be adhered to

3.1.4 booster

power amplifier of which the signal gain is unity

3.1.5 competent person

person who by reason of training, experience, theoretical and practical knowledge, and maturity of judgement, is able to carry out the specified duties

NOTE Competent persons need to have the necessary ability in the particular operation of the type of plant and equipment with which they are concerned, an understanding of the relevant statutory regulations, an appreciation of the hazards involved, and sufficient authority to ensure that any action which they recommend is carried out. They need to be duly authorized to undertake the work.

3.1.6 control valve

power-operated device forming a final element in an industrial process control system

NOTE It consists of a body sub-assembly containing internal means for changing the flow rate of the process fluid. The body sub-assembly is linked to one or more actuators which respond to a signal transmitted from a controlling element.

3.1.7 converter

specialized device that converts one standardized transmission signal into another

3.1.8 crash dump

information taken from a computer at or immediately after a crash, which can subsequently permit the diagnosis of the cause of the crash

3.1.9 distributed control system

system where control responsibility is divided into a variety of modules that are arranged either geographically (per unit process) or logically (control functions) around a plant so that the failure of one does not affect the operation of others

3.1.10 gas flooding system

system which in the event of smoke or fire being detected in a given area has the ability to fill that area with a fire-retardant gas

3.1.11 hysteresis

property of a device or instrument whereby it gives different output values in relation to its input values, depending on the direction sequence in which the input values have been applied

3.1.12 instrument personnel

persons who form the labour force required to install and commission instrumentation and associated pipework, equipment and services

NOTE The trades involved are likely to include pipefitters, welders, instrument mechanics and technicians, and electricians.

3.1.13 instrument supervisor

person who directs and controls the installation personnel and whose responsibility to the owner/employer includes safety matters, work progress and standards, labour discipline and industrial relations

NOTE This includes all supervisors and managers up to and including the site agent.

3.1.14 inverter

device that converts a direct current to an alternating current

NOTE This is normally employed to provide 110 V a.c. or 230 V a.c. from a battery-supplied d.c. source.

3.1.15 listing

document containing all of the codes and comments associated with a particular computer program

3.1.16 positioner

device to position an actuator in accordance with a standardized signal

NOTE The positioner compares the input signal with a mechanical feedback link from the actuator, then produces an output signal necessary to move the actuator until the position feedback corresponds with the signal value.

3.1.17 power line disturbance monitor

instrument designed to analyse and monitor various power line parameters such as frequency, r.m.s. values, transient amplitudes, duration and frequency

3.1.18 process control computer

computer that, by means of inputs from and/or outputs to a process, directly controls and/or monitors the operation of elements in the process

3.1.19 programmable multi-loop controller

controller capable of controlling two or more variables and whose control strategy is changeable by programming or software configuration

3.1.20 responsible engineer

engineer with particular responsibility for the specific project or parts of a project

3.1.21 semi-rigid coaxial cable

transmission line with two concentric conductors separated by an insulator, the outer conductor being of a solid rather than the normal braided construction resulting in a stiff though not inflexible cable

3.1.22 standby power supply

NOTE Also known as “back-up power supply” or uninterruptible power supply (UPS).

power supply that supplies the load of another power supply in the event of the other supply failing

3.1.23 star configuration

set of three or more branches connected to a common node

3.1.24 time domain reflectometer

NOTE The principle involves applying a pulse to the cable under test, measuring the delay in reception of any reflections and analysing the shape of any reflected pulses.

device designed to detect and locate cable faults in coaxial and twisted pair cables

3.1.25 transmission line

cable connecting two remote points along which electrical/ electromagnetic signals are transmitted

3.2 Abbreviations

For the purposes of this British Standard, the following abbreviations apply.

ALARP	as low as reasonably practicable
ATEX	atmosphere explosive
ATEX Regulations	Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996
BDM	basic drive module
CASS	conformity assessment for safety-related systems
CDM	complete drive module
CHIP	Chemicals (Hazardous Information and Packaging for Supply) Regulations 2002
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations 2002
DTS	distributed temperature sensing
ELV	extra low voltage
ESD	electrostatic discharge
FISCO	fieldbus intrinsically safe concept

FNICO	fieldbus non-incendive concept
HMI	human-machine interface
IECEX	IEC hazardous area certification scheme
IPPC	integrated pollution prevention and control
IS	intrinsically safe
LOLER	Lifting Operations And Lifting Equipment Regulations 1998
MCB	miniature circuit breaker
MCCB	moulded case circuit breaker
MCERTS	Monitoring and Certification Scheme (of the Environment Agency)
MICC	mineral insulated copper cable
n.b.	nominal bore
o.d.	outside diameter
PDS	power drive system
PELV	protective extra low voltage
PPC	pollution prevention and control
PPE	personal protective equipment
PUWER	Provision and Use of Work Equipment Regulations 1998
PV	process variable
RCD	residual current device
Redox	reduction/oxidation
RF	radio frequency
RFID	radio frequency identification device
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995
RoHS Regulations	Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2008
RPS	radiation protection supervisor
RTD	resistance temperature detector
RTTE	radio equipment and telecommunications terminal equipment
SEP	sound engineering practice
SIL	safety integrity level
SRS	safety requirements specification
SWA	steel wire armour
UPS	uninterruptible power supply
VPN	virtual private network
VA	variable area (flowmeter)
VSD	variable speed drives
WEEE	waste from electrical and electronic equipment

4 Personnel safety

COMMENTARY ON CLAUSE 4

The advice given in this clause is primarily concerned with those personnel who are engaged in the installation of instrumentation.

Attention is drawn to the statutory acts and regulations listed in Annex A.

All employers, self-employed and employees have a duty to be aware of all current workplace health and safety regulations that apply to them.

The regulations listed or referenced in this British Standard are not necessarily exhaustive, and whilst every effort has been made to ensure that the information is up to date at the time of publication, users of this British Standard need to be aware that legislation in this area is constantly changing.

4.1 General

COMMENTARY ON 4.1

Under statutory regulations, employers, the self-employed, and employees have a duty to, as far as reasonably practicable, protect the general public and health, safety and welfare at work. Other regulations require action in response to particular hazards, or in industries where hazards are particularly high and might not be qualified by "as far as reasonably practicable".

Hazards are particularly high in many areas where instrument personnel will work.

The major statutory act and regulations relevant to instrumentation installation are the Health and Safety at Work etc. Act 1974 [1], the Management of Health and Safety at Work Regulations 1999 [2] and their equivalents in Northern Ireland (see Table A.1). Guidance is given in A.1.1. Attention is also drawn to the Workplace (Health, Safety and Welfare) Regulations 1992 [3].

NOTE *The attention of all personnel is drawn to HSE publications L21 [4], L24 [5], INDG244 [6], INDG368 [7] and INDG259 [8].*

In all workplaces the occupier should formulate a set of safety rules and site recommendations or procedures appropriate to the type of installation. These should cover the operation of equipment/plant and the work to be carried out.

Health and safety regulatory requirements and local site-related health and safety requirements should be included in site safety instructions, and it should be confirmed that all personnel working on the site have read and understood them.

A site safety brief should be prepared for all contractors entering or working on the site, and it should be confirmed that each contractor has read and understood it.

Records should be retained of compliance with regulations of all work equipment, including equipment to be installed, and tools and equipment used for installation and commissioning.

Regulations require particular competencies for some equipment and locations that instrument personnel are likely to work on or in. Records should be kept of the competencies of all personnel working on a site/installation.

4.2 Responsibilities

COMMENTARY ON 4.2

Employers, the self-employed and persons in control of work premises have duties to report some work-related accidents, diseases and dangerous occurrences under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 [9]. Guidance is given in A.1.2.

NOTE 1 *Attention is drawn to HSE publication L73 [11], which includes the text of the Regulations and the requirements for duty holders to comply with them, including the additional provisions relating to mines, quarries and offshore workplaces.*

The occupier or employer should:

- ensure that all relevant safety rules and recommendations are brought to the attention of all persons entering the premises (or site);
- ensure that all relevant safety signs and rules are in languages understood by those persons;

There are also requirements for operators to take measures to prevent major accidents and limit their consequences. They are required to develop and maintain a major accident prevention policy document. Attention is drawn to the Control of Major Accident Hazards Regulations 1999 [10], as amended (see Table A.1).

NOTE 2 The Health and Safety Executive provides information in a number of foreign languages.

- ensure that precise instructions are issued setting out the procedures for handling and testing equipment safely; and
- monitor the arrangements to ensure that these procedures are effectively carried out.

NOTE 3 Where procedures or processes that are the responsibility of the person in charge of the premises (or site) or of any contractor could endanger persons not in their employment, there is a legal obligation on the site management to provide information and instruction to all personnel about the safety procedures to be adopted.

Before commencement of work, the person in charge of the premises (or site) or employer should inform all instrument personnel of the potential hazards on site and the action to be taken in an emergency.

Management should ensure that all personnel are fully aware of their responsibility for the safety of installations under their control and for ensuring that their own work is carried out safely.

Instrument supervisors should be fully conversant with the safety requirements and recommendations, and should ensure that instrument personnel under their control have been made familiar with the site safety practices.

It is important that all instrument personnel are aware of the site arrangements for emergency services, including the type and location of available first aid equipment, the method of summoning medical assistance, the fire service and other emergency services, and that they also know the location of all the personnel assembly points in the event of a site emergency.

4.3 Permit-to-work

NOTE 1 Attention is drawn to HSE publication HSG250 [12].

NOTE 2 "Installation" in this context includes work on all plant and equipment within the area covered by the permit-to-work system, i.e. instrumentation, electrical switchgear, pressure testing, radiography, etc.

A permit-to-work may form part of the site procedures that enable an operating department to authorize certain specified engineering work to proceed on the installation. It should contain instructions on the nature of the work, the whereabouts and the part of the installation to which it applies, the protective equipment to be provided, and to be used or worn, the precautions to be taken, the precautions already taken, the period for which it is valid, the name of the person and organization to whom it is issued and the name of the person authorized to issue it. It should also include details of any additional permits deemed to be necessary for the safe execution of the work.

Paper copies of a permit-to-work should be clearly displayed at or near the work site and in the central or main control room.

If electronic permits can be used, they should have a suitable system in place to prevent unauthorized issue or acceptance, should not be able to be issued remotely without a site visit, should have a system in place to prevent permits already issued from being altered without the alterations being communicated to all concerned, and should have a suitable back-up in the event of a software failure or power outage.

A copy of the permit should be kept with the issuing authority, or with the area authority if that person is not located at the site or control room.

Operators should be adequately trained to assess the specific job and should not rely on cutting and pasting from other permits.

Instrument personnel working under a permit-to-work system should stop work if any unsafe conditions are found, and should inform the issuing and performing authorities immediately.

4.4 Work equipment

4.4.1 General

COMMENTARY ON 4.4.1
Employers and the self-employed have a legal obligation, under the Provision and Use of Work Equipment Regulations 1998 (PUWER) [13], as amended (see Table A.1), to ensure that all equipment in their workplace is safe. The Regulations apply to all work equipment used, installed, commissioned, repaired, maintained, decommissioned or removed by instrument personnel, including work equipment used by personnel working from home. Guidance is given in A.1.3.

NOTE 1 *Attention of all personnel is drawn to HSE publications L22 [14] and INDG271 [15]. L22 is approved for use in Northern Ireland.*

NOTE 2 *HSE publications L22 [14] states that compliance with relevant European directives can be established by checking that the equipment bears the CE marking and asking for a copy of the Declaration of Conformity (DoC). Regulations do not always require the CE marking to be on the equipment, e.g. on small items. Neither does it always require the EC Declaration of Conformity to accompany equipment or to be in English.*

NOTE 3 *Equipment placed on the market before the mandatory dates for CE marking can still be installed and/or used, provided that it meets the requirements of the relevant regulations and is safe in accordance with the requirements of PUWER. Equipment that was put into use before the mandatory date for CE marking can continue to be used, maintained and repaired provided that it is safe in accordance with the requirements of PUWER. The mandatory date for CE marking varies according to the type of equipment in question.*

NOTE 4 *The onus for deciding which directives apply to (work) equipment is placed solely on the product manufacturer. Some regulations allow the CE marking to be on the packaging, delivery documentation or guarantee, or in the instructions for use. There are no specific requirements for the media on which the instructions for safe installation and use are to be provided.*

A system to verify that the work equipment conforms to all relevant legislation should be established and documented.

