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Instrumentation in process control systems: installation design and practice – Code of practice

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Summary of pages

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 October 2024. 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 the committee manager.

Supersession

This British Standard supersedes [BS 6739:2009](#), which is withdrawn.

Information about this document

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

- existing installation practices referenced in the previous edition have been changed due to further understanding and/or recommendations;
- new hardware, which was not included in the previous edition, has been introduced and adopted by industry (including new transmission media);
- clear guidance, specifically for safety instrumented systems (SISs), that a SIS is to be initiated by manipulation of the process variable, rather than injection;
- new methods of measuring, controlling and protecting processes;
- revised installation methods, based on lessons learned from (world) industrial incidents;
- new materials for improved anti-corrosion/erosion performance and cost-effectiveness in both the manufacture of instruments and installation; and
- increased awareness of and reference to legislation regarding emissions (to land, water and air) and the incorporation of associated emission monitoring.

This publication can be withdrawn, revised, partially superseded or superseded. Information regarding the status of this publication can be found in the Standards Catalogue on the BSI website at knowledge.bsigroup.com, or by contacting the Customer Services team.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

Use of this document

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

Users may substitute any of the recommendations in this British Standard with practices of equivalent or better outcome. Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of 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.

The word “should” is used to express recommendations of this standard. The word “may” is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word “can” is used to express possibility, e.g. a consequence of an action or an event.

Notes and commentaries are provided throughout the text of this standard. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

Where words have alternative spellings, the preferred spelling of the *Shorter Oxford English Dictionary* is used (e.g. “organization” rather than “organisation”).

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

1 Scope

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

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

2 Normative references

Standards publications

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions, or limits the application, of this document¹⁾. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

[BS 5839](#) (all parts), *Fire detection and alarm systems for buildings*

[BS 5839-1](#), *Fire detection and alarm systems for buildings – Part 1: Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises*

[BS 6231](#), *Electric cables – Single core PVC insulated flexible cables of rated voltage 600/1000 V for switchgear and controlgear wiring*

[BS 6266](#), *Fire protection for electronic equipment installations – Code of practice*²⁾

[BS 6423](#), *Code of practice for maintenance of low-voltage switchgear and controlgear*

[BS 7273](#) (all parts), *Code of practice for the operation of fire protection measures*

[BS 7430](#), *Code of practice for protective earthing of electrical installations*

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

[BS 7629-1](#), *Electric cables – Specification for 300/500 V fire resistant, screened, fixed installation cables having low emission of smoke and corrosive gases when affected by fire – Part 1: Multicore cables*

[BS 7671](#), *Requirements for electrical installations – IET wiring regulations*

[BS 7846](#), *Electric cables – Thermosetting insulated, armoured, fire-resistant cables of rated voltage 600/1 000 V for fixed installations, having low emission of smoke and corrosive gases when affected by fire – Specification*

[BS 8444-3](#), *Risk management – Part 3: Guide to risk analysis of technological systems*

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

¹⁾ Documents that are referred to solely in an informative manner are listed in the Bibliography.

²⁾ This British Standard also gives an informative reference to [BS 6266:2011](#).

- [BS EN 614-1](#), *Safety of machinery – Ergonomic design principles – Part 1: Terminology and general principles*
- [BS EN 1127-1](#), *Explosive atmospheres – Explosion prevention and protection – Part 1: Basic concepts and methodology*
- [BS EN 10204:2004](#), *Metallic products – Types of inspection documents*
- [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: Electric welded and submerged arc welded 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 12845](#), *Fixed firefighting systems – Automatic sprinkler systems – Design, installation and maintenance*
- [BS EN 15004](#) (all parts), *Fixed firefighting systems – Gas extinguishing systems*
- [BS EN 50173](#) (all parts), *Information technology – Generic cabling systems*
- [BS EN 50173-1](#), *Information technology – Generic cabling systems – Part 1: General requirements*
- [BS EN 50174](#) (all parts), *Information technology – Cabling installation*
- [BS EN 50381](#), *Transportable ventilated rooms with or without an internal source of release*
- [BS EN 50575](#), *Power, control and communication cables – Cables for general applications in construction works subject to reaction to fire requirements*
- [BS EN 60079](#) (all parts), *Explosive atmospheres*
- [BS EN 60079-14](#), *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*
- [BS EN 60079-27](#), *Explosive atmospheres – Part 27: Fieldbus intrinsically safe concept (FISCO)*
- [BS EN 60204-1](#), *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*
- [BS EN 60529](#), *Degrees of protection provided by enclosures (IP Code)*
- [BS EN 60584-1](#), *Thermocouples – EMF specifications and tolerances*
- [BS EN 60825-1](#), *Safety of laser products – Part 1: Equipment classification and requirements*
- [BS EN 60825-2](#), *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)*
- [BS EN 61131-2](#), *Programmable controllers – Part 2: Equipment requirements and tests*
- [BS EN 61285](#), *Industrial-process control – Safety of analyzer houses*
- [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 61508-1:2010](#), *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements*
- [BS EN 61511](#) (all parts), *Functional safety – Safety instrumented systems for the process industry sector*

[BS EN 61511-1:2017+A1:2017](#), *Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements*

[BS EN 61518](#), *Mating dimensions between differential pressure (type) measuring instruments and flanged-on shut-off devices up to 413 bar (41,3 MPa)*

[BS EN 62262](#), *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

[BS EN 62305](#) (all parts), *Protection against lightning*

[BS EN 62337](#), *Commissioning of electrical, instrumentation and control systems in the process industry – Specific phases and milestones*

[BS EN 62444](#), *Cable glands for electrical installations*

[BS EN 62708](#), *Document kinds for Electrical and Instrumentation Projects in the Process Industry*

[BS EN IEC 60079-17](#), *Explosive atmospheres – Part 17: Electrical installations inspection and maintenance*

[BS EN IEC 60079-25](#), *Explosive atmospheres – Part 25: Intrinsically safe electrical systems*

[BS EN IEC 60751](#), *Industrial platinum resistance thermometers and platinum temperature sensors*

[BS EN IEC 60793-2](#), *Optical fibres – Part 2: Product specifications – General*

[BS EN IEC 60825-12](#), *Safety of laser products – Part 12: Safety of free space optical communication systems used for transmission of information*

[BS EN IEC 61010](#) (all parts), *Safety requirements for electrical equipment for measurement, control and laboratory use*

[BS EN IEC 61158-2](#), *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

[BS EN IEC 61784-5](#), *Industrial networks – Profiles – Part 5: Installation of fieldbuses*

[BS EN IEC 61800-5-1](#), *Adjustable speed electrical power drive systems – Part 5-1: Safety requirements – Electrical, thermal and energy*

[BS EN IEC 61918](#), *Industrial communication networks – Installation of communication networks in industrial premises*

[BS EN IEC 62061](#), *Safety of machinery – Functional safety of safety-related control systems*

[BS EN IEC 62368-1](#), *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

[BS EN IEC 62381](#), *Automation systems in the process industry – Factory acceptance test (FAT), site acceptance test (SAT) and site integration test (SIT)*

[BS EN IEC 62382](#), *Control systems in the process industry – Electrical and instrumentation loop check³⁾*

[BS EN IEC 62443](#) (all parts), *Security for industrial automation and control systems*

[BS EN ISO 1461](#), *Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods*

[BS EN ISO 3266](#), *Forged steel eyebolts grade 4 for general lifting purposes*

[BS EN ISO 4126-1](#), *Safety devices for protection against excessive pressure – Part 1: Safety valves*

[BS EN ISO 4413](#), *Hydraulic fluid power – General rules and safety requirements for systems and their components*

³⁾ This British Standard also gives an informative reference to BS 62382:2013.

- [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 5167-2](#), *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full – Part 2: Orifice plates*
- [BS EN ISO 5167-3](#), *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full – Part 3: Nozzles and Venturi nozzles*
- [BS EN ISO 5167-4](#), *Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full – Part 4: Venturi tubes*
- [BS EN ISO 9241](#) (all parts), *Ergonomics of human-system interaction*
- [BS EN ISO 9300](#), *Measurement of gas flow by means of critical flow nozzles*
- [BS EN ISO 9539](#), *Gas welding equipment – Materials for equipment used in gas welding, cutting and allied processes*
- [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 80079](#) (all parts), *Explosive atmospheres*
- [BS EN ISO 80079-36](#), *Explosive atmospheres – Part 36: Non-electrical equipment for explosive atmospheres – Basic method and requirements*
- [BS EN ISO 80079-37](#), *Explosive atmospheres – Part 37: Non-electrical equipment for explosive atmospheres – Non-electrical type of protection constructional safety “c”, control of ignition sources “b”, liquid immersion “k”*
- [BS ISO 1219](#) (all parts), *Fluid power systems and components – Graphical symbols and circuit diagrams*
- [BS ISO 4406](#), *Hydraulic fluid power – Fluids – Method for coding the level of contamination by solid particles*
- [BS ISO 6162](#) (all parts), *Hydraulic fluid power – Flange connectors with split or one-piece flange clamps and metric or inch screws*
- [BS ISO 10474](#), *Steel and steel products – Inspection documents*
- [BS ISO 10790](#), *Measurement of fluid flow in closed conduits – Guidance to the selection, installation and use of Coriolis flowmeters (mass, flow, density and volume flow measurements)*
- [BS ISO 12242](#), *Measurement of fluid flow in closed conduits – Ultrasonic transit-time meters for liquid*
- [BS ISO 15489-1](#), *Information and documentation – Records management – Part 1: Concepts and principles*
- [BS ISO 17089-1](#), *Measurement of fluid flow in closed conduits – Ultrasonic meters for gas – Part 1: Meters for custody transfer and allocation measurement*
- [IEC 60331-21](#), *Tests for electric cables under fire conditions – Circuit integrity – Part 21: Procedures and requirements – Cables of rated voltage up to and including 0,6/1,0 kV*
- [ISO 4021](#), *Hydraulic fluid power – Particulate contamination analysis – Extraction of fluid samples from lines of an operating system*
- [ISO 17089-2](#), *Measurement of fluid flow in closed conduits – Ultrasonic meters for gas – Part 2: Meters for industrial applications*
- [ISO/IEC 11801-3](#), *Information technology – Generic cabling for customer premises – Part 3: Industrial premises*

PD 5304, *Guidance on safe use of machinery*

PD 5500, *Specification for unfired pressure vessels*

PD CLC/TR 60079-32-1, *Explosive atmospheres – Part 32-1: Electrostatic hazards, guidance*

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

PD IEC/TR 61831, *On-line analyser systems – Guide to design and installation*

Other publications

[N1] HEALTH AND SAFETY EXECUTIVE. *The safe isolation of plant and equipment*. HSG253. London: HSE Books, 2006.⁴⁾

[N2] HEALTH AND SAFETY EXECUTIVE. *Protecting lone workers – How to manage the risks of working alone*. INDG73(Rev4). London: HSE Books, 2020.⁵⁾

[N3] AMERICAN SOCIETY OF MECHANICAL ENGINEERS. *Thermowells*. PTC 19.3 TW. ASME, 2016.⁶⁾

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

3.1.1 actuator

mechanism for changing a signal into a corresponding movement

3.1.2 asset management system

system populated with all assets of a plant

NOTE For example, for instrumentation, the system would be for instruments, valves, safety instrumented functions, cables, hazardous area equipment, etc. It usually contains technical information for each asset and allows maintenance activities to be scheduled and results recorded for each asset.