Personal work equipment and employer provided work equipment used in the workplace should be registered with the employer and there should be periodic checks to ensure it is safe for the location, environment and application.

All markings and labelling, pertinent to equipment compliance or legislation should be recorded for future reference. Particular care should be taken to record markings on packaging before it is removed and disposed of.

All instructions for safe installation and use and their media/storage location should be recorded and all such instructions should be readily accessible to the intended user.

4.4.2 Instructions

NOTE *UK regulations generally require instructions for the safe installation and use of (work) equipment to be in English.*

Instrument supervisors should ensure that they and all personnel under their supervision are able to read the instructions and know the meaning of any warning pictograms before commencing work.

Instrument personnel should not use or install work equipment without having, and understanding, the manufacturer's instructions for safe installation and/or use.

Before installation, it should be confirmed that the manufacturer's instructions essential for safe installation and use are available in paper format.

4.4.3 Use of tools

Acceptable standards for welding, brazing, the use of hand tools and portable machinery should be specified by the responsible engineer. It is essential that the practices adopted comply with the site requirements.

Installation personnel are responsible for the care, regular examination and arranging replacement (when necessary) of tools and equipment.

In areas where there might be a risk of fire or the presence of flammable material, installations should be carried out using only approved non-sparking tools used in accordance with permit-to-work procedures (see 4.3).

Unattended tools should be left in a safe condition.

4.4.4 Electrical safety

COMMENTARY ON 4.4.4

The Electrical Equipment (Safety) Regulations 1994 [16] apply to electrical equipment placed on the market that is designed or adapted for use between certain voltage limits, and cover all risks, electrical and mechanical, to the safety of persons, domestic animals and property. Guidance is given in A.1.4.

Electrical equipment should conform to the relevant product standard. Examples include the following.

- Process instrumentation, test and measuring instruments and laboratory instruments should conform to BS EN 61010.
- Information technology equipment should conform to BS EN 60950.
- Electrical, thermal and energy safety of adjustable speed electrical power drive systems should conform to BS EN 61800-5-1.
- Programmable controllers should conform to BS EN 61131-2.

Where equipment is to be used in relation to functional safety in a safety-related system, the requirements of BS EN 61508 and BS EN 61511 should be followed where appropriate, and instrument personnel should be competent to install and commission the equipment.

4.4.5 Safety of machinery

COMMENTARY ON 4.4.5

Machinery is subject to the Supply of Machinery (Safety) Regulations 1992 [17], as amended (see Table A.1). Guidance is given in A.1.5.

Machinery supplied prior to the introduction of the Supply of Machinery (Safety) Regulations 1992 [17] should be used in accordance with the guidance given in PD 5304, which lists standards that can be used for demonstration of compliance with the Regulations.

Electrical equipment of machines should conform to BS EN 60204-1 in respect of general aspects of electrical safety. BS EN 60204-1 applies to electrical, electronic and programmable electronic equipment and systems of machines not portable by hand while working, including a group of machines working together in a coordinated manner.

Where machinery is to be used in relation to functional safety in a safety-related electrical, electronic or programmable electronic control system, the requirements of BS EN 62061 should be followed where appropriate, and instrument personnel should be competent to install and commission the equipment.

NOTE Although concerned with machinery safety, BS EN 614-1 provides useful guidance on ergonomic design of all work systems, including instrument systems, throughout their life cycle.

The installation design should take account of the ergonomic principles given in BS EN 614-1 for the safety of machinery throughout its life cycle.

4.4.6 Safety of pressure equipment

COMMENTARY ON 4.4.6

This subclause only addresses equipment covered by the Pressure Equipment Regulations 1999 [18], as amended (see Table A.1). The Regulations do not apply to the assembly of pressure equipment on site(s) under the responsibility of the user, as in the case of industrial installations, or to pipelines outside an industrial installation: see 4.13 and 4.16. Guidance is given in A.1.6.

Pressure equipment conforming to the Pressure Equipment Regulations 1999 (as amended) is not subject to further pressure regulations during installation on site. However, ongoing use is subject to other regulations and in-service inspection.

Instrument personnel should ensure that the appropriate documentation for the instruments used on the pressure equipment is available before the equipment is put into use.

This documentation should be included in the documentation for the safe installation and use of the pressure equipment/assembly. It should include information showing conformity of pressure accessories, safety accessories and instruments that have been used in the equipment/assembly but have not been placed on the market as pressure or safety accessories. Where such accessories/instruments have not been placed on the market as pressure or safety accessories, the information provided should include the material requirements for pressure-bearing faces, including for flanges and thermowells, and the material manufacturer's certificate.

4.4.7 Hazardous area equipment

COMMENTARY ON 4.4.7

Hazardous area equipment includes electrical and mechanical equipment, protective systems, safety devices, components and their combinations, which, separately or jointly, are intended for the generation, transfer, storage, measurement, control and conversion of energy and/or the processing of material and which are capable of causing an explosion in a potentially explosive atmosphere through their own sources of ignition. All such equipment is subject to the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 (ATEX Regulations) [19], as amended (see Table A.1). Guidance is given in A.1.7.

Instrument personnel should not work on hazardous area equipment, inside or outside the hazardous area, unless they are competent to do so and, where relevant, are authorized under a permit-to-work system (see 4.3).

4.4.8 Radio equipment and telecommunications terminal equipment (RTTE)

COMMENTARY ON 4.4.8

RTTE is subject to the Radio Equipment and Telecommunications Terminal Equipment Regulations 2000 [20], as amended (see Table A.1). Guidance is given in A.1.8. Attention is also drawn to the Electromagnetic Compatibility Regulations 2006 (EMC Regulations) [21].

The RTTE Regulations are intended to ensure the protection of the health and safety of the user and any other person, including the objectives with respect to safety requirements contained in Council Directive 73/23/EEC [2006/95/EC] [22, 23] but as if there were no voltage limit.

NOTE RTTE can be stand-alone or incorporated into IT equipment or process equipment and instrumentation.

Before radio equipment is installed, the user instructions should be checked to ensure that the equipment is suitable for connection to the public telecommunications network or to be used in the specific radio environment.

4.5 Personal protective equipment

COMMENTARY ON 4.5

Personal protective equipment (PPE) is defined as all equipment designed to be worn or held to protect against one or more risks to health and safety at work. Included are hard hats, safety footwear, life-jackets, eye and hearing protection, high visibility clothing and adverse weather (sufficient to cause a risk to health and safety) clothing, but not ordinary working clothes and uniforms, PPE for road transport or portable devices for detecting or signalling risks and nuisances. Also included is PPE intended for use in potentially explosive atmospheres, which has to be designed and manufactured so that it cannot be the source of an electric, electrostatic or impact-induced arc or spark likely to cause an explosive mixture to ignite.

Instrument personnel should wear PPE in accordance with site safety instructions. They should ensure that it is suitable for their use and not faulty before commencing work. If it is damaged while they are working, such that it no longer provides the intended protection, they should withdraw from the hazardous work area before reporting it to their employer.

PPE procured before the current Regulations can still be used, but employers should only allow such PPE to be used if they have retained evidence pertaining to its procurement.

Employees are required by the Personal Protective Equipment at Work Regulations 1992 [24], as amended (see Table A.1), to make full and proper use of PPE provided to them by their employer, to report any defective PPE to their employer and to return PPE to its storage space after use. Guidance is given in A.1.9.

4.6 Lifting and handling operations

4.6.1 Manual handling

COMMENTARY ON 4.6.1
Manual handling is subject to the Manual Handling Operations Regulations 1992 [25], as amended (see Table A.1). Guidance is given in A.1.10 and in HSE publication L23 [26].

NOTE 1 *Equipment and instruments conforming to BS EN 61010-1 will be fitted with lifting and carrying handles if weighing 18 kg or more, or be supplied with lifting and carrying instructions. The IET Code of practice for in-service inspection and testing of electrical equipment [27] suggests that equipment above 18 kg without lifting handles is classified as fixed equipment.*

NOTE 2 *There are no specific limits for the mass of a single-person lift. Guidelines on the Regulations recommend 25 kg for men and 16 kg for women.*

Management personnel should ensure that the person(s) performing the lifting operation have been instructed in lifting techniques. Managers and supervisors should assess the risks for any equipment weighing 5 kg or more for men and 3 kg or more for women.

Instrument personnel performing lifting operations should only do so if they know the mass of the equipment, have taken into account their own physical capabilities, have been instructed in suitable lifting techniques, and, where appropriate, have the equipment manufacturer's instructions.

4.6.2 Lifting equipment

COMMENTARY ON 4.6.2
Lifting equipment is subject to the Lifting Operations and Lifting Equipment Regulations 1998 [28], as amended (see Table A.1). Guidance is given in A.1.11 and in HSE publication L113 [29].

Instrument personnel should only participate in lifting operations under the supervision of a competent person, and should ensure that equipment is lifted in accordance with the manufacturer's instructions.

NOTE *Where equipment is fitted with eyebolts, or where eyebolts can be fitted, there is a legal requirement for a manufacturer's or supplier's certificate of test to be made available.*

Before eyebolts are fitted, the installer should ensure that the manufacturer's test certificate is available (see Note). Particular care should be taken to ensure that eyebolts are not overtightened or screwed into holes with a different thread form. Eyebolts should conform to BS 4278.

4.7 Working at height

COMMENTARY ON 4.7

Working at height is subject to the Work at Height Regulations 2005 [30] and related legislation (see Table A.1). Guidance is given in A.1.12 and in HSE publication INDG401 [31].

NOTE 1 *Where work at height is required, all employers, self-employed and persons controlling work at height of others are required to ensure that the work is properly planned and supervised, those working at height are competent, work equipment is selected and used that is appropriate to the work, risks from fragile surfaces are controlled and equipment for work at height is properly inspected and maintained.*

Work at height should be avoided wherever possible.

Instrument personnel should only work at height if they have been trained and are competent to do so. Before working at height, personnel should ensure that any equipment to be used has been inspected and is safe to use.

Ladders should only be used where work at height is for a short period of time.

NOTE 2 Under the provisions of the Work at Height

Regulations 2005 [30], personnel are not allowed to use equipment for work at height unless they have confirmed that it has been inspected. They are required to report any defect or activity relating to work at height that they know is likely to endanger the safety of them or others. They are also required to use the equipment in accordance with the instructions provided by their employer.

4.8 Safe access and egress

COMMENTARY ON 4.8

Employers have a legal duty under the Workplace (Health, Safety and Welfare) Regulations 1992 [3], as amended (see Table A.1), to ensure suitable and sufficient access to and egress from workplaces and health/welfare facilities and, so far as is reasonable, to keep them free of obstructions that could cause a risk to health or safety. Safe access and egress are required to be provided for all persons likely to be in the workplace or health/welfare facilities, including persons with disabilities. Guidance is given in A.1.13.

Instrument personnel should take care not to block access/egress routes when installing equipment and cables. Floor sections removed to give access to underfloor cable rooms should be surrounded by protective barriers to prevent falls.

Where obstructions are unavoidable, suitable instructions should be given to personnel, and clearly visible warning notices should be placed at or near the obstruction (see also 4.9).

For work at height, additional precautions should be taken (see 4.7).

4.9 Safety signs and signals

COMMENTARY ON 4.9

Where the risk assessment made under the Management of Health and Safety at Work Regulations 1999 [2] (see 4.1) indicates risks that cannot be avoided or adequately controlled in other ways, employers have a duty under the Health and Safety (Safety Signs and Signals) Regulations 1996 [32] to provide or use safety signs and signals, including fire safety signs. Management personnel also have a duty to ensure that employees receive adequate training in the meaning of safety signs and signals and the measures to be taken in connection with them. Guidance is given in A.1.14.

Where verbal signals are used, either direct, by human voice, or indirect, by broadcast, management personnel have to ensure that the persons involved have a sufficiently good knowledge of the language used and that the verbal skills of hearers is sufficient to ensure reliable communication. Acoustic evacuation signals have to be continuous.