3.1.3 atmospheric contamination

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

3.1.4 authorized person

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

3.1.5 booster

power amplifier of which the signal gain is unity

3.1.6 cause and effect diagram

diagram which details the action of control and/or safety systems outputs in response to dynamic changes to input signals, including safety instrumented functions

NOTE BS EN IEC 62881 gives guidance on cause and effect diagrams.

⁴⁾ Available at www.hse.gov.uk/pubns/books/hsg253.htm.

⁵⁾ Available at www.hse.gov.uk/pubns/indg73.htm.

⁶⁾ Available at www.asme.org/codes-standards/find-codes-standards/thermowells.

3.1.7 cold commissioning

phase during which functional testing of equipment and facilities, using test media such as water or inert substances, takes place

3.1.8 competent person

person, suitably trained and qualified by knowledge and practical experience, and provided with the necessary instructions, to enable the required task(s) to be carried out correctly

NOTE Competent persons are expected 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 applicable statutory regulations, an appreciation of the hazards involved, and sufficient authority so that any action that they recommend is carried out.

3.1.9 control valve

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

NOTE A control valve 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.

3.1.10 converter

specialized device that converts one standardized transmission signal into another

3.1.11 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

3.1.12 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

3.1.13 explosive atmosphere

mixture of dangerous substances with air, under atmospheric conditions, in the form of gases, vapours, mist or dust in which, after ignition has occurred, combustion spreads to the entire unburned mixture

3.1.14 fire suppression 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

3.1.15 hot commissioning

phase during which activities associated with the testing and operation of equipment using the actual process chemicals (initial start-up of process) are performed

3.1.16 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

3.1.17 instrument personnel

engineers, designers and installation operatives responsible for the design, installation and commissioning of control and instrumentation, and associated pipework, equipment and services

NOTE Installation operatives are likely to include pipefitters, welders, instrument mechanics and technicians, and electricians.

3.1.18 instrument process lines

any pipework installed by the instrument discipline downstream of the pipework system via a piping specification isolation valve

NOTE Examples include pressure instrument impulse lines or analyser sample lines.

3.1.19 instrument supervisor

person who has responsibility for the management of instrument personnel conducting the execution of the installation of control and infrastructure, and whose responsibility to the owner/operator includes safety matters, work progress and standards, labour discipline and industrial relations

3.1.20 inverter

device that converts a direct current to an alternating current

NOTE This is usually employed to provide 110 V AC or 230 V AC from a battery-supplied DC source.

3.1.21 listing

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

3.1.22 mode of operation (of a SIF)

way in which a safety instrumented function (SIF) operates, which can be either low demand mode, high demand mode or continuous mode

NOTE 1 Low demand mode: mode of operation where the SIF is only performed on demand, in order to transfer the process into a specified safe state, and where the frequency of demand is no greater than one per year.

NOTE 2 High demand mode: mode of operation where the SIF is only performed on demand, in order to transfer the process into a specified safe state, and where the frequency of demand is greater than one per year.

NOTE 3 Continuous mode: mode of operation where the SIF retains the process in a safe state as part of normal operation.

3.1.23 OSI (open systems interconnection) model

conceptual model which enables diverse communication systems to communicate using standard protocols

NOTE The OSI was created by ISO and provides a standard for different computer systems to be able to communicate with each other.

3.1.24 owner/operator

organization that has accountability for the execution of any instrument installation on a given industrial processing/manufacturing facility

NOTE The owner/operator is in control of the premises where work is performed and is the ultimate client or employer for the work. The owner/operator is responsible for engaging a responsible instrument engineer.

3.1.25 positioner

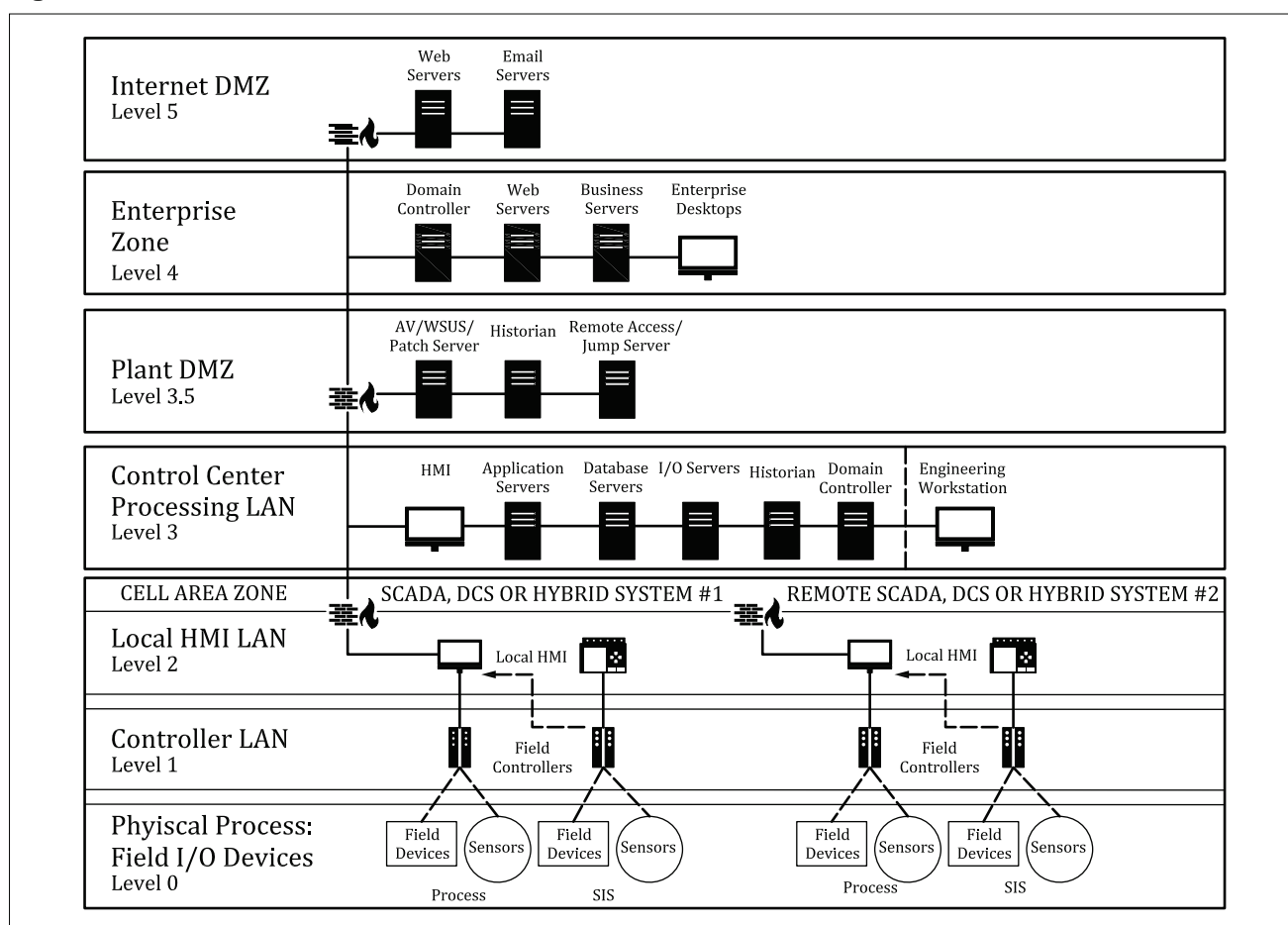
device to position an actuator in accordance with a standardized signal

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.

3.1.26 Purdue model

concept model for industrial control system (ICS) network segmentation

NOTE The Purdue model is illustrated in [Figure 1](#). It divides ICS architecture into four major zones and five different levels. The enterprise zone is where business systems such as enterprise resource planning (ERP) systems and logistics management are typically installed.

Figure 1 — Purdue model**3.1.27 responsible instrument engineer**

engineer with technical responsibility for verifying and checking the control and instrumentation design and installation

3.1.28 standby power supply

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

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

3.1.29 star configuration

set of three or more branches connected to a common node

3.1.30 time domain reflectometer

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

3.1.31 transmission line

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

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.

3.2 Abbreviated terms

For the purposes of this British Standard, the following abbreviated terms apply.

ALARP	as low as reasonably practicable
AST	analyser sample train
AV	anti-virus
CAD	computer-aided design
CCTV	closed circuit television
CEMS	continuous emission monitoring system
DCS	distributed control system
DMZ	demilitarized zone
DP	differential pressure
DTS	distributed temperature sensing
EA	Environment Agency
EIA	Electronic Industries Alliance
ELV	extra low voltage
EMC	electromagnetic compatibility
EMF	electromotive force
ERP	enterprise resource planning
Ex	explosion protected
F&G	fire and gas
FAT	factory acceptance test
FEP	fluorinated ethylene propylene
Gb/s	Giga bits per second
GWR	guided wave radar
HAZOP	hazard and operability study
HMI	human-machine interface
HP	high pressure
HVAC	heating, ventilation and air conditioning
IACS	industrial automation and control system
ICS	industrial control system
IE	industrial ethernet
I/O	input output
IP	internet protocol
IS	intrinsically safe
ISP	internet service provider
LAN	local area network
LP	low pressure

Mb/s	Mega bits per second
MCERTS	Monitoring Certification Scheme
MICC	mineral-insulated copper cables
MTTR	mean time to restore
NACE	National Association of Corrosion Engineers
NB	nominal bore
OD	outside diameter
OSI	open systems interconnection
OT	operational technology
P&ID	piping and instrument diagram
PBB	polybrominated biphenyls
PBDE	polybrominated diphenyl ethers
PELV	protective extra low voltage
PFA	perfluoro alkoxy
PFD	probability of failure on demand
PID	proportional, integral, derivative
PLC	programmable logic controller
PPE	personal protective equipment
PRT	platinum resistance thermometer
PST	partial stroke testing
PTFE	polytetrafluoroethylene
PV	process variable
PVC	polyvinyl chloride
RF	radio frequency
RMS	root mean squared
RPS	radiation protection supervisor
RTD	resistance temperature detector
SAT	site acceptance test
SCADA	supervisory control and data acquisition
SCS	sample conditioning system
SEPA	Scottish Environment Protection Agency
SIF	safety instrumented function
SIL	safety instrumented level
SIS	safety instrumented system
SIT	site integration test
SPD	surge protection device
SRS	safety requirements specification

SWA	steel wire armour
TDR	time domain reflectometry
TIA	Telecommunications Industry Association
UPS	uninterruptible power supply
USB	universal serial bus
UTP	unshielded twisted pair
VOC	volatile organic compound
VPN	virtual private network
WSUS	Windows server update service
XLPE	cross-linked polyethylene

4 Personnel and work equipment safety

COMMENTARY ON CLAUSE 4

The recommendations given in this clause are primarily for personnel who are involved in the management or execution of the installation, modification and/or commissioning of instrumentation equipment on process plants.

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

4.1 General

COMMENTARY ON 4.1

Attention is drawn to the major statutory acts and regulations relevant to instrumentation installation: the Health and Safety at Work etc. Act 1974 [1], the Management of Health and Safety at Work Regulations 1999 [2] and the Workplace (Health, Safety and Welfare) Regulations 1992 [3].

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

In all workplaces, the owner/operator 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 or 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, which should be provided to all personnel working on site.

A site safety brief should be prepared and given to all contractors entering or working on the site.

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

Instrument personnel are required to have particular competencies to work on some types of equipment and in certain locations; records should be kept of the competencies of all personnel working on a site/installation.

4.2 Responsibilities

COMMENTARY ON 4.2

Attention is drawn to:

- the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 [8];
- the Control of Major Accident Hazards Regulations 2015 [9], as amended; and
- HSE publication HSIS1 [10].

The owner/operator should verify that:

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

NOTE 1 The Health and Safety Executive provides information in various foreign languages, as well as in English.

- c) precise instructions are issued, setting out the procedures for handling and testing equipment safely; and
- d) monitor arrangements are in place to check that these procedures are effectively carried out.

NOTE 2 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, attention is drawn to the requirement for site management to provide information and instruction to all personnel about the safety procedures to be adopted.

Before work begins, the owner/operator should inform all instrument personnel of the potential hazards on site and the action to be taken in an emergency.

The owner/operator should check that all personnel are fully aware of their responsibility for the safety of installations under their control and for carrying out their work safely.

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

All instrument personnel should be made aware of the site arrangements for emergency services, including the type and location of available first-aid equipment, the methods of summoning medical assistance, the fire service and other emergency services, and the location of all the personnel assembly points in the event of a site emergency.

4.3 Permit-to-work system

COMMENTARY ON 4.3

Attention is drawn to HSE publication HSG250 [11].

"Installation" includes work on all plant and equipment within the area covered by the permit-to-work system, such as instrumentation, electrical switchgear, pressure testing and radiography.

A permit-to-work system should 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, as well as where and the part of the installation to which it applies. The specific equipment to be worked on should have a permanently fixed unique identifier, which should be recorded on the permit to avoid any potential confusion, especially where there are multiple work streams. The permit should detail:

- a) the protective equipment to be used in executing the work;
- b) the risks and control measures in place/to be taken in the period for which it is valid;

- c) the name of the person and organization to whom it is issued;
- d) the name of the person authorized to issue it; and
- e) 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 permit issuing office.

NOTE The permit issuing office is normally in or near the main control room for operating plants or in a central location for major construction or overhaul works.

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.

If electronic permits are used, there should be a suitable system in place to prevent them being issued or accepted unless they have been authorized. This system should prevent a permit from being issued remotely without a site visit and prevent an existing permit from being altered without the alteration being communicated to all concerned. The system should also have a suitable back-up in the event of a software failure or power outage.

Personnel responsible for issuing permits should be competent to assess the specific job.

Instrument personnel working under a permit-to-work system should stop work if any unsafe conditions are found, or if a change is required to their written procedure, and inform the permit-issuing authorities immediately.

Any safe condition that the workplace should be left in on the initiation of a work area evacuation should be agreed in writing as necessary.

4.4 Work equipment

COMMENTARY ON 4.4

Attention is drawn to the Provision and Use of Work Equipment Regulations 1998 (PUWER) [12], as amended. Annex A gives further information on UK-specific product safety regulations.

4.4.1 General

COMMENTARY ON 4.4.1

Attention is drawn to HSE publications L22 [13] and INDG271 [14]. HSE publication L22 [13] states that compliance with relevant UK product safety regulations can be established by checking that the equipment bears the UKCA marking and asking for a copy of the Declaration of Conformity (DoC), with the exception of the Construction Products (Amendment) Regulations 2022 [15], which requires a Declaration of Performance (DoP). Regulations do not always require UKCA marking to be on the equipment, e.g. on small items. Nor do they always require the UK DoC to accompany equipment or to be in English. 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 [12]. 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 [12]. The mandatory date for CE or UKCA marking (as applicable) varies according to the type of equipment in question. The onus for deciding which UK regulations apply to (work) equipment is placed solely on the product manufacturer. Some regulations allow the UKCA (formerly CE) marking to be on the packaging, delivery documentation or guarantee, or in the instructions for use. There are no specific requirements for the medium on which the instructions for safe installation and use are to be provided. Legislation continues recognition of the current EU requirements, including CE marking, and the legislation applies indefinitely for a range of product regulations. This means businesses have the flexibility to use either UKCA or CE marking to sell products in Great Britain. Guidance can be found on the UK government web page, www.gov.uk/guidance/using-the-ukca-marking.

The owner/operator should check that instrument personnel have a system in place to demonstrate and document that the work equipment conforms to all relevant legislation.

Work equipment used as part of installation should be registered with the organization responsible for executing the work. The organization should also carry out periodic checks to verify that the equipment is safe for the location, environment and application.

Markings on all work equipment should undergo a documented check to verify that it complies with the relevant regulations and work specifications prior to use.

All instructions for the safe installation and use of work equipment should be available during installation and be made available to the owner/operator for incorporation within an asset management system.

4.4.2 Instructions

COMMENTARY ON 4.4.2

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

Instrument supervisors should check 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. The manufacturer's instructions for safe installation and use of equipment should be made available to the installer prior to installation and be available for reference.

4.4.3 Use of tools

The instrument supervisor should check that instrument personnel follow site specific work instructions and manufacturers' operating procedures for the use of hand tools and portable machinery. Installation personnel are responsible for the care, regular examination and replacement (when necessary) of tools and equipment.

Unless permitted by the manufacturer, tools should not be modified.

In areas where there might be an increased risk of fire or the presence of flammable material, installations should only be carried out using tools approved for use in potentially explosive atmospheres and in accordance with permit-to-work procedures (see 4.3).

4.4.4 Electrical safety

COMMENTARY ON 4.4.4

Attention is drawn to the health and safety requirements of the Electrical Equipment (Safety) Regulations 2016 [16].

Process instrumentation, test and measuring instruments and laboratory instruments should conform to the [BS EN IEC 61010](#) series.

Electrical and electronic equipment within the field of audio, video, information and communication technology, and business and office machines (with a rated voltage not exceeding 600 V) should conform to [BS EN IEC 62368-1](#).

Electrical, thermal and energy safety of adjustable speed electrical power drive systems should conform to [BS EN IEC 61800-5-1](#).

Programmable controllers should conform to [BS EN 61131-2](#).

NOTE Essential health and safety requirements for electrical equipment in potentially explosive atmospheres is covered by the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 (EPS Regulations) [17] and not the Electrical Equipment (Safety) Regulations 2016 [16].

Instrument personnel should only work on low-voltage or high-voltage equipment associated with an instrumentation installation if they have the necessary recognized electrical competencies.

4.4.5 Safety of machinery

COMMENTARY ON 4.4.5

Attention is drawn to the Supply of Machinery (Safety) Regulations 2008 [18], as amended, and the Supply of Machinery (Safety) Regulations 1992 [19].

Machinery supplied prior to 1992 should be used in accordance with [PD 5304](#).

Where identified as being required as part of a machinery risk assessment, machinery should incorporate guards and protective functions to protect against continuous or high-demand mode risks. Such protection should conform to [BS EN IEC 62061](#).

Machines incorporated within process applications should have a hazard and operability study (HAZOP) undertaken by a competent team and, where required, a further “low demand” mode protective functions (such as a layers of protection analysis and/or fault tree analysis) in accordance with the [BS EN 61508](#) series and the [BS EN 61511](#) series.

Safety of electrical parts of machines should conform to [BS EN 60204-1](#).

Machinery that is supplied part complete and requires integration with other partially complete machinery or other equipment (e.g. customer safety system) to form a completed machine should be supplied with a Declaration of Incorporation.

NOTE 1 It is advisable to check that the completed machine undergoes a final conformity assessment against the Supply of Machinery (Safety) Regulations 2008 [18] before being placed into operation.

Instrument personnel should determine who is responsible for the safe performance of a machine before planning to undertake any work relating to that machine.

NOTE 2 During installation and prior to customer acceptance and handover, this is likely to be the manufacturer. The manufacturer is likely to retain responsibilities under guarantee/maintenance agreement post-handover.

If authorized to perform work under a permit-to-work system (see [4.3](#)), instrument personnel should be competent to install and commission any instrumentation which is part of or connected to a machine. This should include induction and familiarization with machinery risks and safeguards incorporated.

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.

NOTE 3 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.

4.4.6 Safety of pressure equipment

COMMENTARY ON 4.4.6

This subclause only addresses equipment covered by the Pressure Equipment (Safety) Regulations 2016 [20], as amended. 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](#).

Pressure equipment conforming to the Pressure Equipment (Safety) Regulations 2016 [20], as amended, is not subject to further pressure regulations during installation on site.

Instrument personnel should receive induction and training in the risks and the required control measures to be put into place before working on instrumentation and valves installed on pressure equipment/systems. They should carry out work only if authorized under a permit-to-work system (see [4.3](#)).

Instrument personnel should be provided with appropriate documentation for the instruments, safety devices and instrument valves used on the pressure equipment before the equipment is commissioned. This should include certificates of conformity for applicable components, including pressure and safety accessories (i.e. Category I, II, III or IV).

NOTE Where piping components do not have individual categorization and are not designated as pressure or safety accessories, users are advised to consider the suitability of components representing part of the piping system boundary having quality assurance documentation verified to support examination by an approved or notified body. This includes materials test certificates for piping components such as orifice plates, thermowells, and instrument-wetted or pressure-bearing faces.

4.4.7 Equipment for use in potentially explosive atmospheres

COMMENTARY ON 4.4.7

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 EPS Regulations 2016 [17].

Work on equipment for use in potentially explosive atmospheres, inside or outside the boundary of the hazardous area, should be carried out by personnel who are competent and, where relevant, authorized under a permit-to-work system (see 4.3).

Where equipment for use in potentially explosive atmospheres has been installed, or covers removed, the installation should be inspected or signed-off, as appropriate, by a competent person.

4.4.8 Radio equipment

COMMENTARY ON 4.4.8

Attention is drawn to the Radio Equipment Regulations 2017 [21], which set out requirements on how to protect the health and safety of the user and any other person. Attention is also drawn to the Electromagnetic Compatibility Regulations 2016 (EMC Regulations) [22].

Radio equipment can be stand-alone or incorporated into information technology (IT) equipment or process equipment and instrumentation.

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

4.4.9 Construction products

COMMENTARY ON 4.4.9

The objective of the Construction Products (Amendment) Regulations [15] is to demonstrate reliable safety performance of construction products with reference to accepted standards. Components relevant to instrumentation works include building fire detection and alarm systems and cables. The performance requirements to be complied with relate to safety performance in connection with fires, as defined within "UK Designated Standards" (i.e. BS EN 54 for fire alarm systems and BS IEC 61892-7 for cables). A DoP is made by the manufacturer against a normalized performance requirement. The level of performance required is dependent on installation function/criticality and is specified by authorities or users (e.g. architects, engineers, builders). By affixing the UKCA marking to a product, manufacturers indicate that they take responsibility for the conformity of that product based on its declared performance.

The owner/operator should verify that the safety performance requirements for instrumentation components classified as construction products are correctly specified based on the nature of the installation and conform to the applicable UK Designated Standard.

4.5 Personal protective equipment

COMMENTARY ON 4.5

Personal protective equipment (PPE) intended for use in potentially explosive atmospheres 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. Attention is drawn to the Personal Protective Equipment at Work Regulations 1992 [23], as amended, which require employees 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. PPE procured before the current regulations can still be used, but employers can only allow such PPE to be used if they have retained evidence to demonstrate its suitability for safe use.