NOTE 1 Attention is drawn to HSE publications INGD184 [33] and L64 [34].

Fire safety signs should conform to BS 5499-1. Fire alarms should conform to BS 5839-1.

NOTE 2 Rotary or hand bells are also acceptable types of alarm.

Instrument personnel should not work in any area where there is a safety sign they do not know the meaning of, and should adhere to site safety instructions when working in an area covered by a safety sign.

4.10 Materials, dust and escaping fumes, gases and process fluids giving rise to fire, asphyxiation, toxic or explosion hazard

COMMENTARY ON 4.10

A potentially explosive atmosphere is an atmosphere that could become explosive under local and operational conditions and is a mixture with air, under atmospheric conditions, of flammable substances in the form of gases, vapours, mists or dusts in which, after ignition has occurred, combustion spreads to the entire unburned mixture.

Personnel should not work in or enter places where there are dangerous substances or explosive hazards identified by warning signs or in site safety instructions unless they have been suitably trained and instructed. They should adhere to the site safety instructions and work control procedures, and should report any defect in them to their employer.

Care should be taken by all personnel to avoid the escape of hazardous substances and preparations from the plant. Particular care should be taken where such escapes are not detectable by smell or where the sensory nerves in the nose can be desensitized by gradually increasing concentrations.

Dangerous substances and preparation are those that:

- *can cause fires and explosions or other energetic events such as runaway exothermic reactions or decompositions of unstable substances;*
- *can result in burns, blast injuries or asphyxiation;*
- *are a material, biological agent or dust (above certain concentrations) with the potential to cause harm to the health of a person.*

Such atmospheres and substances are subject to the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) [35]. Guidance is given in A.1.15.

NOTE 1 See also 4.12, 4.15 and Clause 5.

4.11 Physical agents

4.11.1 Mechanical vibration

COMMENTARY ON 4.11.1
Attention is drawn to the Control of Vibration at Work Regulations 2005 [36]. Guidance is given in A.1.16.

NOTE *There is hand-arm vibration arising from the use of power tools, which is most likely to affect instrument personnel, if at all, and whole body vibration, which will affect people travelling in vehicles, particularly over rough terrain, such as in mines and quarries and on construction sites.*

All personnel entering workplaces where there are dangerous substances should be made aware of the fire risks created by enriched oxygen atmospheres and oxidizing agents, including the likelihood of an increase in the flammability of clothing and the possibility that the hazard will persist for a time.

All personnel should be informed of the site safety emergency evacuation procedures, including the location of fire alarms and the method of initiating them, the operation of fire-fighting equipment, the position of escape routes and the reporting arrangements.

Management should ensure that site safety instructions include requirements to protect against risks arising from exposure to mechanical vibration, such that regulatory exposure limits are not exceeded, and to identify when action value limits are exceeded, necessitating implementation of exposure reduction measures.

Management should ensure that all persons likely to be exposed to mechanical vibration in the workplace are provided with adequate information and training.

Instrument personnel should be aware of the risks from mechanical vibration and should comply with site safety rules for protection of their health.

4.11.2 Noise

COMMENTARY ON 4.11.2
Attention is drawn to the Control of Noise at Work Regulations 2005 [37]. Guidance is given in A.1.17.

Noise can be a significant health risk at work.

Management should ensure that site safety instructions include requirements to monitor and control noise.

Management should have procedures in place to ensure that ear protectors are used when needed, and to inform and train personnel before they work in noisy areas.

As far as reasonably practicable, control of noise should take place at the design stage, through selection of equipment and layout of the plant and control room. Installation of instruments in noisy locations should be avoided if they are intended to be monitored frequently.

Instrument supervisors should ensure that instrument personnel only install instruments in noisy areas under strict control. Ideally, noisy plant and equipment should be switched off for installation of instruments.

4.11.3 Electromagnetic fields

COMMENTARY ON 4.11.3

There is at present no UK legislation specific to electromagnetic fields. Control is exercised through the general duties in the Health and Safety at Work etc. Act 1974 [1], the Management of Health and Safety at Work Regulations 1999 [2] (see A.1), and by reference to ICNIRP guidelines. A European Directive, 2004/40/EC [38], was to be implemented in national regulations by 30 April 2008, but has been deferred until 30 April 2012.

NOTE Attention is drawn to NRPB Document Volume 15, No.2 [39]. The NRPB is now incorporated in the Health Protection Agency Radiation Protection Division (HPA RPD).

Management should ensure that site safety instructions contain procedures for the measurement of electromagnetic fields to ensure that guidance limits for the protection of workers from their short-term affects are not exceeded.

Instrument personnel are likely to work with or near equipment that has been identified as of particular concern. This can include electricity generating equipment, resistance welders, magnetic tape erasers, crack detection equipment, induction dielectric heater, plasma etchers, RF sputtering units, RFID systems, electronic surveillance equipment and broadcast/telecommunications equipment. Controls should be in place for working with or near such equipment.

4.11.4 Optical radiation

COMMENTARY ON 4.11.4

At present there are no specific legislative requirements for protection from optical radiation. This is covered by the general duties to assess risks in the Health and Safety at Work etc. Act 1974 [1] and the Management of Health and Safety at Work Regulations 1999 [2] (see A.1.1).

4.11.4.1 General

Management personnel should ensure that procedures are in place to control the exposure of workers to all types of optical radiation (artificial and natural). Optical radiation covers the ultraviolet, visible and infrared wavelengths, i.e. between 100 nm and 1 nm.

4.11.4.2 Artificial optical radiation

NOTE 1 New regulations will be put in place for artificial optical radiation, to become effective from 27 April 2010. These are expected to be based on ICNIRP guidelines and to give exposure limit values that are designed to prevent adverse health effects, mainly to the skin and eyes, which are most at risk from optical radiation. They are expected to place duties on employers to assess and control exposure, reduce risk, provide information and training and make provisions on health surveillance for laser and broadband (non-coherent) sources of artificial optical radiation.

For protection from exposure to artificial optical radiation, the ICNIRP guidelines should be followed. Artificial optical radiation can be coherent (lasers) or non-coherent.

Where class 3A, class 3B or class 4 lasers are in use, a permit-to-work system should be employed (see Note 2 and 4.3).

NOTE 2 Where such lasers are in use, there is a legal requirement to appoint a laser safety officer.

Laser equipment should conform to the classifications specified in BS EN 60825 and should be used in accordance with BS EN 60825 and PD IEC/TR 60825-14.

Free space optical communication systems used for the transmission of information should conform to BS EN 60825-12.

Optical fibre communication systems should conform to BS EN 60825-2.

Instrument personnel should be aware of the risks from optical radiation and should not commence work unless they have the appropriate documentation for the equipment, including the manufacturer's instructions for use. The documentation for laser-related equipment

should as a minimum conform to the requirements specified in BS EN ISO 11252.

Instrument personnel should only work on laser equipment if they wear suitable eye protection. Laser eye protectors for adjustment work on lasers and laser systems should conform to BS EN 207.

4.11.4.3 Natural optical radiation

NOTE Attention is drawn to HSE publications INDG337 [40] and INDG147 [41].

Instrument personnel working outside should take particular care to ensure they have adequate protection against ultraviolet radiation, e.g. by wearing appropriate personal protective equipment (see 4.5).

4.12 Work in confined spaces

COMMENTARY ON 4.12

Where there is a risk of death or serious injury from hazardous substances or dangerous conditions (e.g. lack of oxygen) the Confined Spaces Regulations 1997 [42] apply. Examples of confined spaces are storage tanks, silos, reaction vessels, enclosed drains, sewers; open-topped chambers, vats, combustion chambers in furnaces etc.; ductwork and unventilated or poorly ventilated rooms. Guidance is given in A.1.18.

NOTE Attention is drawn to HSE publications L101 [43] and INDG258 [44].

Employers are required to avoid the need for anyone to work in confined spaces wherever practicable. However, instrument personnel are likely to work in confined places, such as plant, instrument cubicles, ducts, unvented or poorly vented rooms, behind wall panels and in areas where there are gas-flooding fire extinguishing systems. Site safety instructions should therefore include requirements for working in confined spaces where there are risks from oxygen deficiency, poisonous gases fumes or vapours, dangerous substances, high dust concentrations or hot conditions. A permit-to-work system should be employed where there are such risks (see 4.3).

It should be ensured that there is a sufficient supply of fresh air before any person enters a confined space, e.g. by securing doors in the open position or removing them completely, removing duct coverings, or removing panelling. Forced ventilation should be installed where necessary.

Where there is a risk from toxic or flammable vapours, the atmosphere in the confined space should be tested immediately before entry into it, using a correctly calibrated gas detector. Where there is likely to be a change in the atmosphere, continuous monitoring should be employed.

Non-sparking tools and specially protected lighting are essential where flammable or potentially explosive atmospheres are likely.

Work involving welding, brazing or the use of solvents and glues should be avoided in confined spaces. Where this is not possible, work should be closely supervised, time restricted, and a permit-to-work system employed.

In all confined spaces where the air quality cannot be guaranteed, breathing apparatus should be worn.

No person should enter or work in a confined space unless there is a person outside within sight and sound. Persons working in confined spaces and those outside monitoring the work should be adequately instructed in all relevant emergency procedures.

4.13 Pressure equipment

COMMENTARY ON 4.13
Attention is drawn to the Pressure Systems Safety Regulations 2000 [45]. Guidance is given in A.1.19. See also the Pressure Equipment Regulations 1999 [18], as amended (see Table A.1), in 4.6, 4.4.6 and A.1.6.

NOTE 1 *Attention is drawn to HSE publication L122 [46].*

NOTE 2 *Pressure equipment and assemblies meeting the requirements of the Pressure Equipment Regulations 1999 [18], as amended (see Table A.1), can be installed without any additional assessment.*

Instrument personnel should only work on pressure equipment under the supervision of a competent person. A permit-to-work system should be employed (see 4.3).

Measuring and control instruments and systems and protective devices should only be installed if they are fit for purpose with respect to safety. They should be installed in accordance with the manufacturer's instructions for safe installation and use.

Materials for pressure-bearing faces of instrumentation should be suitable for the intended use. It is recommended that a log be kept of the material manufacturer's certificates, which should be obtained from the instrument/pressure equipment, system or assembly manufacturers.

Pressure equipment should be provided with suitable measuring or indicating devices to give clear indications of relevant critical conditions, such as temperatures, pressures and liquid levels, and their display should be clearly visible. Pressure-relieving devices should have an adequate discharge capacity in order to limit pressure to within safe operating limits and, where appropriate, should be able to deal with the dynamic flow characteristics of those fluids which result in two phase flow conditions. Gauge glasses, e.g. on tubular water level gauges, should be effectively protected to prevent injury from the glass breaking and the contents being ejected.

Where high and/or low fluid levels could lead to unsafe conditions, such as in water boilers, suitable fluid level indicators and alarms should be fitted directly to the plant equipment.

Where the safety of pressure equipment and systems is controlled by safety instrumented systems, these systems should conform to BS EN 61511.

Where installation work necessitates breaking into process or impulse lines which are, or have been, in operation, care should be taken to reduce any risks that could arise from the escape of dangerous substances or fluids under pressure, e.g. compressed air, natural and other gases, steam, oxygen, water and chemicals. Such lines should be fully isolated from the remainder of the system and made safe for work by removing the contents by draining, venting and purging, where necessary. Isolation should be achieved by the use of isolating valves, manually secured in the closed position, while valves used for draining and venting should be secured in the open position. Control valves should not be used for these purposes and it should be noted that single valve isolation cannot be relied upon. In such situations, two isolating valves are normally provided for this purpose, but where this is not the case it might be necessary to fit an isolation spade in the line. The latter is particularly recommended if the isolation is applied over an extended period of time.

Hydraulic pressure testing of impulse lines should be done with liquids compatible with the process fluid and should not contaminate the interior of the impulse lines. Testing should only be carried out after disconnection of all instruments that might be damaged by the test pressure.

4.14 Work on or with electrical systems and equipment

COMMENTARY ON 4.14
Electrical installations in all workplaces are subject to the Electricity at Work Regulations 1989 [47]. The Regulations cover all electrical systems and equipment used, intended to be used or installed for use, to generate, provide, transmit, transform, rectify, convert, conduct, distribute, control, store, measure or use electrical energy. Guidance is given in A.1.20 and in HSE Guidance Note GS38 [48].

All work equipment, including fixed, portable or transportable instruments and equipment connected to a source of electrical energy, is also covered by the Provision and Use of Work Equipment Regulations 1998 [13], as amended (see 4.4, A.1.3 and Table A.1).

Instrument personnel should only work on electrical systems or connect instruments and equipment to the site electrical installation if they are competent to do so or are adequately supervised by a competent person.

No person should work on live electrical systems unless it is impracticable to do otherwise. Work on live electrical systems requires special tools, and only those tools should be used. A permit-to-work system should be employed for live working on electrical systems (see 4.3).

NOTE *In hazardous areas, live working is not permitted except on intrinsically safe equipment.*

Wherever possible all equipment should be isolated from its electrical supply before any work commences. Procedures should be in place to ensure that the supply cannot be reconnected whilst work is in progress. Appropriate and known working voltage detectors should be used to confirm that the voltage has been disconnected before work commences. Isolation procedures should conform to the guidance in BS 6423.

4.15 Potentially explosive atmospheres

COMMENTARY ON 4.15
The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) [35] require workplaces to be assessed for areas where there are potentially explosive atmospheres. Areas where explosive atmospheres might occur have to be classified into zones and have to be protected from sources of ignition by suitable equipment and protective systems. Where necessary, hazardous areas have to be marked with the "EX" sign at the point of entry. Guidance is given in A.1.15 and in HSE publications L134 [49], L135 [50], L136 [51] and L138 [52].

NOTE See also 4.4.7 and 4.10.

Explosion prevention and detection measures should be implemented in accordance with BS EN 1127-1. Equipment for use in hazardous areas should conform to BS EN 60079-10.

Instrument personnel should be made aware of the hazardous areas on the site before starting work and should not work in them unless they are competent to do so, have all necessary PPE (see 4.5) and have been instructed in the emergency warning and evacuation procedures.

4.16 Ionizing radiation and radioactive substances

4.16.1 General

NOTE *Instrument personnel working in radioactive controlled or supervised areas are required to be classified.*

Site safety instructions should include requirements for working with or near apparatus generating hazardous levels of ionizing radiation or containing hazardous levels of radioactive substances, and, where appropriate, their safe storage. Instrument personnel working in radioactive controlled or supervised areas should ensure that they use the supplied PPE (see 4.5), particularly dose rate monitors, and that they maintain records and log books accurately.

All persons involved should be instructed on the hazards and the handling of equipment and instruments generating hazardous levels of ionizing radiation or containing radioactive substances.

No work should commence on or near equipment generating hazardous levels of ionizing radiation or containing radioactive substances without following the manufacturer's detailed instructions for safe handling, installation and use. It is recommended that control procedures be in place for storage of manufacturers' instructions. Particular care should be taken to control the storage of instructions provided in electronic format.

4.16.2 Ionizing radiations

COMMENTARY ON 4.16.2

Attention is drawn to the Ionising Radiations Regulations 1999 [53].

Equipment generating ionizing radiations that might be encountered by instrument personnel that require authorization/generic authorization by the Regulator for use include:

- *X-ray sets intended for industrial radiography, e.g. for non-destructive testing of welds and joints;*
- *X-ray sets for processing of products that include some physical, chemical or biological change in the material being processed;*
- *accelerometers (other than electron microscopes) emitting ionizing radiation with an energy higher than 1 MeV, including those used for industrial purposes and non-destructive testing.*

Where it is planned to use this equipment, employers are required to appoint a radiation protection supervisor (RPS).

NOTE *X-ray gauging and detection systems in measurement processes do not require any authorization.*

Personnel should only work on or near ionizing radiation equipment when under the control of the RPS.

4.16.3 Radioactive substances

COMMENTARY ON 4.16.3

Keeping and using radioactive materials and mobile radioactive apparatus, and accumulation and disposal of radioactive waste, has to be registered with the appropriate Regulator, with some exceptions. Radiation substances are not subject to registration if they do not exceed a specified quantity or concentration per unit mass, or where they are HSE type approved apparatus or constructed in the form of a sealed source and do not cause a dose rate of more than $1 \mu\text{Svh}^{-1}$ at a distance of 0.1 m from any accessible surface under normal operating conditions, and where conditions for disposal have been agreed by the Regulator. Registered radioactive material and apparatus are required to be protected against accidental damage or loss under the control of the supervisor. Instrument personnel are required to report to the supervisor any loss or damage to radioactive material or apparatus.

NOTE 1 This subclause does not cover license holders for nuclear installations.

NOTE 2 Where it is planned to use radioactive substances emitting ionizing radiation, employers are required to appoint a radiation protection supervisor (RPS).

Instrument personnel should adhere to the control procedures and should only work with or near radioactive substances emitting ionizing radiation when under the supervision of the RPS. Sealed source apparatus is the type most likely to be encountered by instrument personnel, who should not handle, use or install such apparatus without following the manufacturer's detailed instructions.

It is recommended that:

- a) radioactive sources securely attached to machines or other fixed equipment are checked once a month and after maintenance or repair that could have affected the source;
- b) portable radioactive sources are checked daily.

Records should be kept of all checks.

4.17 Working with display screens

COMMENTARY ON 4.17

Workstations involving display screen equipment are required to be ergonomically designed if regularly used. Particular care needs to be taken in control rooms for workstations that have multiple screens. Regular use of display screens is considered to be more than 1 h per day or 5 h per week.

Attention is drawn to the Health and Safety (Display Screen Equipment) Regulations 1992 [54], as amended (see Table A.1). Guidance is given in A.1.21.

The design, layout, dimensioning, environmental requirements and evaluation of control centres should be carried out in accordance with BS EN ISO 11064, which also gives principles for the arrangement of control suites and layout of control rooms. The ergonomic principles for work with display screens based on flat panels should follow the requirements specified in BS EN ISO 13406.

Work with display screens by instrument personnel is likely to be for long periods, especially during commissioning. Work should be planned to take breaks or change activity. It is recommended that breaks should be taken for 5 min to 10 min in every hour.

Personnel who consider they are having vision problems due to work with display screens should report it to their employer and request an eyesight test.

NOTE 1 This subclause does not cover office work with display screens.

NOTE 2 Employers are required to provide sight tests where problems arise as a result of working with display screens.

COMMENTARY ON 4.18

The Construction (Design and Management) Regulations 2007 [55] apply to temporary and mobile construction sites. They concern occupational health, safety and welfare in construction, and place duties in relation to management arrangements and practical measures on a range of construction project participants, including clients, designers and contractors. They apply to all temporary and mobile construction sites, but give additional requirements where a project is notifiable, including the duty of the client to appoint a CDM coordinator and a principal contractor. Guidance is given in A.1.22.

NOTE Attention is drawn to HSE publication L144 [56].

4.18 Work on construction sites

Where installation of instrumentation is on a construction site, instrumentation managers and supervisors should ensure that they are fully familiar with the health and safety plan of the principal contractor before any installation work commences. They should raise any concerns they have about the plan with the principal contractor and ensure that these are adequately addressed before any installation work commences.

Instrumentation managers and supervisors should ensure that all personnel under their control have been adequately instructed on the site health and safety plan and have the appropriate PPE (see 4.5) before entering the site and starting work.

Instrument personnel working on a construction site should adhere to the safety rules, wear the supplied PPE, and report any risk to health and safety that they identify and any faulty PPE.

5 Instrumentation in hazardous areas

COMMENTARY ON CLAUSE 5

This clause covers the installation of electrical and non-electrical instrumentation in areas that are defined as being hazardous due to the presence of flammable gases, vapours, mist and/or dusts or of the likelihood of them occurring in both onshore and offshore installations.

NOTE 1 The precautions necessary for personnel safety are given in 4.4.7.

NOTE 2 Requirements for electrical installations on mobile and fixed offshore units are given in BS IEC 61892-7.

NOTE 3 Terms and definitions for equipment and protective systems intended for use in potentially explosive atmospheres are given in BS EN 13237.

5.1 Classification of hazardous areas and selection of instrumentation

NOTE 1 Attention is drawn to the legal requirement under DSEAR [35] to classify all areas where potentially explosive atmospheres can occur, and to install and use only suitable instrumentation. See 4.15 and A.1.15.

Before starting work in an installation, the risk assessment identifying and classifying any hazardous areas should be available (see BS EN 60079-10 for classification of hazardous areas) and it should be confirmed that controls are in place to ensure compliance with regulatory requirements. The controls should prevent equipment being taken into a classified hazardous area if it is not correctly certified and/or marked for the zone and the nature of the hazard (simple apparatus does not have to be marked), unless:

- a) there has been a specific risk assessment for the equipment included in the site risk assessment; or

NOTE 2 This option is not preferred and should only be considered where there is no suitable certified and/or marked equipment available. Close cooperation is needed between the manufacturer, installer and person responsible for the installation's risk assessment.

- b) the area has been certified as free of an explosive atmosphere.

The use of steel tools might cause an unacceptable risk of ignition due to incendive sparking in Zones 1, 2, 21 and 22. However, tools should only be taken into a hazardous area by personnel having knowledge of the risk associated with incendive sparking.

Extremely small apparatus and Ex components might not be marked. Where this is the case, it should be confirmed that the manufacturer has provided documentation with the apparatus or component having the markings.

Portable, transportable and hand-held equipment should only be used in areas appropriate to the type of protection. Where there is a risk of such equipment being inadvertently taken into a hazardous area with a higher classification, the equipment should be suitable for the highest classification where it can be taken.

Some tools and equipment can become electrostatically charged. Precautions for avoiding electrostatic hazards in explosive atmospheres should be taken in accordance with PD CLC/TR 50404.

Appropriate clothing and footwear should be worn when in a hazardous area not certified as free of an explosive atmosphere (see also 4.5).

Before installation begins in a classified hazardous area, it should be confirmed that the equipment manufacturer's declaration of conformity and instructions for the safe assembly, installation, commissioning, taking into service, operation, maintenance and decommissioning/dismantling are available.

All warnings on equipment should be noted and procedures put in place to ensure that they are adhered to, since they take precedence over any other instructions.

Surface applications at mines and quarries should be subject to the same risk assessment as used in other industries, and the same forms of protection should be used as for any other non-underground applications. For example, a gas-fired power generation plant installed on the surface of a mine would have a control system designed in the same manner as that of a non-mining application fired with landfill or natural gas.

NOTE 3 Mining and quarrying applications, particularly underground, are subject to statutory regulation and approval. Attention is drawn to mines and quarries legislation in respect of the installation of instrumentation and monitoring equipment. This requires all such equipment and installation to conform to BS EN 60079-1 specifically for group 1 gases.

5.2 Electrical apparatus

NOTE 1 Non-hazardous area aspects of electrical/electronic instrument safety are covered in the relevant product standard (see 4.4.4).

NOTE 2 The BS EN 50000 series (i.e. BS EN 50014 to BS EN 50021) is gradually being replaced by the BS EN 60079 series. The appropriate standards to use need to be confirmed before commencing work.

NOTE 3 Equipment that was placed on the market before the mandatory date of the ATEX Regulations [19] can still be put into use provided that a risk assessment has been carried out and it is safe in accordance with the requirements of PUWER (see 4.4).

NOTE 4 Attention is drawn to DSEAR [35] (see A.1.15), which generally requires that only electrical equipment having the European Epsilon-x mark (ATEX) can be installed and put into use in a hazardous area. Equipment with only other marks, such as IECEx (the IEC hazardous area certification scheme), cannot usually be installed and put into use in a hazardous area, even if it conforms to the same standard.

NOTE 5 There is a form of protection Ex s, special equipment, for which there is no standard. The manufacturer and certification body have to ensure that the apparatus is safe for use in the intended hazardous area. If such equipment is to be used there should be close cooperation between the manufacturer, installer and person responsible for the installation's risk assessment.

NOTE 6 The requirements in the BS EN 61241 series will eventually be incorporated into the BS EN 60079 series.