Instrument personnel should wear PPE in accordance with the manufacturer's instructions and site safety instructions. Personnel should check that it is suitable for their use, in date and not faulty before commencing work. If an item of PPE is damaged while they are working, such that it no longer provides the intended protection, they should withdraw from the work area before reporting it to their employer.

4.6 Lifting and handling operations

COMMENTARY ON 4.6

Attention is drawn to the Manual Handling Operations Regulations 1992 [24], as amended. Guidance is given in HSE publication L23 [25].

Equipment and instruments conforming to BS EN 61010-1 are fitted with lifting and carrying handles if weighing 18 kg or more or are supplied with lifting and carrying instructions. The IET Code of practice for in-service inspection and testing of electrical equipment [26] suggests that equipment above 18 kg without lifting handles is classified as fixed equipment.

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 for weights lifted close to the body at elbow height.

4.6.1 Manual handling

Owners/operators should check that anyone who performs a lifting operation has been instructed in lifting techniques. Risks should be assessed for lifting/moving 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

Attention is drawn to the Lifting Operations and Lifting Equipment Regulations 1998 (LOLER) [27]. Guidance is given in HSE publication L113 [28].

Instrument personnel should participate in lifting operations using lifting equipment only if they are competent to do so and should operate lifting equipment 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 to equipment to be lifted, it should be verified that the manufacturer's test certificate is available. Eyebolts should not be overtightened or screwed into holes with a different thread form. Eyebolts should conform to BS EN ISO 3266.

4.7 Working at height

COMMENTARY ON 4.7

Attention is drawn to the Work at Height Regulations 2005 [29], which cover the owner's/operator's responsibilities regarding work at height. Guidance is given in HSE publication INDG401 [30].

A risk assessment should be undertaken on all tasks involving working at height; this should include the person(s) working at height and those who might be affected by those persons (i.e. people below).

Working at height should be avoided wherever possible.

Instrument personnel should only work at height (i.e. a place where there are no precautions in place to prevent a person falling a distance) if they have been trained and are competent to do so.

Ladders should only be used where they are safe and suitable for the work to be undertaken, in accordance with the risk assessment.

Lanyards should be used on all tools while working at height; equipment at height should be secured from falling, in accordance with the risk assessment.

Instrument personnel should report any defect or activity relating to work at height that they know is likely to endanger the safety of them or others. They should use the equipment in accordance with the instructions provided by their employer.

4.8 Safe access and egress

COMMENTARY ON 4.8

Attention is drawn to the requirements of the Workplace (Health, Safety and Welfare) Regulations 1992 [3], as amended for employers to ensure suitable and sufficient access to and egress from workplaces and health and welfare facilities and, so far as is reasonably practicable 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 and welfare facilities, including persons with disabilities.

Instrument personnel should take care not to block access and egress routes when installing equipment and cables. Floor sections removed to give access to underfloor cable rooms should be surrounded by suitable 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).

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 [31] to provide or use safety signs and signals, including fire safety signs. Management personnel also have a duty to provide employees with adequate training in the meaning of safety signs and signals, and the measures to be taken in connection with them.

Where verbal signals are used, either direct (by human voice) or indirect (by broadcast), management personnel are expected to verify that the persons involved have a sufficiently good knowledge of the language used and that the verbal skills of hearers is good enough so that they can be communicated with. Acoustic evacuation signals are expected to be continuous.

Attention is drawn to HSE publication L64 [32].

Rotary or hand bells are also acceptable types of alarm.

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

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

COMMENTARY ON 4.10

Dangerous substances and preparations 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; and*
- *are a material, biological agent or dust (above certain concentrations) with the potential to cause harm to the health of a person.*

Such substances and potentially explosive atmospheres are subject to the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) [33].

Instrument personnel should avoid areas where there is risk of the escape of hazardous substances and preparations from the plant.

Instrument personnel should not cross through, work in or enter places where there are dangerous substances or explosive hazards identified by warning signs or in site safety instructions, unless it is specifically covered in their permit to work and 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.

The owner/operator should put control measures in place to warn instrument personnel when high concentrations of hazardous atmospheres are present and, for inert gases, alarms to indicate oxygen depletion.

NOTE 1 These include monitors for combustible gas, toxic gas and oxygen.

Owners/operators should put control measures in place to allow for situations where gas escapes are not detectable by smell or where the sensory nerves in the nose can be desensitized by gradually increasing concentrations.

Where toxic gas would prevent instrument personnel from leaving the area, breathing equipment should be provided together with training in its use.

NOTE 2 See also 4.12, 4.15 and Clause 5.

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

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 [34].

Owners/operators should verify 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 the implementation of exposure reduction measures.

Owners/operators should verify that all instrument personnel likely to be exposed to mechanical vibration in the workplace are provided with adequate information and training.

4.11.2 Noise

COMMENTARY ON 4.11.2

Attention is drawn to the Control of Noise at Work Regulations 2005 [35].

Noise can be a significant health risk at work; it can also impact on warning signals (e.g. fire alarms) and should be taken into account when a risk assessment is carried out as part of the permit-to-work process. Owners/operators should check that site safety instructions contain procedures for the measurement of noise so that guidance limits for the protection of workers from their short- and long-term effects are not exceeded.

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

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

Owners/operators should check that instrument personnel only install instruments in noisy areas under strict control. Ideally, noisy plant and equipment should be switched off when instruments are installed.

4.11.3 Electromagnetic radiation

COMMENTARY ON 4.11.3

The control of occupational safety relating to electromagnetic radiation 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], and by reference to the ICNIRP guidelines [36].

Equipment used to install, or incorporated within, an installation is required to conform to the essential requirements of the EMC Regulations [22] and be UKCA marked accordingly. Unlike other product safety regulations, the essential requirements to be met are to place limits on electromagnetic emissions from equipment and to minimize susceptibility to the effects of existing electromagnetic radiation. Attention is drawn to the EPS Regulations 2016 [17] and the Supply of Machinery (Safety) Regulations 2008 [18], which set out EMC conformity in relation to hazardous area equipment and machinery.

EMC can be a significant health risk at work and should be taken into account when conducting a risk assessment as part of the permit-to-work process. This should include specific risks associated with workers' medical histories.

Owners/operators should check that site safety instructions contain procedures for the measurement of electromagnetic fields so that guidance limits for the protection of workers from their short-term effects are not exceeded.

NOTE 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 heaters, plasma etchers, radio frequency (RF) sputtering units, radio-frequency identification (RFID) systems, electronic surveillance equipment and broadcast/telecommunications equipment. Such equipment can cause interference with electronic instrumentation systems, particularly when doors are open or covers off.

Controls should be in place for working with or near such equipment, which should be detailed in the permit-to-work and associated risk assessment, together with controls (e.g. warning notices).

4.11.4 Optical radiation

COMMENTARY ON 4.11.4

The risks to health of personnel working with hazardous sources of artificial optical radiation are covered by the Control of Artificial Optical Radiation at Work Regulations 2010 [37].

4.11.4.1 General

Management personnel should check that procedures are in place to control the exposure of workers to all types of optical radiation (artificial and natural).

NOTE Optical radiation covers the ultraviolet, visible and infrared wavelengths, i.e. between 100 nm and 1 nm.

4.11.4.2 Artificial optical radiation

COMMENTARY ON 4.11.4.2

Attention is drawn to the Control of Artificial Optical Radiation at Work Regulations 2010 [37], which are based on the ICNIRP guidelines [36] and 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. Employers are expected to assess and control exposure, reduce risk, provide information and training, and make provisions for health surveillance for laser and broadband (non-coherent) sources of artificial optical radiation.

Protection from exposure to artificial optical radiation should be in place.

NOTE 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 4.3).

Laser equipment should conform to the classifications specified in BS EN 60825-1 and should be used in accordance with BS EN 60825-1 and PD IEC/TR 60825-14.

Free space optical communication systems used for the transmission of information should conform to BS EN IEC 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 BS EN ISO 11252.

Instrument personnel should be aware of the risks when using or installing lasers within areas where explosive atmospheres might exist.

Suitable eye protection should be worn when working with lasers. Laser eye protectors for adjustment work on lasers and laser systems should conform to BS EN 207.

4.11.4.3 Natural optical radiation

Instrument personnel working outside should have adequate protection against ultraviolet radiation, e.g. by wearing appropriate PPE (see 4.5).

NOTE Attention is drawn to HSE publication INDG147 [38].

4.12 Work in confined spaces

COMMENTARY ON 4.12

Attention is drawn to the Confined Spaces Regulations 1997 [39] where there is a risk of death or serious injury from hazardous substances or dangerous conditions (e.g. lack of oxygen). Examples of confined spaces include storage tanks, silos, reaction vessels, enclosed drains, sewers, open-topped chambers, vats, combustion chambers in furnaces, ductwork, and unventilated or poorly ventilated rooms.

Attention is drawn to HSE publications L101 [40] and INDG258 [41].

Employers are required to avoid the need for anyone to work in confined spaces wherever practicable. However, in certain circumstances, working in confined spaces is unavoidable, such as inside ducts, unvented or poorly vented rooms, behind wall panels and in areas where there is active gas-flooding fire extinguishing systems.

A risk assessment and site safety instructions should include requirements for working in confined spaces where there are risks from getting stuck, 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).

There should be 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. Prior to entry, a test to verify that oxygen levels are acceptable should be undertaken and recorded by a competent person.

Where there is a risk from toxic or flammable vapours, the atmosphere in the confined space should be tested and recorded by a competent person immediately before entry, using a correctly calibrated gas detector.

Where there is likely to be a change in the atmosphere, continuous monitoring should be employed.

Where there is a risk of potentially explosive atmosphere, a specific risk assessment should be undertaken, which should take into account the use of non-sparking tools and specially protected lighting.

Work involving welding, brazing or the use of solvents and glues should be avoided in confined spaces. Where this is not possible, the environment should be monitored (by a competent person) and work should be closely supervised and time restricted. The permit-to-work system should detail the associated risks and controls.

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 they are competent to do so.

NOTE Attention is drawn to the Confined Spaces Regulations 1997 [39], which requires that another competent person is outside the confined space and within sight and sound of the person inside.

Persons working in confined spaces and those outside monitoring the work should be instructed in all relevant emergency procedures and should have the necessary rescue equipment at the site of the work.

4.13 Pressure equipment

COMMENTARY ON 4.13

Attention is drawn to the Pressure Systems Safety Regulations 2000 [42] and the Pressure Equipment (Safety) Regulations 2016 [20] and to the HSE publication L122 [43].

Pressure equipment and assemblies meeting the requirements of the Pressure Equipment (Safety) Regulations 2016 [20] can be installed without any additional assessment (see 4.4.6 for further information).

Wherever possible, instrument personnel should only work on an instrumentation pressure system if it is safely isolated from the plant and depressurized. Where this is not possible, a permit-to-work system should be employed detailing the risks and control measures to be employed (see 4.3).

Measuring and control instruments and systems 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 their intended use.

NOTE 1 Attention is drawn to the Pressure Equipment (Safety) Regulations 2016 [20] which require that copies of the material manufacturer's certificates are compiled. These can be obtained from the instrument/pressure equipment, system or assembly manufacturer.

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 to process operators via the control system and/or locally, in accordance with the plant's working culture. 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. Exhaust ports of pressure-relieving devices should be directed away from access routes.

Magnetic float level gauges should be used in preference to gauge glasses, to avoid risk of injury from the glass breaking and the contents being ejected.