NOTE 7 PD CLC/TR 50427 gives guidance on power thresholds of RF impinging on hazardous area structures, that can act as antennas, from outside the hazardous area.

The selection, installation, testing and inspection of electrical apparatus in hazardous areas should be carried out in accordance with:

- a) BS EN 60079-14 and BS EN 60079-17 for gases and vapours;
- b) BS EN 61241-14 and BS EN 61241-17 for dust.

Electrical apparatus intended for use in hazardous areas should conform to the relevant standard, i.e. BS EN 60079 series for explosive gas atmospheres and BS EN 61241 series for explosive dust atmospheres and combustible dust layers.

- 1) Equipment suitable for use in Zone 0 is Ex ia and Ex MA and Zone 20 is Ex tD, Ex iaD and Ex maD. The use of dual protected equipment in accordance with BS EN 60079-26 is permitted in Zone 0.
- 2) Equipment suitable for use in Zone 1 is any equipment suitable for use in Zone 0 and Ex d, Ex p, Ex q, Ex o, Ex e, Ex ib and Ex mb, and in Zone 21 is any equipment suitable for use in Zone 20 and Ex tD, Ex PD, Ex ibD and Ex mbD.
- 3) Equipment suitable for use in Zone 2 is any equipment suitable for use in Zones 0 and 1 and Ex nA, Ex nL, Ex nR, Ex nC and Ex nP, and in Zone 22 is any equipment suitable for use in Zones 20 and 21 and Ex tD and Ex PD.

CAUTION. Where working in hazardous areas with installed equipment conforming to superseded standards and Regulations, care should be taken to avoid confusion with markings. Particular care should be taken if considering replacing this equipment with equipment conforming to the new standard, as it might not be compatible. Consultation with the manufacturer is recommended.

The use of electronic equipment should be controlled where there is a risk of RF emissions, intended or otherwise, affecting hazardous area equipment, either inside or outside the hazardous area, and structures in hazardous areas to the extent that the safety of the hazardous area can be compromised. Particular care should be taken to control the taking/use of personal portable electronic devices such as walkie talkies, PDAs, mobile phones, remote controls, watches, cameras and laptops/hand-held computers, into hazardous areas or near hazardous area apparatus, especially where, for safety reasons, cable screens are only terminated at one end, so that the screens can act as antennas, or near to structures in hazardous areas that can act as antennas.

5.3 Batteries, power packs and portable electrical equipment

5.3.1 General

Controls should be in place to prevent the inadvertent taking of batteries into hazardous areas, particularly spares for portable electric/electronic equipment, and to check that batteries in hazardous area apparatus are only replaced with batteries of the correct type, according to the apparatus manufacturer's instructions, and have been correctly fitted.

5.3.2 Battery replacement

NOTE The fitting of a non-recommended battery or power pack to certified equipment will invalidate the equipment's certification.

Only batteries or power packs recommended by the manufacturer for the particular model of certified instrument or equipment should be used.

All battery or power pack replacement should be undertaken in a non-hazardous area, and/or in accordance with an approved safe process.

5.4 Non-electrical equipment

COMMENTARY ON 5.4

Under the terms of the ATEX Regulations [19], non-electrical equipment placed on the market after the mandatory date can generally only be installed and used in hazardous areas if it has the European Epsilon-x mark.

Non-electrical equipment assessment requirements are as follows.

- *Category 3 equipment needs to be safe for use in normal operation. It can be self-assessed by the manufacturer, who is required to maintain a technical file.*
- *Category 2 equipment needs to be safe for use in normal operation and expected malfunction. It can be self-assessed by the manufacturer, but a technical file has to be lodged with a notified body.*
- *Category 1 equipment needs to be safe for use in normal operation, expected and rare malfunction. It has to be assessed by a notified body.*

The risk assessment should identify potential ignition sources.

Non-electrical equipment should conform to the relevant standard in the BS EN 13463 series of standards:

- a) all non-electrical equipment should meet the general requirements specified in BS EN 13463-1;
- b) equipment suitable for use in Zones 2 and 22 should meet the flow restriction (fr) requirements of BS EN 13463-2;
- c) equipment suitable for use in Zones 1 and 21 should meet the requirements of:
 - BS EN 13463-3 for flameproof (d); or
 - BS EN 13463-5 for constructional safety (c); or
 - BS EN 13463-6 for control of ignition sources (b); or
 - BS EN 13463-7 for pressurization (p); or
 - BS EN 13463-8 for liquid immersion (k).

6 Documentation

NOTE 1 Guidance on BS ISO 15489-1 is given in PD ISO/TR 15489-2. BIP 0025 also gives guidance on the practical implementation of BS ISO 15489-1 and management guidance as to its value and to the performance management of it. BS 7799-3 gives guidance and support for the implementation of BS ISO/IEC 27001, and BS 7799-1 is a code of practice for information security management. BS 25999-2 addresses business continuity management.

NOTE 2 Documentation and records management is relevant to traceability, compliance, accountability, integrity and availability of information.

NOTE 3 Information security is an essential part of documentation management. The standards cover all aspects of security for documentation, such as personnel, building access, storage, storage access, protection against the environment, equipment used and utility supplies to and protecting it, access to the equipment, mobile computing and communications and operational procedures.

NOTE 4 BS ISO/IEC 20071 specifies the requirements for establishing, implementing, operating, monitoring, reviewing, maintaining and improving a documented information security management system, so requirements can change through a project.

Before design of the installation begins, the document management system and documentation requirements should be agreed with the site owner/operator and prime contractor.

The document management system should have an audit trail and should address format, media, accessibility, security and storage, and there should be a periodically validated, documented, systematic back-up and restore procedure, disaster recovery procedure and software and documentation traceability procedure, for business continuity management. It should meet the requirements of BS ISO 15489-1 and BS ISO/IEC 27001, which gives the requirements for information security management.

Electronic documentation management systems should meet the recommendations of BIP 3081 (BIP 0008 and BIP 0009).

NOTE 4 BIP 0008 is the actual code of practice and BIP 0009 is a workbook designed to enable a historical audit trail of compliance to BIP 0008.

NOTE 5 There are a number of proprietary systems currently in use in the process industries. Manufacturers, suppliers and installation designers might be contractually obliged to provide documentation in acceptable formats for one of these. A number of standards for electronic data exchange of product data and engineering information have been or are being developed that might be suitable for use in the process industries, but have not yet been widely taken up. Published standards include BS ISO 10303, ISO 15926, BS EN 61804 and BS EN 61987-1. Various standards are being developed, including IEC 62424.

7 Process sensors and measuring devices

COMMENTARY ON CLAUSE 7

This clause deals with devices commonly used in industry for the measurement of flow, pressure, temperature, level and some mechanical functions such as speed and vibration.

The detecting element or measuring device responds directly to the physical condition, and its location needs to be carefully selected so that the reading or output obtained is truly representative of the variable to be measured.

7.1 Flow

7.1.1 General

COMMENTARY ON 7.1.1

There are many types of flow measuring device which are each appropriate for a different range of applications. Many of these devices form part of the process pipework and therefore may be installed by mechanical rather than instrument personnel.

Flowmeters often have considerable commercial importance when the price paid for a quantity of product is calculated from flowmeter readings. These metering applications require high accuracy and repeatability.

Custody transfer and fiscal meter systems employ calibrated flowmeters and often use density, temperature or pressure measurements close to the flowmeter to allow corrections to standardized set of conditions to be made. These measurements should be made so that they are representative of the whole flow. Installation of devices for these correction measurements should be in accordance with 7.1.2 to 7.1.11 as appropriate.

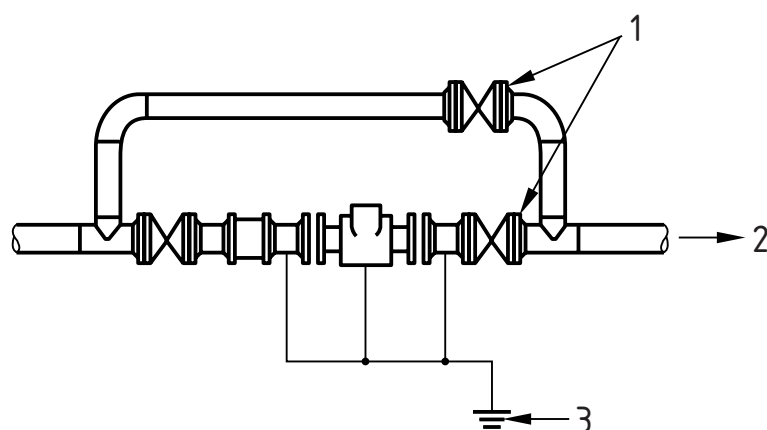
Where the flowmeter has been calibrated complete with adjacent pipe sections, the whole calibrated assembly sequence should be detailed unambiguously on the certificate. Where practicable, the entire assembly as calibrated should be delivered in one piece for installation. If the equipment needs disassembling to facilitate transport from the calibration facility, all sections of pipework, flow straightener(s) and meter, etc., should be clearly labelled such that their sequence and orientation can be replicated precisely at installation. It might also be advisable to document torque settings and tightening sequences. The level of disassembly should be minimized. All parts should be suitably protected from the environment and in a manner which protects them from any damage during transit. Failure either to deliver the parts in a controlled manner or to replicate precisely the assembly at installation might render the calibration certificate invalid.

It is essential that all flow measuring devices are installed precisely according to the design requirements and that no alteration be made without prior reference to the responsible engineer. This applies particularly to straight-pipe length requirements upstream and downstream of the device.

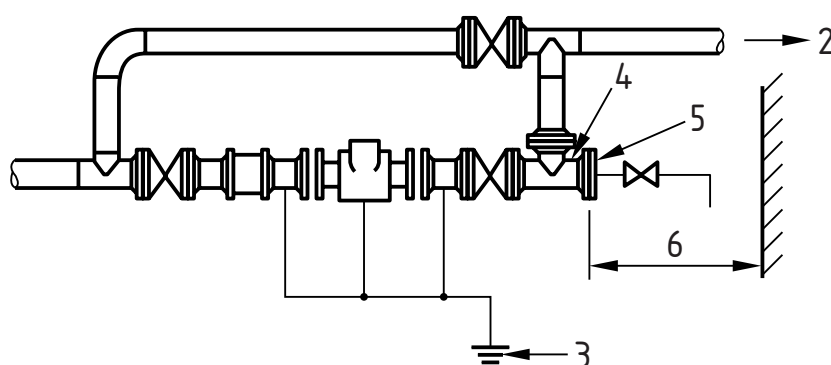
Instrument manufacturers' instructions should be retained and the specified installation procedure strictly followed in order to minimize the risk of measurement inaccuracies, instrument damage or warranty issues.

Where flow interruption for maintenance or for zero checking is not acceptable, bypass pipework may be incorporated. Examples of arrangements are shown in Figure 1. If a cleanout tee is required, the recommended arrangement is shown in Figure 1b).

Figure 1 Typical in-line flowmeter installations



a) Standard installation



b) Installation with a clean-out tee

Key

- 1 Bypass and isolating valves as specified
- 2 Flow
- 3 Piping and transducer earthed to manufacturer's instructions
- 4 Clean-out tee
- 5 Blank flange with drain valve
- 6 Access clearance

7.1.2 Differential pressure**7.1.2.1 Principle**

Flow through a primary element causes a fall in static pressure and the differential pressure so created is a function of the flow rate. This differential is measured by a differential pressure instrument which may be calibrated in flow units, or the conversion to flow units may be performed on the instrument output signal elsewhere.

7.1.2.2 Installation arrangement

7.1.2.2.1 Primary element location

To obtain the best accuracy from a differential pressure flow measurement it is important that flow disturbances are eliminated before they reach the measuring point. Selection of a measurement location preceded by a sufficient length of straight piping will minimize such disturbances. The length of straight piping depends upon the source of disturbance, such as valves, bends, tees, concentric/eccentric reducers, or changes in section upstream of the device and on the type of primary element employed. Minimum straight lengths upstream and downstream to obtain the desired accuracy and repeatability of measurement are specified in BS EN ISO 5167-2, BS EN ISO 5167-3 and BS EN ISO 5167-4, and should be incorporated in the pipework design. Where it is not practicable to accommodate straight lengths, flow conditioners or straighteners should be used (see BS EN ISO 5167-1:2003, 7.2.2 and 7.4).

7.1.2.2.2 Primary element mounting

Certain primary elements, particularly nozzles or Dall inserts, are mounted within the process pipework. To facilitate installation and removal of these inserts they should normally be located at the inlet to a short flanged pipe spool.

7.1.2.2.3 Tapping point location

Tapping points may be integral with the primary element, be part of a carrier ring or be made on the pipe itself in accordance with the design specification and BS EN ISO 5167-2 (see Figure 2, Figure 3 and Figure 4).

Figure 2 Typical tapping point location on a Venturi tube

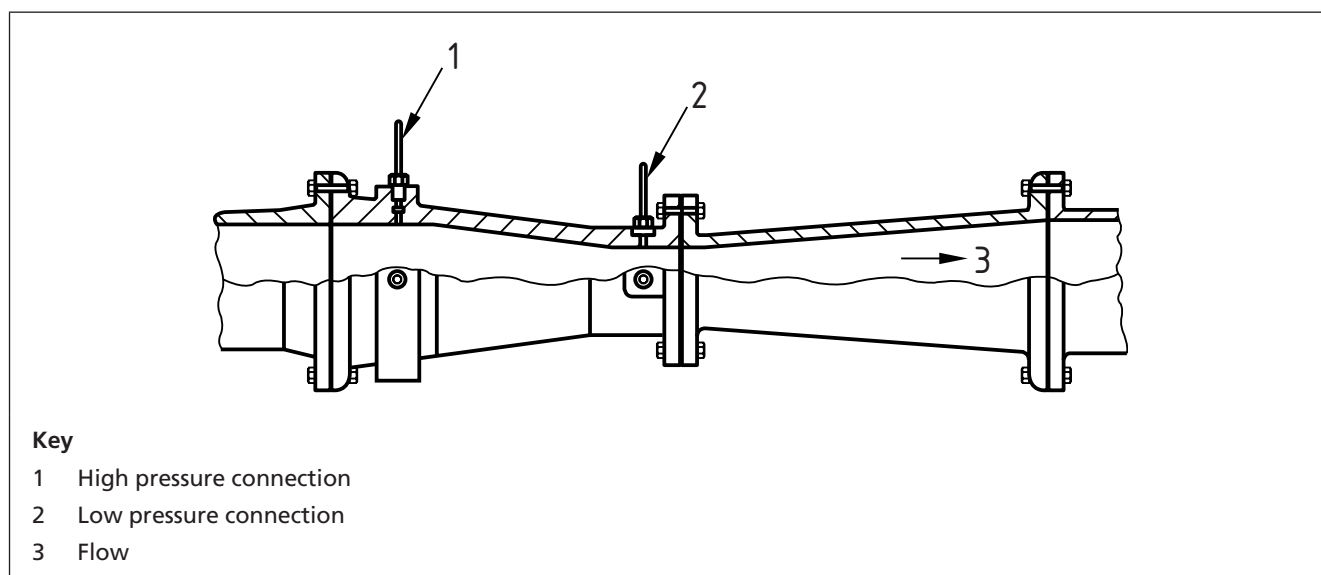
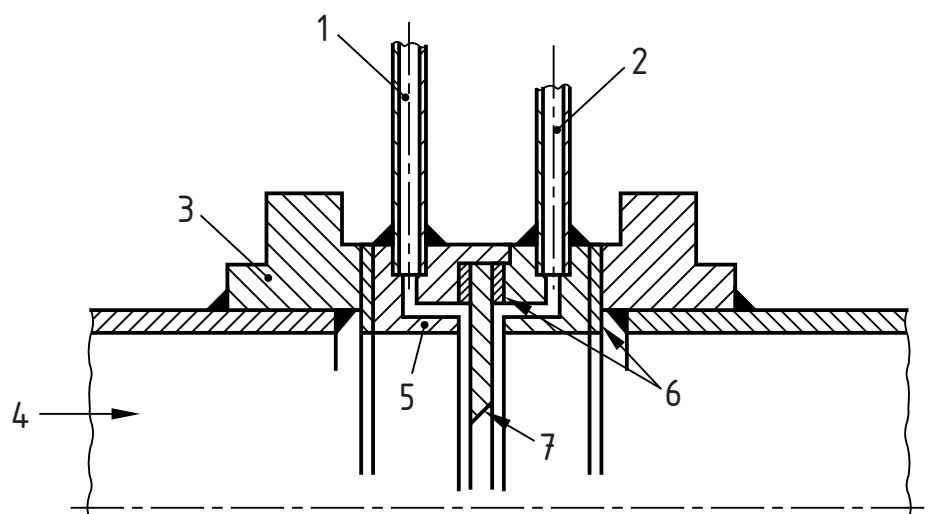
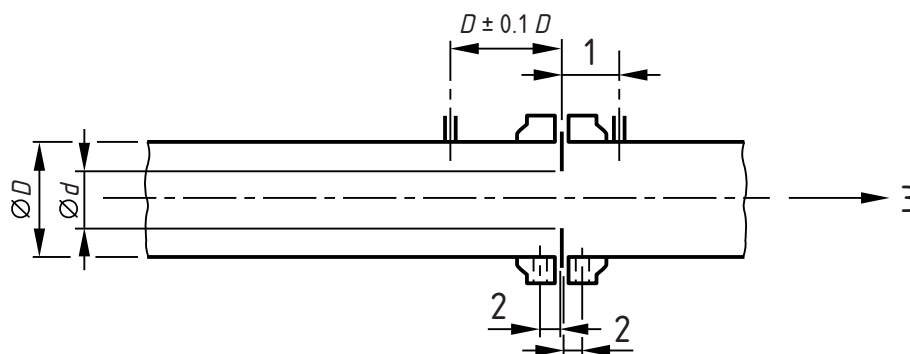


Figure 3 Typical pipe tapping point location on an orifice plate carrier ring

**Key**

- 1 High pressure connection
- 2 Low pressure connection
- 3 Pipe flange
- 4 Direction of flow
- 5 Carrier ring
- 6 Gasket or joint rings should not protrude into flow or obstruct tapping slot
- 7 Orifice plate

Figure 4 Typical tapping point locations for flange-mounted orifice plate



NOTE β is the diameter ratio, $\beta = \frac{d}{D}$

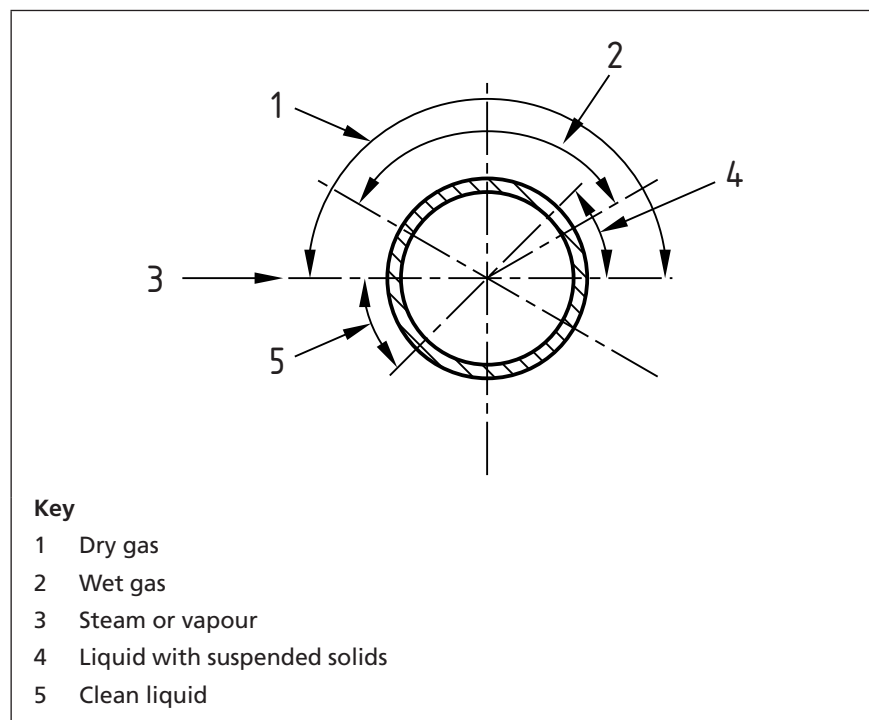
Key

- 1 Pipe tappings:
 - $0.5D \pm 0.02D$ for $\beta \leq 0.6$
 - $0.5D \pm 0.01D$ for $\beta > 0.6$
- 2 Flange tappings:
 - $(25.4 \pm 0.5) \text{ mm}$ for $\beta > 0.6$ and $58 \text{ mm} < D < 150 \text{ mm}$
 - $(25.4 \pm 1.0) \text{ mm}$ for $\beta \leq 0.6$
 - or for $\beta > 0.6$ but $50 \text{ mm} \leq D \leq 58 \text{ mm}$
 - or for $\beta > 0.6$ but $150 \text{ mm} \leq D \leq 760 \text{ mm}$
- 3 Direction of flow

7.1.2.2.4 Tapping points on horizontal or sloping pipes

The radial location of the tapping points on horizontal or sloping pipe sections should take into account the nature of the process fluid as shown in Figure 5. Other orientations are permissible but might require special arrangements for venting and draining.

Figure 5 Typical radial location for tapplings on a horizontal or sloping pipe



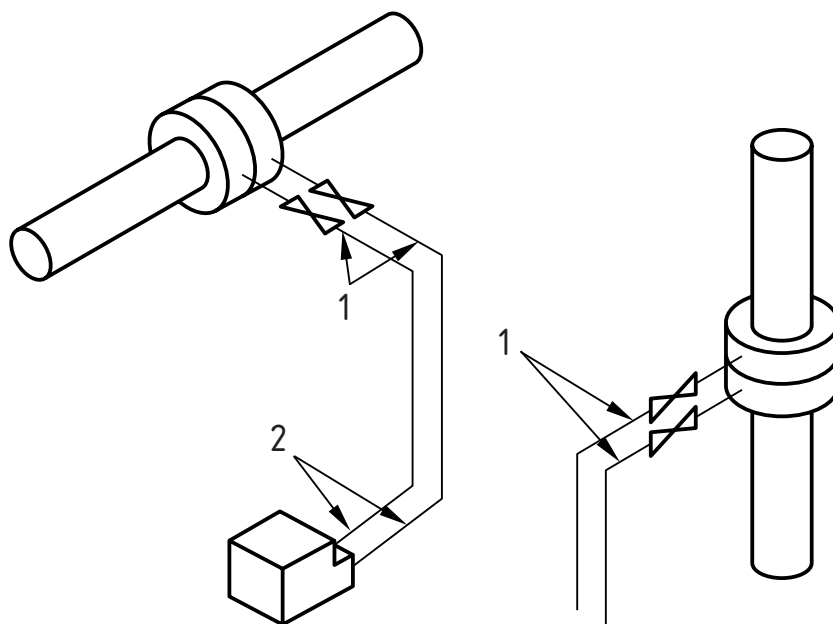
7.1.2.2.5 Vertical lines

Where metering orifices are installed in vertical lines, the direction of flow should preferably be upwards for liquids and downwards for gases. This practice obviates the need for drain or vent holes in the primary element.