NOTE 2 The exception to this is where regulatory standards specifically require the use of gauge glasses.

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 according to a formal risk assessment, including a HAZOP, to identify the specific instrument and its installation to limit the risk to an acceptable level.

Where pressure equipment and systems are protected by safety instrumented systems (SISs), these systems should be designed and implemented in accordance with the [BS EN 61511](#) series for process industry applications. For nuclear applications, they should be designed in accordance with the standards required by the national nuclear regulator.

NOTE 3 An SIL-rated protection function does not require marking as a category IV device. SIF components (e.g. valve final elements) take the pipeline or vessel classification (predominantly categories I, II and III). SIF sensing elements, such as pressure transmitters, predominantly, do not require approval.

Safe means for isolation of instrumentation, control valves and final elements should be designed within the piping system according to the risk category, in accordance with HSG253, *The safe isolation of plant and equipment* [N1] and detailed within the permit to work. Isolation from the main piping system 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, as single valve isolation cannot be relied on.

NOTE 4 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 in accordance with local site work instructions.

Means for isolation, venting and calibration should also be provided within the instrument process hook-up on the instrument side of the piping system main isolation valves.

Where installation work necessitates breaking into instrument process lines (i.e. sample lines 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.

Pressure testing of instrument process lines should be done with fluids compatible with the process fluid and should not contaminate the interior of the impulse lines. Testing should only be carried out after disconnecting all instruments that might be damaged by the test pressure. The test pressure should be in excess of the maximum possible process pressure (150%) of the maximum plant design pressure.

4.14 Work on or with electrical systems and equipment

COMMENTARY ON 4.14

Attention is drawn to the Electricity at Work Regulations 1989 [44], which 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 HSE Guidance Note GS38 [45].

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 [12], as amended (see 4.4).

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 Guidance on live working in hazardous areas is given in the [BS EN 60079](#) series.

Wherever possible, all equipment should be isolated from its electrical supply before any work commences. Procedures should be in place to prevent the supply being reconnected while work is in progress. Appropriate and proven to be working voltage detectors should be used to confirm that the voltage has been disconnected before work commences. Isolation procedures should conform to [BS 6423](#).

4.15 Dangerous substances and potentially explosive atmospheres

COMMENTARY ON 4.15

Attention is drawn to the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) [33], which 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 HSE publication L138 [46].

Explosion prevention and detection measures should be implemented in accordance with [BS EN 1127-1](#). Equipment for use in hazardous areas should conform to the [BS EN 60079](#) series.

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.

NOTE See also 4.4.7 and 4.10.

4.16 Control of substances hazardous to health

COMMENTARY ON 4.16

Attention is drawn to the Control of Substances Hazardous to Health Regulations 2002 (COSHH) [47], which require employers to control substances that are hazardous to health.

During UK membership of the EU, the Registration, Evaluation, Authorisation and Restriction of Chemicals Regulations (EU REACH) [48] were implemented. They require that substances that are manufactured or imported be registered. They provide a regulatory framework to control or restrict the use of hazardous substances based on these registrations. This process was regulated by the European Chemicals Agency. The UK, on exit from the EU, implemented the UK REACH Regulations [49], which replicate EU REACH and provide a similar system operable in the UK market and provide interoperability with chemicals imports/exports between the UK and EU countries. The HSE is the regulator for UK REACH. EU REACH (and now UK REACH) requires that the hazards presented by chemicals are clearly communicated to workers and consumers. EU REACH remains in force in Northern Ireland.

The UK has adopted into post-Brexit law the Classification, Labelling and Packaging Regulations (GB CLP) [50], which is a UK enactment of the EU CLP Regulations. The GB CLP Regulations require that the United Nations "Globally Harmonized System of Classification and Labelling of Chemicals" (GHS) is followed in the UK.

Prior to commencing any instrumentation installation works, personnel should be made aware of all substances that are hazardous to health.

NOTE 1 Potential hazardous substances might be part of the workplace (e.g. manufacturing plant) and/or associated with the installation scope being executed.

The risks related to substances associated with the works should be taken into account as part of the permit-to-work system and controls set in place to minimize risk. This process should follow the hierarchy of hazard controls (elimination, substitution, engineering controls, administrative controls, use of PPE).

NOTE 2 Further information on hazard controls is given by the National Institute for Occupational Safety and Health (NIOSH), www.cdc.gov/niosh/index.htm.

COSHH safety datasheets should be used to establish hazards associated with all such substances.

NOTE 3 Hazardous substances commonly encountered in connection with instrumentation works include solids/fluids associated with a process, compressed air, pressurized hydraulic fluid, solvents, lubricants and adhesives.

4.17 Lone working

COMMENTARY ON 4.17

A lone worker is "someone who works by themselves without close or direct supervision". In the context of instrumentation installation works, lone workers are instrumentation personnel who work alone on an operational or construction site.

The owner/operator should check that instrumentation personnel who are lone workers follow the guidance given in HSE document INDG73(rev4) [N2].

4.18 Ionizing radiation and radioactive substances

4.18.1 General

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 use the supplied PPE (see 4.5), particularly dose rate monitors, and maintain records and logbooks accurately.

NOTE Instrument personnel working in radioactive controlled or supervised areas are required to undertake relevant training and security clearance.

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. Control procedures should be in place for the storage of manufacturers' instructions.

The storage of instructions provided in an electronic format should take into account:

- the level of security needed (to prevent unauthorized access, etc.);
- the type of storage device (e.g. disk, dongle, chip, etc.);
- the environment (i.e. radioactivity levels, etc.); and
- the need to register the date the data was released, its revision, etc.

4.18.2 Ionizing radiations

COMMENTARY ON 4.18.2

Attention is drawn to the Ionising Radiations Regulations 2017 [51].

Equipment generating ionizing radiations that might be encountered by instrument personnel that require specific authorization or 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; and
- radioactive sources required to implement radioactive measurement techniques, such as level measurement.

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

Instrument personnel should only work on or near ionizing radiation equipment when under the supervision of an RPS.

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

4.18.3 Radioactive substances

COMMENTARY ON 4.18.3

Owner/operators who store and use radioactive materials and mobile radioactive apparatus/sources, or who accumulate and dispose of radioactive waste, are required to register with the appropriate regulator, with some exceptions. Separate government agencies look after the registration/permitting process of such for England & Wales, Scotland and Northern Ireland.

Radioactive apparatus/sources are not subject to registration/permitting 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 $1 \mu\text{Sv h}^{-1}$ 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.

While a registration certificate/permit allows an owner/operator to hold radioactive apparatus/sources on site, the use and safety aspect of working with radiation is covered by separate regulations. In the UK, this is covered by the Ionising Radiations Regulations 2017 [51].

Owners/operators using radioactive apparatus or sources (such as for use within instrumentation detailed in 7.5.10) on their sites should obtain a permit or registration certificate from their regulator before they accept it on site.

NOTE 1 This requirement makes the authorities aware of every user of radioactive apparatus and sources, and the number and type of apparatus/sources they hold.

Owners/operators should follow the requirements of the permit/registration certificate such that the radioactive apparatus/sources are held securely and responsibly.

NOTE 2 This includes during receipt on site and storage prior to installation in final positions (e.g. within measurement instrumentation).

The owner/operator should verify that radioactive apparatus and sources are protected against accidental damage or loss and engage an RPS to check that the discharge of this duty is in line with regulations.

Instrument personnel should report to the supervisor any loss or damage to radioactive material or apparatus.

Instrument personnel should adhere to the control procedures and should only work with or near radioactive substances (including instrumentation sources) 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.

Radioactive sources securely attached to machines or other fixed equipment should be checked once a month and after maintenance or repair that could have affected the source. Portable radioactive sources should be checked daily.

Records should be kept of all checks.

NOTE 3 This subclause does not cover licence holders for nuclear installations.

4.19 Working with display screens

COMMENTARY ON 4.19

Workstations that contain 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 [52], as amended. Attention is also drawn to the HSE guidance, Working safely with display screen equipment [53].

This subclause does not cover office work with display screens.

The design, layout, dimensioning and environmental requirements and evaluation of control centres should be carried out in accordance with the [BS EN ISO 11064](#) series, 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 the [BS EN ISO 9241](#) series.

Work with display screens by instrument personnel is likely to be for long periods, especially during commissioning, so work should be planned to allow personnel to take breaks or change activity. Breaks should be taken for 5 min to 10 min 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 Attention is drawn to the requirement for employers to provide sight tests where problems arise as a result of working with display screens.

4.20 Work on construction sites

COMMENTARY ON 4.20

Attention is drawn to the Construction (Design and Management) Regulations 2015 [54], which 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 certain specified roles.

Where the installation of instrumentation is carried out on a construction site, instrumentation supervisors should be 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 check that these have been addressed before any installation work commences.

Instrumentation supervisors should check that all personnel under their control have been 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, including faulty PPE.

All instrument personnel should be informed of the site alarm and safety emergency evacuation procedures. This should include the position of safe havens and all local escape routes (in case one is blocked by the incident). They should be informed of the location of the associated site alarm call points, the method of initiating them, how to report the release and to whom (e.g. central control room). Designated instrument personnel should be trained in the operation of fire-fighting equipment for use when there is immediate risk to life.

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.

The precautions necessary for personnel safety are given in 4.4.7.

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

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

COMMENTARY ON 5.1

Attention is drawn to the legal requirement under the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) [33] to classify all areas where potentially explosive atmospheres can occur, and to install and use only suitable instrumentation. See 4.15 for further guidance.

Before starting work in an installation, the risk assessment identifying and classifying any hazardous areas should be made available (see BS EN IEC 60079-10-1 and BS EN 60079-10-2 for classification of hazardous areas). This should classify areas with a likelihood of potentially explosive gas atmospheres according to zone (0, 1 or 2), gas group and temperature class for above-ground installations. Areas with a likelihood of explosive mixtures of dust should be classified into dust zones 20, 21 or 22. All equipment to be installed or used in these areas should conform to the BS EN 60079 series. For above-ground gas applications, equipment should be suitable for the zone, gas group and temperature class of the hazardous area.

NOTE 1 Hazardous areas are classified into zones based on the frequency of the occurrence and the duration of an explosive gas atmosphere. In the case of a secondary release, the relevant zone is zone 2 (i.e. a place where an explosive atmosphere is not likely to occur in normal operation but, if it does occur, persists for a short period only). In areas where the ventilation is "high" relative to the leak size, BS EN IEC 60079-10-1 and BS EN 60079-10-2 recommend that the area classification is zone 2 but of negligible extent (NE). In such areas, equipment not conforming to the BS EN 60079 series can be used.

NOTE 2 Zone 2 Negligible Extent (Zone 2 NE) typically applies to low pressure gas applications, both external and internal, where sufficient dilution can be provided by natural ventilation. Such installations are addressed in IGEM/SR/25 [55]. Zone 2 NE can also be applied to secondary releases using forced ventilation based on the design method detailed in BS EN IEC 60079-10-1 and BS EN 60079-10-2 or for natural gas applications covered in HSE Publication RR630 [56].

NOTE 3 In plants where areas are broadly unclassified, particular attention is drawn to the identification of hazardous areas arising from isolated sources (e.g. a single primary element) and/or within a "thoroughfare" and could be overlooked.

Controls should be in place to prevent any equipment that does not conform to the [BS EN 60079](#) series being taken into a classified area. Such equipment should enter a classified area only if:

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

NOTE 4 This option is not preferred and is only to be considered where there is no suitable equipment available. Close cooperation is needed between the manufacturer, installer and person responsible for the installation's risk assessment.

- b) the area has been demonstrated as being free of an explosive atmosphere and "hot work" controls are in place.

NOTE 5 "Hot work" is work involving equipment or processes (e.g. grinding, welding) that might be a source of ignition.

NOTE 6 This option is typically used to allow maintenance of hazardous area equipment that conforms to the [BS EN 60079](#) series in a zone or to allow temporary access of non-conforming portable equipment.

NOTE 7 In areas where sources of ignition are continually present, such as furnaces and boilers, the basis of safety is through other control measures (typically relating to containment) rather than the designation of hazardous areas.

Extremely small apparatus and Ex (explosion-protected) 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.

Before installation begins in a classified hazardous area, it should be confirmed that the following items are available:

- 1) equipment manufacturer's declaration of conformity; and
- 2) instructions for the safe assembly, installation, commissioning, taking into service, operation, maintenance and decommissioning/dismantling.

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 should have a control system designed in the same manner as that of a non-mining application fired with landfill or natural gas.

NOTE 8 Mining and quarrying applications, particularly underground, are subject to statutory regulation and approval. Attention is drawn to the EPS Regulations 2016 [17] 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 Equipment protection levels (EPLs)

Where a risk assessment shows that the consequences of ignition might be greater or lesser than typical (perhaps because an installation is normally unoccupied and in an unpopulated area, or conversely in an area with a highly vulnerable population), the EPL requirements might change from those normally associated with the zone designations; in such circumstances, the required EPL should be explicitly identified on the area classification drawings.

NOTE The correspondence of equipment groups between [BS EN IEC 60079-0](#), the EPS Regulations 2016 [17] and [BS EN IEC 60079-10-1](#) and [BS EN 60079-10-2](#) are shown in [Table 1](#).

Table 1 — *BS EN IEC 60079-0 equipment groups*

BS EN IEC 60079-0		EPS Regulations 2016 [17]		BS EN IEC 60079-10-1 and BS EN 60079-10-2
EPL	Group	Equipment group	Equipment category	Zones of use
Ma	I	I	M1	N/A
Ma	I	I	M2	N/A
Ga	II	II	1G	0/1/2
Gb	II	II	2G	1/2
Gc	II	II	3G	2
Da	III	II	1D	20/21/22
Db	III	II	2D	21/22
Dc	III	II	3D	22

5.3 Electrical apparatus

The selection, installation, testing and inspection of electrical apparatus in hazardous areas should be carried out in accordance with [BS EN 60079-14](#) and [BS EN IEC 60079-17](#) for gases, vapours and dust.

When replacing equipment that conforms to the [BS EN 60079](#) series, the replacements should be in accordance with the current site zone classifications and the latest hazardous area equipment standards.

Electrical/electronic instruments containing hot process fluids incorporated in pipes running through potentially explosive gas areas should also be used with care. The instrument T class for such devices is often dictated by the maximum fluid temperature within the instrument; this should be checked to avoid exceeding the T class for the zone.

NOTE 1 Details of derating requirements for T Class are detailed on the Ex type examination certificate for the equipment.

Any special conditions detailed on Ex type examination certificates, indicated by a certificate number ending with an “X”, should be adhered to as part of the design, installation and inspections.

NOTE 2 Equipment that was placed on the market before the mandatory date of the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 [57] can still be put into use provided that a risk assessment has been carried out and it is deemed to be safe in accordance with the requirements of PUWER [12] (see 4.4 for further guidance).

5.4 Batteries, power packs and portable electrical equipment/tools

5.4.1 General

Controls should be in place to prevent personnel from taking batteries into hazardous areas, including spares for portable electric/electronic equipment. Batteries used in hazardous area apparatus should be replaced with batteries of the correct type, according to the apparatus manufacturer’s instructions, and be correctly fitted.

Procedures should be in place to check that:

- all new instruments and equipment using batteries contain the correct batteries and that spare/replacement batteries are also of the correct type; and
- all appliances that contain batteries have the manufacturer’s instructions for their safe removal and fitting.

5.4.2 Battery replacement

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

The replacement of batteries and power packs should be undertaken in accordance with the manufacturer's instructions and site safety approved process.

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

5.5 Non-electrical equipment

COMMENTARY ON 5.5

Attention is drawn to the terms of the Equipment and Protective Systems Intended for use in Potentially Explosive Atmospheres Regulations 1996 [57], which requires that non-electrical equipment placed on the market after the mandatory date can only be installed and used in hazardous areas if it has the Ex-h 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 requirements of [BS EN ISO 80079-36](#) and, if applicable, with the requirements as modified by the specific parts of [BS EN 60079](#) and [BS EN ISO 80079](#).

- a) The marking of the equipment should be with an "h". A level of protection is not applied to this, and the instructions should be referred to for the type of protection applied.
- b) All non-electrical equipment should meet the general requirements specified in [BS EN ISO 80079-36](#).
- c) Equipment for use in zones 0, 1, 2, 20, 21 and 22 should meet the requirements of [BS EN ISO 80079-37](#).

NOTE 1 Non-electrical types of protection are:

- constructional safety (c);
- control of ignition sources (b); and
- liquid immersion (k).

NOTE 2 Legacy systems are as follows:

- flameproof (d); and
- pressurization (p).

5.6 Specific precautions to be taken when working in hazardous areas

COMMENTARY ON 5.6

It might be appropriate to restrict the use of hand steel tools in zoned areas (without a "hot work" permit) due to the possibility of incendiary impact or friction sparks. It depends on the materials employed, the nature of the work environment, the nature of work undertaken, and the types of atmospheres that might arise. The use of tools made of spark-resistant materials might be appropriate in some circumstances.

Portable, transportable and powered hand-held equipment should only be used in areas appropriate to the type of protection, or where a “hot work” permit is issued. 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 60079-32-1](#).

Appropriate anti-static clothing and footwear should be worn when in a hazardous area not confirmed as free of an explosive atmosphere (see also [4.5](#)).

All warnings on equipment should be noted and procedures put in place to check that they are adhered to.

The taking/use of personal portable electronic devices, such as walkie talkies, mobile phones, remote controls, watches, cameras, laptops and tablets, into hazardous areas or near hazardous area apparatus should be controlled.

5.7 Hazardous area documentation required to support hazardous area equipment installation verification

All instrumentation should be verified, prior to the introduction of hazardous substances to the plant, to check the correct certification of equipment and that its installation conforms to the [BS EN 60079](#) series. These checks should be performed by suitably qualified and experienced personnel.

NOTE The following information can be used to support such checks:

- hazardous area drawings;
- hazardous areas equipment list;
- hazardous area test certificates/certificates of conformity;
- system conformity documents (i.e. IS descriptive system documents); and
- package equipment hazardous area files and declarations of conformity.

Typically, these documents can be used as part of an Explosive Protection Document (EPD).

6 Safety-related instrumentation

COMMENTARY ON CLAUSE 6

The recommendations in this clause are intended to enable the safety integrity level (SIL) for each safety function, specified in the project safety requirements specification (SRS), to be achieved during all stages: installation design, procurement, installation implementation, commissioning, installation modification and installation decommissioning.

6.1 Safety-related functions

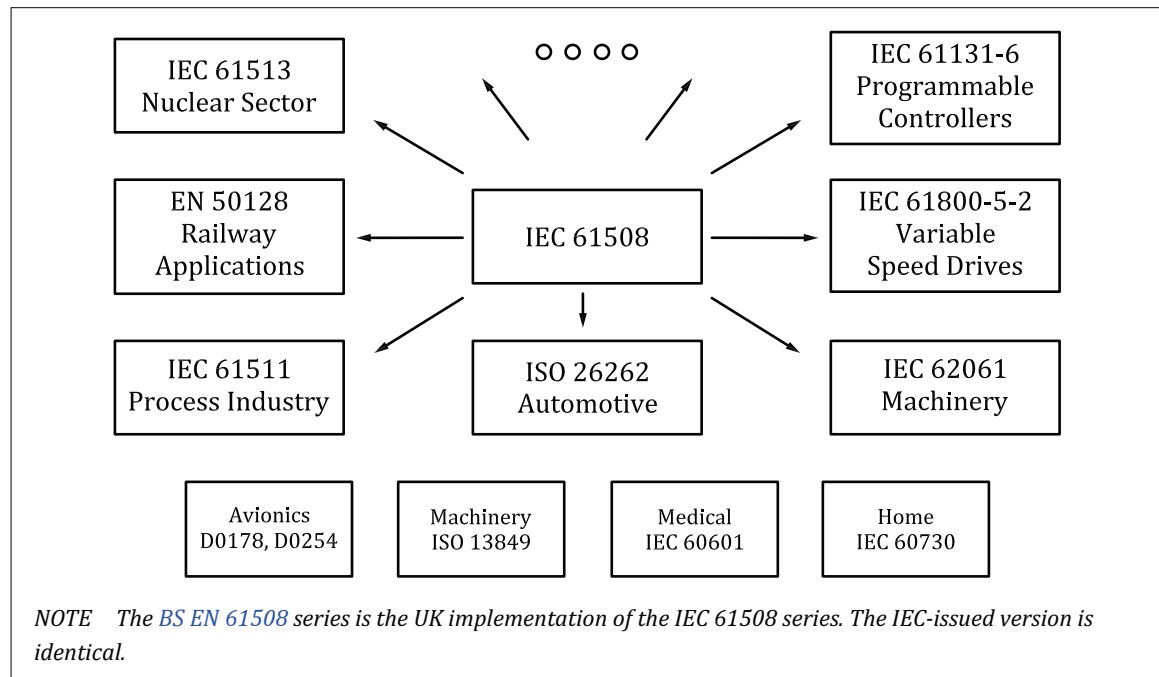
COMMENTARY ON 6.1

The [BS EN 61508](#) series contains the overarching functional safety standard guidance documents addressing the task of specifying and meeting acceptable risk criteria. They cover the two main approaches to functional safety. First, the quantitative approach targets risk in respect of random hardware failures; second, the qualitative approach assesses life cycle activities in order to address systematic failures. The latter invokes the SIL concept, whereby four levels of life cycle activity rigour are established and targeted based on the original quantitative targets. Examples of these activities are a functional safety management plan and the application of appropriate quality assurance to functional safety design, implementation, maintenance, modification and decommissioning activities. [Figure 2](#) illustrates the overarching nature of the guidance.

In the UK industry sector, corporate and professional bodies have also issued guidance documents providing “second-tier” interpretation of the [BS EN 61508](#) series. One relevant example is [IGEM/SR/15 \[58\]](#) covering the gas transmission and distribution industries.

The [BS EN 61511](#) series relates, chiefly, to installations within the process industries. [BS EN IEC 62061](#) is also applicable to some of the equipment installed within process industry installations.

Figure 2 — IEC 61508 (BS EN 61508) series and sector-specific functional safety standards



A machine installed as an integral part of a process should be assessed for low-demand hazardous events in accordance with the [BS EN 61511](#) series as part of the project execution process.

NOTE 1 The [BS EN 61511](#) series is concerned, predominantly, with low-demand mode process hazardous events, although it also provides guidance on dealing with continuous and high-demand scenarios. [BS EN IEC 62061](#) addresses only high and continuous demand-mode machinery risks.