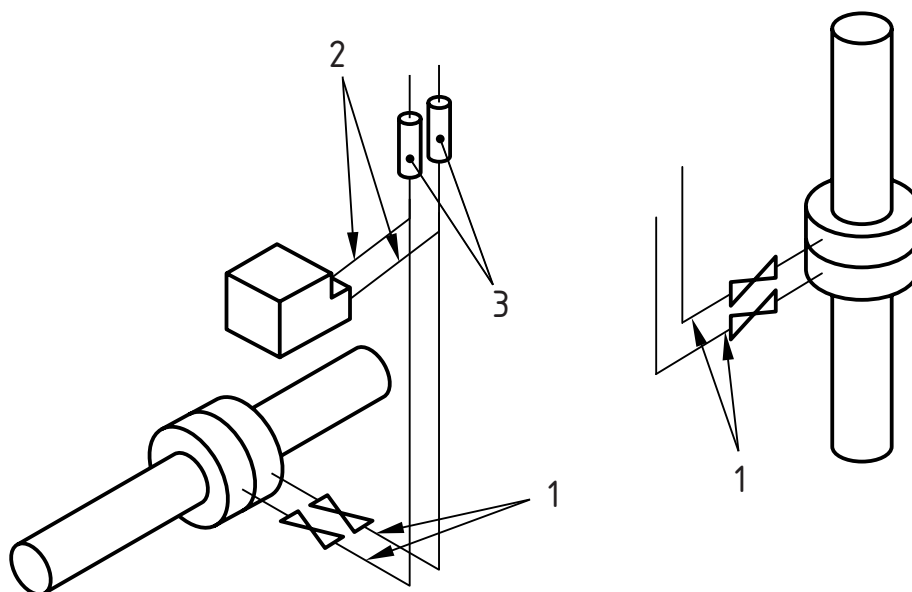
7.1.2.2.6 Impulse pipework connections

Connections between the tapping points and the differential pressure measuring devices should be as short as possible and should conform to 7.2.2. Examples of arrangements are shown in Figures 6 to 10. Where impulse lines are situated in areas where the ambient temperature could approach the freezing or pour-point of the measured fluid, the lines should be suitably thermally insulated or heat traced. All impulse/transmitter valves should be of suitable material and rating for the pipeline service.

Figure 6 Typical impulse pipework connections for measurement of flow of liquid



a) Preferred arrangement: instrument is mounted below tapping points

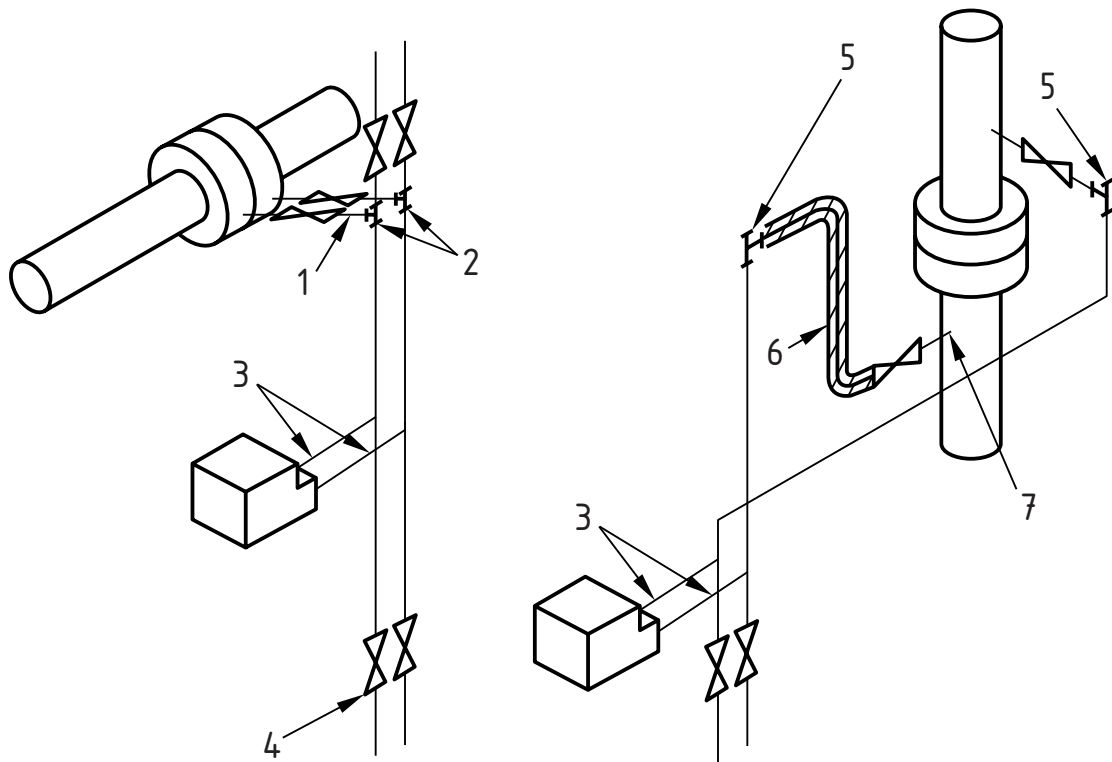


b) Alternative arrangement if instrument has to be mounted above tapping points

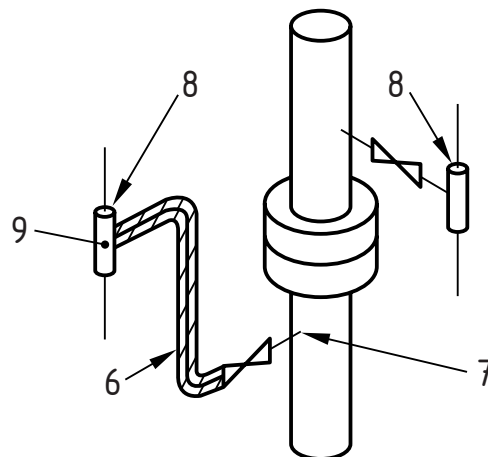
Key

- 1 Impulse lines fall from pipe by 1 in 10
- 2 Impulse lines fall to transmitter by 1 in 10
- 3 Vent chambers

Figure 7 Typical impulse pipework connections for measurement of flow of steam or condensing vapour



a) Preferred arrangement: instrument is mounted below tapping points



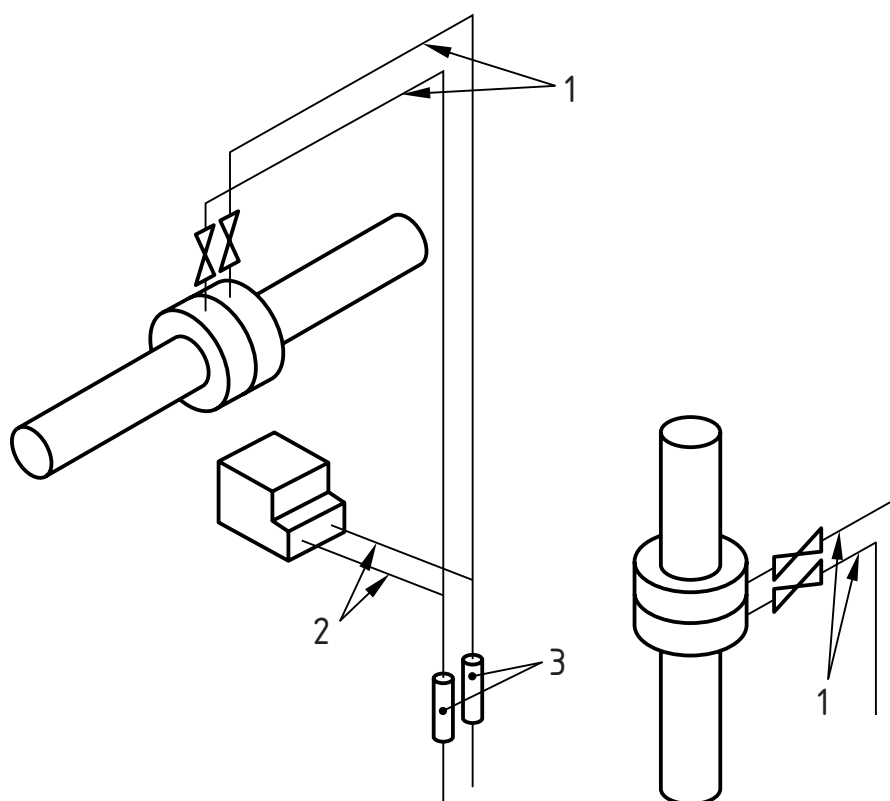
b) Alternative arrangement if instrument has to be mounted above tapping points

NOTE Pipes marked to slope downward in direction of arrow.

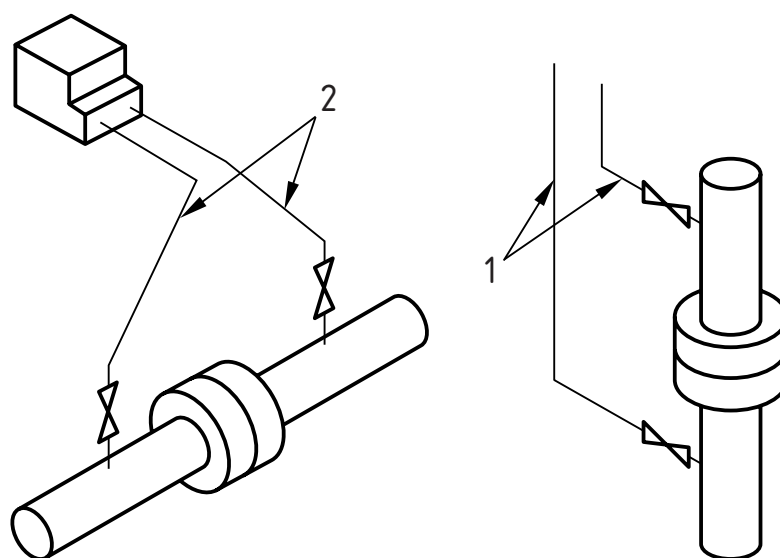
Key

- | | | | |
|---|--|---|-------------------------------------|
| 1 | Impulse lines rise from pipe by 1 in 10 | 6 | Thermal insulation essential |
| 2 | Filling tees | 7 | Minimum tapping size 12 mm |
| 3 | Impulse lines fall to transmitter by 1 in 10 | 8 | Condensate parts at same level |
| 4 | Blowdown valve | 9 | No insulation around condensate pot |
| 5 | Filling tees at same level | | |

Figure 8 Typical impulse pipework connections for measurement of flow of gas



a) Arrangement for instrument mounted below tapping points



b) Arrangement for instrument mounted above tapping points

Key

- 1 Impulse lines rise from pipe by 1 in 10
- 2 Impulse lines rise to transmitter by 1 in 10
- 3 Separating vessels necessary for wet gas

Figure 9 Typical impulse pipework connections for measurement of flow of liquid with suspended material