The term “safety instrumented function” (SIF) is widely used when referring to individual protective functions implemented using electronic/programmable electronic instrumentation and systems; SIFs should be demonstrated as being sufficiently independent of any other protection layers (see the [BS EN 61511](#) series), such as those implemented within a control system or via mechanical devices.

NOTE 2 A safety instrumented system (SIS) consists of a number of SIFs. A SIS is designed to bring the process to a safe state when a hazardous condition occurs. It is a system that only activates when the process is going out of control. SIS protection is based on the integration of electrical/electronic/programmable electronic (E/E/PE) elements, to meet the defined requirements of the SIFs. Elements include:

- power supplies;
- primary element, i.e. input sensors (and/or other input devices);
- logic solver;
- secure logic solver communication network; and
- final element, i.e. a safety device that implements the physical action necessary to achieve or maintain a safe state (e.g. actuators, or other output devices).

NOTE 3 Duty holders are required to demonstrate that risks arising from personnel hazards in the process industries are as low as reasonably practicable (ALARP). SIFs may also be assessed in respect of providing risk reduction against environmental consequences and asset loss risk.

For applications in process industries, SIL rated SIFs should be designed, installed, maintained and, when required, modified in accordance with the functional safety management life cycle requirements in the [BS EN 61511](#) series.

Records should be generated by the design team implementing a SIF to allow for verification that the SIF requirements have been met at each stage of the life cycle and to provide final validation that SIFs meet the requirements as defined in the SRS. Functional safety assessments should be carried out by independent competent personnel at designated stages in the life cycle, in particular prior to proceeding to process commissioning.

NOTE 4 A SIL is a metric, based on the quantified integrity target, for assessing the degree of rigour required in respect of techniques for minimizing/mitigating systematic failures. It is derived from [Table 2](#) after a target PFD (probability of failure on demand) or failure rate has been established for each SIF. [Table 2](#) provides the SIL classification in accordance with the [BS EN 61508](#) series.

Table 2 — Target SIL classification in accordance with the [BS EN 61508](#) series

	Low-demand mode of operation (average probability of failure to perform its function on demand) ^{A)}	High-demand or continuous mode of operation (dangerous failures per hour) ^{B)}
SIL 4	≥ 10 ⁻⁵ to < 10 ⁻⁴	≥ 10 ⁻⁹ to < 10 ⁻⁸
SIL 3	≥ 10 ⁻⁴ to < 10 ⁻³	≥ 10 ⁻⁸ to < 10 ⁻⁷
SIL 2	≥ 10 ⁻³ to < 10 ⁻²	≥ 10 ⁻⁷ to < 10 ⁻⁶
SIL 1	≥ 10 ⁻² to < 10 ⁻¹	≥ 10 ⁻⁶ to < 10 ⁻⁵
^{A)} This column is appropriate for a low-demand (“trip”) function and the random hardware failure integrity is expressed in terms of probability.		
^{B)} This column is appropriate for a high-demand/continuous function and the random hardware failure integrity is expressed in terms of failure rate.		

6.2 Safety-related life cycle

The process under consideration should be risk assessed using process hazard analysis techniques. Risks should then be evaluated using a structured and quantified approach. An example of an approach typically used is layer of protection analysis (LOPA).

NOTE 1 More details on other viable methodologies (qualitative and quantitative) for SIL Determination can be found in [BS EN 61511-3:2017](#), Annex A to Annex F.

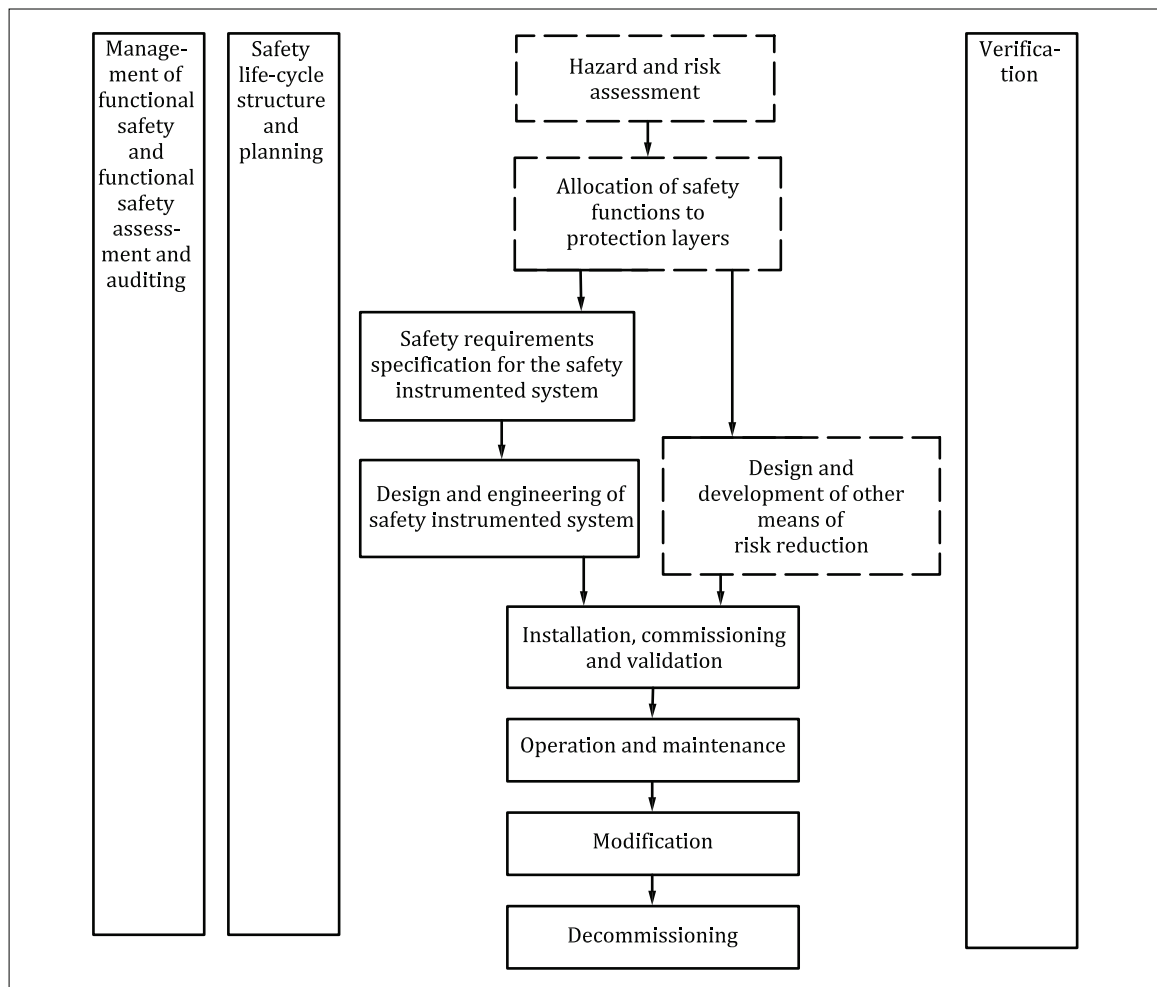
All risks need to be demonstrated to be ALARP.

NOTE 2 The setting of tolerable risk criteria used as the basis of determining the SIL for a SIF is the responsibility of the given duty holder.

NOTE 3 [Figure 3](#) outlines the functional safety management life cycle, as described in the [BS EN 61511](#) series.

Only competent persons should participate in activities involved in the functional safety life cycle of SIFs.

Personnel competency should form part of the overall functional safety planning activity and should be actively managed throughout the life cycle. Assessment of the application of functional safety for an installation should be carried out by competent persons with increasing levels of independence from the implementer the higher the level of preventative risk reduction applied. In other words, personnel involved in undertaking activities in the functional safety life cycle should be able to demonstrate training, knowledge and experience of undertaking the specific activities. The level of competency should be commensurate with the novelty, complexity, accountability and overall engineering requirements of the SIFs.

Figure 3 — Functional safety management life cycle, as described in the BS EN 61511 series

A functional safety management plan should be generated, as required by the BS EN 61508 series (and the BS EN 61511 series for the process industry), to include details of all those responsible for functional safety during the initial design, installation, verification and validation, and commissioning of the SIS, and to control any subsequent modifications. Where project-specific elements of the SIS are designed and implemented by sub-suppliers (e.g. the plant logic solver/safety-related software or machinery package SIS), such vendors should be assessed to verify that they have a compliant functional safety management system.

NOTE 4 It is recognized that relevant good practice, such as contained in HSE Approved Codes of Practice and Guidance, together with relevant standards properly applied within their scope, can play an important role in the achievement of good health and safety performance.

NOTE 5 In the context of electrical/electronic/programmable electronic (E/E/PE) functional safety, the BS EN 61508 series and the BS EN 61511 series (for process sector applications) provide guidance for determining whether a reasonably practicable level of safety has been achieved. Sector standards and specific industry standards or guidelines also provide relevant good practice.

All SIF components (i.e. sensing element, logic solver or final elements) should be chosen to conform through original design with the BS EN 61508 series or (if not originally designed to conform) supported by “prior use” (the BS EN 61511 series) or “proven in use” (the BS EN 61508 series) evidence of suitability. They should also have the required systematic capability demonstrated in accordance with routes 1S, 2S or 3S, as defined in the BS EN 61508 series, or “prior use” as defined in the BS EN 61511 series.

NOTE 6 The rigour required by the BS EN 61508 series to support such systematic capability claims increases with the target SIL of the SIF and with the magnitude of the risk reduction required by that component within the SIF architecture.

Where systems designed/installed before the publication of the BS EN 61508 series in 2002 are to be used in new projects (legacy systems), or existing systems are to be upgraded, there should be a review with the owner/operator to establish their functional safety characteristics and how they were assessed.

NOTE 7 Industry best practice documents are available to provide guidance in this area, including Guidance for management of legacy safety systems [59] and Guideline on functional safety management of installed safety instrumented systems [60].

Newly developed electronic components (e.g. primary elements/sensors, logic solvers and final elements), including those with software intended for use in safety-related functions, should be designed and implemented in accordance with the BS EN 61508 series. They should be supplied with a safety manual containing the safety parameters for the system designer to assess their suitability for use in the SIS and allow incorporation in the design. Third-party or manufacturer assessment reports should be made available to allow verification of the development and performance of such a component. This documentation should be retained within a safety justification file for the installation.

Safety manuals, installation instructions and operating manuals should be adhered to, taking into account any restrictions for use.

NOTE 8 In accordance with the BS EN 61508 series and the BS EN 61511 series, products, subsystems and installations do not require certification but do require adequate and appropriate evidence to demonstrate acceptability in line with these standards.

NOTE 9 Fire and gas (F&G) detection systems are usually not considered a SIS because they mitigate the effects of hazardous event as opposed to preventing it. However, in some cases gas detection systems could be considered a SIF, for example shutting HVAC (heating, ventilation and air conditioning) fire dampers on detection of gas external to a building, thereby preventing a potential hazardous event.

6.3 Installation and commissioning planning

6.3.1 Functional safety management

An installation and commissioning plan for the safety-related instrumentation should be developed to form an integral part of the safety system life cycle. The installation and commissioning of safety-related instrumentation should conform to BS EN 61508-1:2010, 7.9, 7.13 and 7.14, and/or BS EN 61511-1:2017+A1, Clause 14 and Clause 15. Records should be kept throughout the installation and commissioning activities, where all deviations from the safety plan and safety requirements specification (SRS) are logged and actioned with all other safety issues encountered.