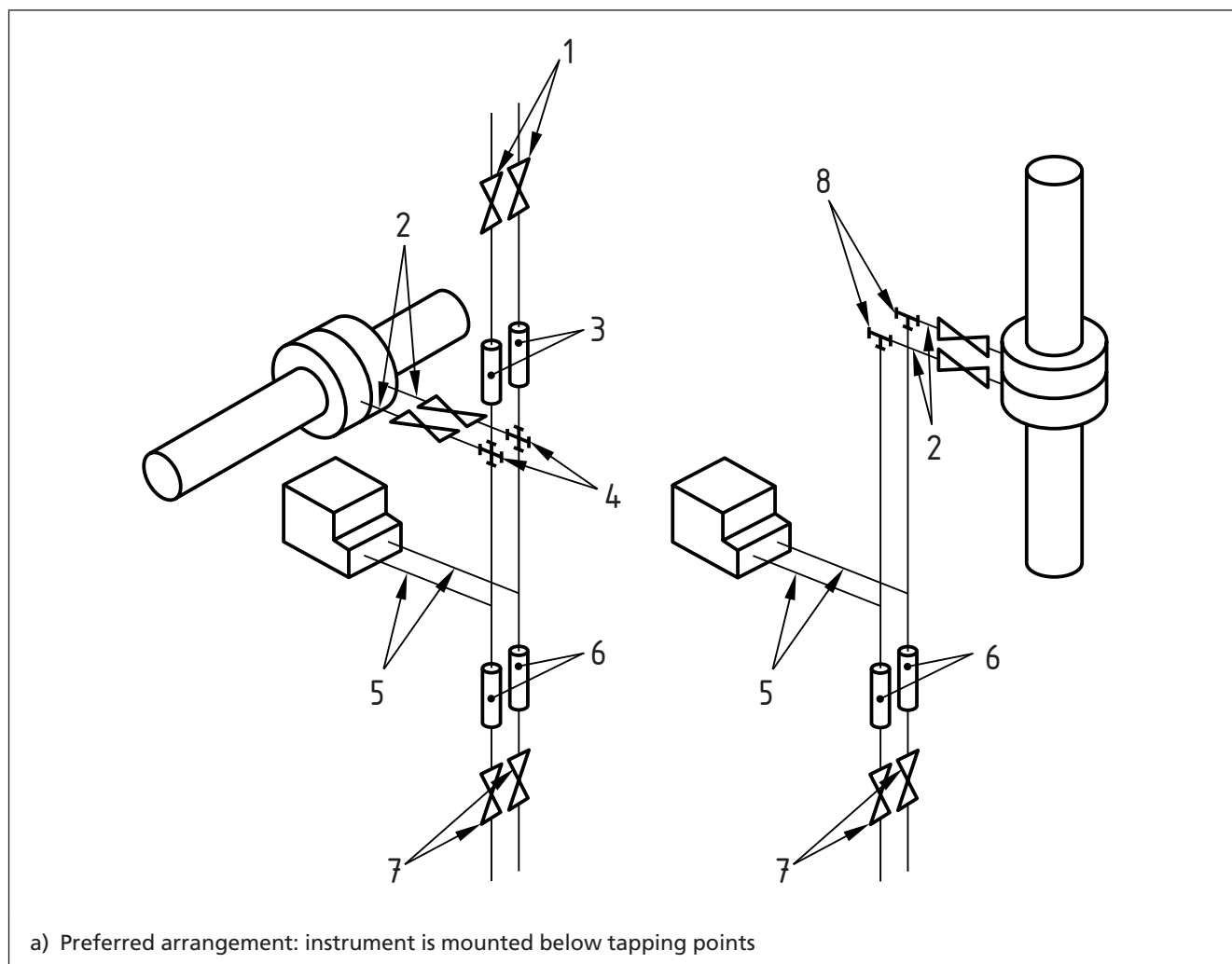
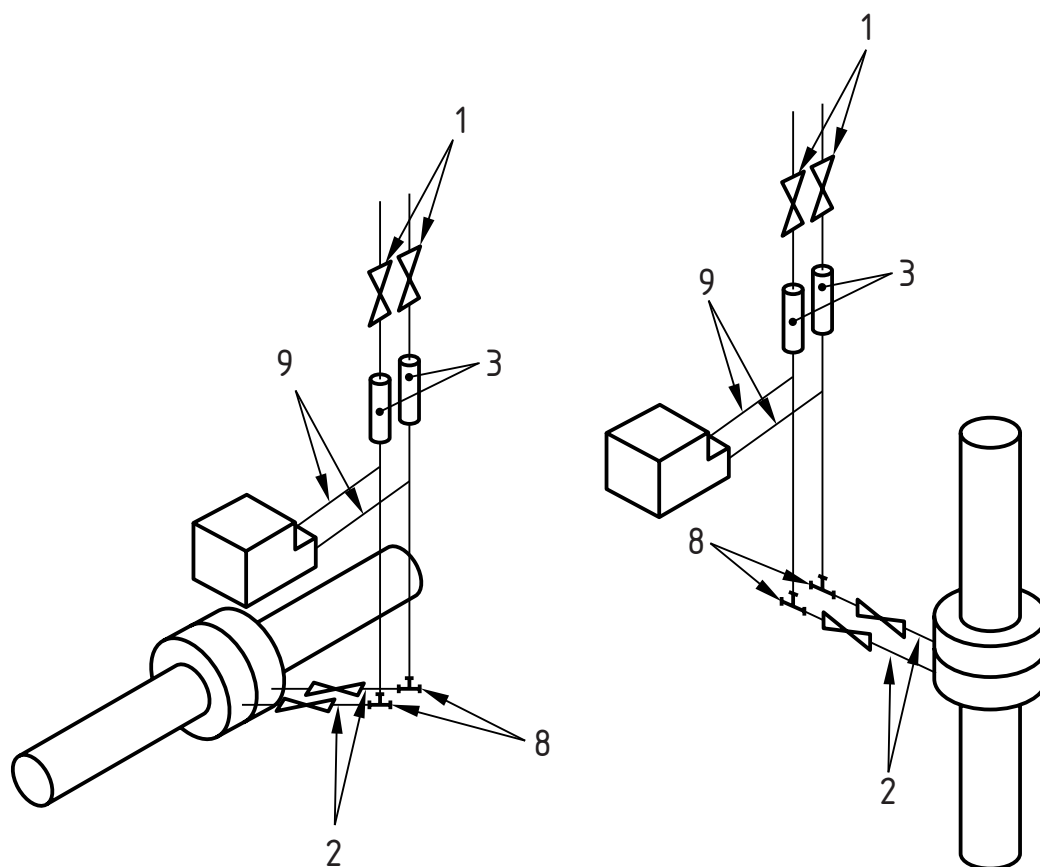


Figure 9 Typical impulse pipework connections for measurement of flow of liquid with suspended material (*continued*)

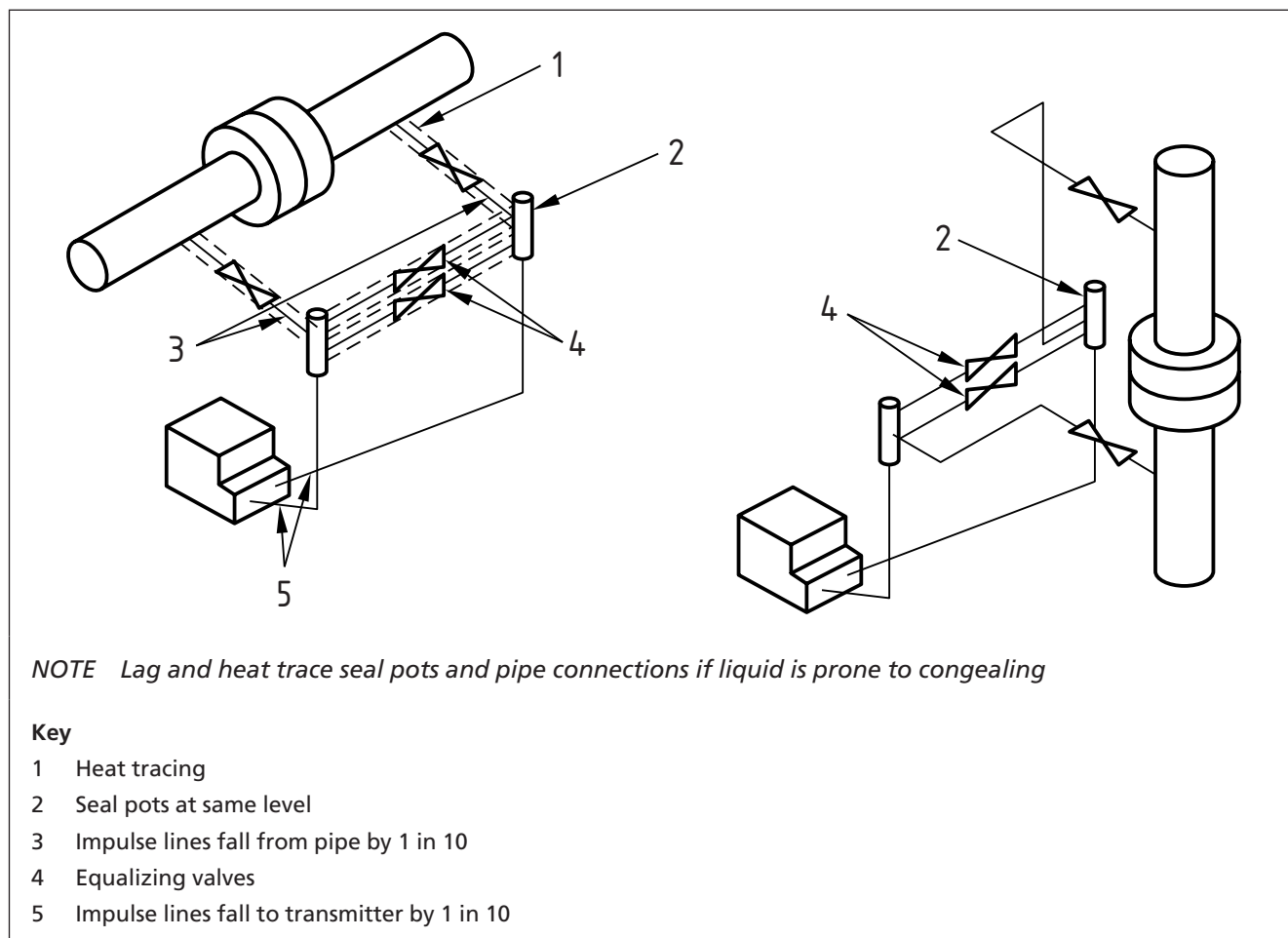


b) Alternative arrangement if instrument has to be mounted above tapping points

Key

- | | |
|---|---|
| 1 Vent valves | 6 Settling chambers |
| 2 Impulse lines rise from pipe by 1 in 10 | 7 Drain valves |
| 3 Vent chambers | 8 Rodding connections – tee with removable plug |
| 4 Rodding connections – cross with removable plug | 9 Impulse lines fall to transmitter by 1 in 10 |
| 5 Impulse lines rise to transmitter by 1 in 10 | |

Figure 10 Typical impulse pipework connections for measurement of flow where seal pots are used (orifice plate)



7.1.2.2.7 Condensate pots

For the measurement of steam or condensing vapours, appropriate condensing devices should be provided at the tapping point. For large displacement instruments, condensate pots should be fitted. For instruments with negligible displacement, such as differential pressure cells, filling tees of about 35 mm bore have adequate capacity. Examples of pipework arrangements are shown in Figure 7.

If the process temperature exceeds 400 °C, vaporizing vessels should be incorporated into the pipework arrangements.

7.1.2.2.8 Wet gas drains

Impulse lines for flow measurement of wet gases should incorporate drain vessels and valves and should slope to ensure drainage. Drain disposal lines, if required, should be of adequate size to avoid excess back pressure (see Figure 8).

7.1.2.2.9 Vents and rodding points

Liquid flow measurement installations should be arranged to prevent gases or suspended material collecting in the impulse pipework. The exact configuration for any particular application will depend on the nature and concentration of the suspended material, the quantity of entrained gas present and the active volume of the measurement transducer. Where solid matter is suspended in the liquid, rodding facilities might be required to clear tapping points. Where the

vented gases might be combustible or otherwise hazardous, the vent line should be led to the specified location or to an adjacent well ventilated point.

7.1.2.2.10 Seal pots and diaphragm seals

Where it is necessary to protect the differential pressure transducer from process conditions (e.g. viscous or corrosive fluids and suspended solids or powders), seal pots or remote diaphragm seals should be fitted. Arrangements for impulse pipework with seal pots are shown in Figure 10.

Diaphragm seals are supplied connected to the differential pressure transducer by a fixed length of capillary tubing filled with a special oil, usually silicone based. The transducer's calibration is usually selected for a given mounting position relative to connection points. If this has to be modified, e.g. due to site changes, the elevation or suppression of the transducer's range should be changed accordingly. The span of the instrument should not be changed.

If the capillary is found to be shorter than required, site modification is not possible and the transducer should be returned to the manufacturer for modification.

7.1.2.2.11 Pitot tubes

NOTE Caution should be exercised if quick-release connections are used.

Connections to a differential pressure pitot tube installation usually include flexible connections to allow a traverse across the pipe to obtain an average velocity measurement. Such connections are shown in Figure 11. Averaging and amplifying pitot tubes have several impact tubes and therefore do not require traversing facilities. In this case the flexible connections may be omitted unless otherwise specified in the original design drawing.

Electronic pitot tubes should be installed in accordance with the manufacturer's instructions.

7.1.2.3 Installation

7.1.2.3.1 General

Many problems with flow measuring devices are caused by dirt and foreign matter left in the lines after installation. Consequently the proper sequence of cleaning and assembly should be followed to minimize difficulties.

7.1.2.3.2 Tapping connections

Where tapping connections are to be made into the pipe, the bosses should be fitted and drilled before the lines are cleaned. Bosses should be drilled after welding. Taps in flanges should be drilled and deburred as necessary.

7.1.2.3.3 Cleaning and purging

The pipework upstream of the flow measuring primary elements should be descaled and flushed with the primary devices omitted and spool pieces used where necessary for pipework continuity. Where descaling is not possible, other approved cleaning techniques should be used to clear the line of dirt and foreign matter.