6.3.2 Safety reviews

The installation and commissioning safety plan should include regular functional safety reviews during which all reported discrepancies, deviations and issues are analysed, resolved or, where necessary, reported upwards to the relevant authority. All safety reviews should be scheduled in the installation and commissioning safety plan.

6.3.3 Control and safety instrumentation segregation

COMMENTARY ON 6.3.3

For process plant control and safety systems, the SIFs and control functions are usually implemented in separate independent control and safety systems.

A device used by the control system should not also be used by the safety system where a failure of that device might result in both a demand on the SIF and a dangerous failure of the SIF, unless an analysis has been carried out to confirm that the overall risk is acceptable.

NOTE 1 For example, if a single valve was used to control vessel filling, and that valve stuck open, any high-level protection function making use of that valve would also be disabled. It is, however, acceptable to share elements where this would not compromise the safety function, e.g. the closing by a SIF of both a safety isolation valve and a valve usually operated by the control system. This would enhance the safety integrity over that achieved if just the isolation valve were used for protection purposes.

In some cases (e.g. packaged plant items such as boilers and compressors), control and safety functions can be located within a common logic solver; in such cases, the SIL target for the logic solver should match or exceed the maximum SIL target of the SIF(s) implemented in the logic solver.

Control functions implemented in a logic solver should be separated from SIL software and should be implemented in accordance with the [BS EN 61511](#) series. Where a control function is credited as a protection layer, in combination with a SIF, then sufficient independence should be demonstrated between the control and SIF functions. In particular, this should include sufficiently segregated sensors, final elements, cabling and terminations (see the [BS EN 61511](#) series). Common cause effects within the SIS (e.g. logic solver, power supplies) should be quantified to verify risk reduction targets are met.

The safety system functions should be sufficiently segregated from the control system functions in order to minimize the common cause failure. The risk of failure should be below that defined for the application. Segregation should include sensors, final elements, cabling, actuation piping, terminations, system cabinets, system power supplies and distribution.

NOTE 2 The [BS EN 61511](#) series allows for the implementation of SIFs of SIL 2 maximum within an uncertified general-purpose Programmable Logic Controller, provided that it can be demonstrated as meeting “prior use” requirements. This approach would usually be used for the implementation of SIFs within legacy systems. The same provisos as detailed for common logic solvers apply.

The instrumentation installation and commissioning testing should be designed such that the required segregation between the control and safety systems and loops implemented within them is maintained.

6.4 Safety function proof testing

SISs should be designed to support periodic proof testing in accordance with the [BS EN 61511](#) series.

To enable the specified SILs of each safety function to be met, a periodic safety function proof test should be performed.

NOTE The specific frequency of the proof test for each safety function is calculated based on:

- the target SIL;
- the reliability of the equipment in the safety function loop;
- the coverage and frequency of any online diagnostics provided;
- the proof test coverage to be achieved by the proof test procedure; and
- the mission time of the SIF equipment after which it is restored to the “as new” condition.

Where online diagnostics is credited, the mean time to restore (MTTR) the element affected by a revealed dangerous failure to healthy state should be included in the PFD calculation.

Where failure is revealed by a proof test, the mean repair time (MRT) for the affected element to be returned to a healthy condition should be included in the PFD calculation.

The installation of all parts of the safety system, including instrumentation, should accommodate the specified proof testing.

6.5 Redundancy

Where instrument redundancy is implemented as part of the calculated risk reduction, the installation should be such that it minimizes common cause failures.

NOTE This may be achieved by location, segregation, different manufacturers, or different technologies.

6.6 Cabling and piping

6.6.1 Segregation

Where practicable, all safety-related instrument cabling and piping should be segregated from control-related cabling and piping to prevent or minimize common cause failure from affecting the integrity of the safety system. Where this is not practicable, the control system cabling and piping should be designed, installed and maintained as if it was all part of the safety system.

6.6.2 Routing

Where redundancy is specified in the field equipment for a safety loop and/or system power supplies, the routing of the redundant paths of the cabling or piping should follow diverse paths where practicable to do so. The residual risk should be reduced as low as reasonably practicable (ALARP).

6.7 Digital communications

Any safety-related functions using communications as part of the SIF should be of sufficiently high safety integrity.

NOTE 1 Safety-related digital communications use the classifications "white channel" and "black channel". White channel communications inherently provide a sufficient degree of integrity for secure applications. All usual fieldbus communications are black channel. A number of fieldbus profiles for safety-related applications are identified in [BS EN IEC 61784-3](#). These achieve white channel performance by adding additional design features and protocol checks to the basic fieldbus.

NOTE 2 Black channel communications are common, as the integrity is not affected by communication devices in the network, therefore standard communications equipment can be used subject to performance limitations being addressed.

NOTE 3 Fieldbuses certified for safety are available. Such buses are generally applied to communications between safety controllers or to remote input/output systems. However, they may be used to connect to individual devices.

6.8 Identification

All equipment required to implement a safety function should be clearly identified as safety related.

7 Primary elements

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 selected so that the reading or output obtained is truly representative of the variable being measured.

7.1 General

The design and installation of process sensors used in functional safety applications should be designed (where possible) to allow complete “end-to-end” proof testing, with a preference for using the process medium as the test medium or proving that the process medium acts without decrement on the sensor.

7.2 Flow measurement

7.2.1 General

COMMENTARY ON 7.2.1

There are many types of flow measurement devices 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.

Depending on meter type and flow measurement requirements, density, temperature or pressure measurements are employed close to the flowmeter to allow corrections to a 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 7.2.2 to 7.2.11 as appropriate.

For high accuracy applications (i.e. fiscal or custody applications), 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 to be disassembled 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.

NOTE 1 It might be advisable to document bolt 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.

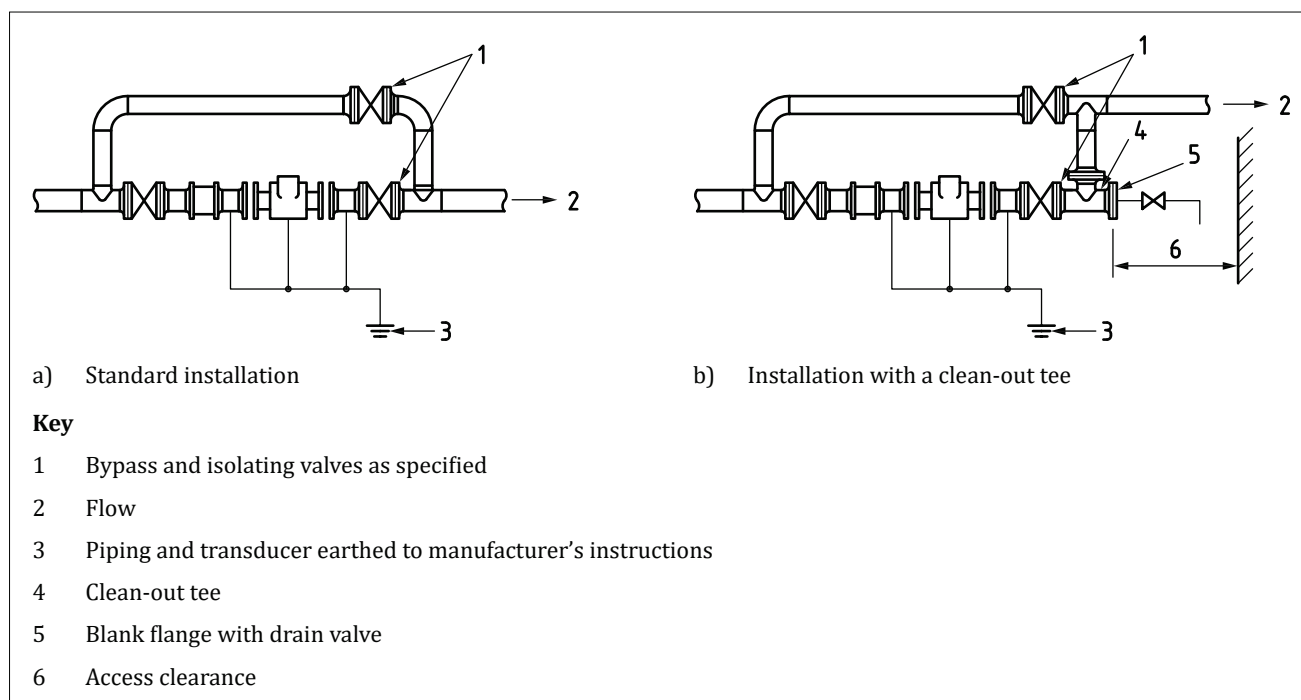
NOTE 2 Failure either to deliver the parts in a controlled manner or to precisely replicate the assembly at installation might render the calibration certificate invalid.

All flow-measuring devices should be installed precisely according to the design requirements and no alteration should be made without prior reference to the responsible instrument engineer.

NOTE 3 This applies particularly to straight-pipe length requirements upstream and downstream of the device.

The instrument manufacturer's 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.

NOTE 4 Where flow interruption for maintenance or for zero checking is not acceptable, bypass pipework may be incorporated. Examples of arrangements are shown in Figure 4. If a clean-out tee is required, the recommended arrangement is shown in Figure 4b). These arrangements are not suitable for continuous custody transfer or fiscal measurement, however, which require two 100% meters to be employed.

Figure 4 — Typical in-line flowmeter installations

7.2.2 Custody transfer and fiscal metering

COMMENTARY ON 7.2.2

Custody transfer and fiscal meter systems can measure either mass flow rate directly (Coriolis meters) or volumetric flow rate. Volumetric flow rate is measured at flowing conditions (i.e. pipeline pressure and temperature) and requires correction to standard reference conditions. Volume flowmeters either measure volume flow directly (positive displacement meters and turbine meters), measure fluid velocity (ultrasonic meters) or derive volume flow from pressure drop measurements across accurately machined restrictions in the line (orifice plates, Venturi, etc.). Mass flow, direct volume meters and velocity meters in custody transfer or fiscal service all require calibration using specialist facilities (either offsite facilities, master meters or provers) which determine meter measurement uncertainty against known references. Depending on meter type density, temperature and pressure measurements are employed close to the flowmeter or incorporated within a multivariable device. Corrections to standardized sets of conditions may be made by interfacing these instruments to a flow computer.

For best performance, the meter (and associated pipework where possible) should be calibrated on similar fluid at close to line conditions.

NOTE 1 *Otherwise, corrections can be applied when the meter application is different to calibration conditions. Some meters are more susceptible to difference in fluid properties than others.*

For some indirect flow measurement methods, where external calibration is deemed impractical (e.g. large orifice plates), the geometry and accurate dimensions of the meter installations are critical; in these instances, such dimensions should be periodically checked, and corrections made within empirical flow algorithms to allow for wear.

NOTE 2 *Some indirect flow measurement meters, such as venturi meters, require external calibration against a standard to correct for wear. Some meters require measurement or calculation of fluid density at operating conditions to achieve the lowest uncertainty in operation.*

Measurements for correction should be made so that they are representative of the whole flow or average across the full pipe flow profile. Installation of devices for these correction measurements should be in accordance with 7.2.1 and 7.2.3 to 7.2.11, as appropriate.