PRESSURE REGULATING INSTALLATIONS FOR NETWORK PIPELINE SYSTEMS, PIPELINES AND PIPES

DRAFT FOR COMMENT

1 This draft Standard IGEM/TD/13 Edition 2 has been prepared by a Panel under the chairmanship of Les Harris.

2 This Draft for Comment is presented to Industry for comments which are required by Friday 23rd October 2009, and in accordance with the attached Reply Form.

3 This is a draft document and should not be regarded or used as a fully approved and published Standard. It is anticipated that amendments will be made prior to publication.

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Attached is the Draft for Comment of IGEM/TD/13 Edition 2 – “Pressure regulating installations for Network pipeline systems, pipelines and pipes” and the associated comment form.

Organisations to which this Draft has been circulated:
AIGT
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BSi
DNO Collaboration Forum
Energy Institute
ENA
EU Skills
Gas Forum
GIRSAP
GISG
Gas Safe
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Pressure regulating installations for Network pipeline systems, pipelines and pipes

Draft for Comment
Pressure regulating installations for Network pipeline systems, pipelines and pipes

Draft for Comment
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SECTION 1 : INTRODUCTION

1.1 This Standard revises and supersedes the Recommendations on Transmission and Distribution Practice IGE/TD/13, Communication 1672 which is obsolete.

This Standard now incorporates the updated content of IGE/SR/9 Edition 2, Communication 1654, which is obsolete.

1.2 This Standard complements, as far as practicable, the requirements of BS EN 12186 and BS EN 12279, the equivalent European Standards on which IGE/TD/13 provides more specific requirements.

Note: A limited number of the individual requirements prescribe a more stringent standard than BS EN 12186 and BS EN 12279 to reflect United Kingdom (UK) practice.

1.3 This Standard has been drafted by a Panel appointed by the Institution of Gas Engineers and Managers’ (IGEM’s) Gas Transmission and Distribution Committee, subsequently approved by that Committee and published by the authority of the Council of IGEM.

1.4 This Standard applies to the safe design, construction, inspection, testing, operation and maintenance of pressure regulating installations (PRIs) in accordance with current knowledge and operational experience.

The Standard reflects the need to ensure adequate reliability and continuity of supply at pressures that are safe for the downstream system and equipment.

1.5 This Standard now addresses Natural Gas, liquefied petroleum gas (LPG) and LPG/air. As a result, the scope of this Standard is shown in Table 1.

<table>
<thead>
<tr>
<th>GAS</th>
<th>MOP (bar)</th>
<th>PIPE SIZE (mm)</th>
<th>MAXIMUM CAPACITY (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td>≤ 100</td>
<td>No limit</td>
<td>No limit</td>
</tr>
<tr>
<td>LPG</td>
<td>≤ 16</td>
<td>No limit</td>
<td>No limit</td>
</tr>
<tr>
<td>LPG/air</td>
<td>≤ 2</td>
<td>No limit</td>
<td>No limit</td>
</tr>
</tbody>
</table>

MOP is maximum operating pressure

TABLE 1 - SCOPE OF IGE/M/TD/13 EDITION 2

In addition, significant changes have been made to this Standard including the addition of specific requirements for “small” PRIs as defined in Table 2.

<table>
<thead>
<tr>
<th>GAS</th>
<th>MOP (bar)</th>
<th>PIPE SIZE (mm)</th>
<th>MAXIMUM CAPACITY (m³ h⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td>≤ 7</td>
<td>No limit</td>
<td>200</td>
</tr>
<tr>
<td>LPG</td>
<td>≤ 16</td>
<td>28</td>
<td>80</td>
</tr>
<tr>
<td>LPG/air</td>
<td>≤ 2</td>
<td>50</td>
<td>310</td>
</tr>
</tbody>
</table>

TABLE 2 - DEFINING A “SMALL” PRI
1.6 It is now widely accepted that the majority of accidents in industry generally are in some measure attributable to human as well as technical factors in the sense that actions by people initiated or contributed to the accidents, or people might have acted better to avert them.

It is therefore necessary to give proper consideration to the management of these human factors and the control of risk. To assist in this, it is recommended that due cognisance be taken of HS(G)48.

1.7 This Standard makes use of the terms “should”, “shall” and “must” when prescribing particular requirements. Notwithstanding Sub-Section 1.9:
- the terms “must” identifies a requirement by law in Great Britain (GB) at the time of publication
- the term “shall” prescribes a requirement which, it is intended, will be complied with in full and without deviation
- the term “should” prescribes a requirement which, it is intended, will be complied with unless, after prior consideration, deviation is considered to be acceptable.

1.8 The primary responsibility for compliance with legal duties rests with the employer. The fact that certain employees, for example “responsible engineers”, are allowed to exercise their professional judgement does not allow employers to abrogate their primary responsibilities. Employers must:
- have done everything to ensure, so far as is reasonably practicable, that there are no better protective measures that can be taken other than relying on the exercise of professional judgement by “responsible engineers”
- have done everything to ensure, so far as is reasonably practicable, that “responsible engineers” have the skills, training, experience and personal qualities necessary for the proper exercise of professional judgement
- have systems and procedures in place to ensure that the exercise of professional judgement by “responsible engineers” is subject to appropriate monitoring and review
- not require “responsible engineers” to undertake tasks which would necessitate the exercise of professional judgement that is beyond their competence. There should be written procedures defining the extent to which “responsible engineers” can exercise their professional judgement. When “responsible engineers” are asked to undertake tasks which deviate from this, they should refer the matter for higher review.

1.9 This Standard does not attempt to make the use of any method or specification obligatory against the judgement of the responsible engineer. Where new and better techniques are developed and proved, they should be adopted without waiting for modification of this Standard. Amendments to this Standard will be issued when necessary and their publication will be announced in the Journal of IGEM and other publications as appropriate.

1.10 Requests for interpretation of this Standard in relation to matters within its scope, but not precisely covered by the current text, may be addressed to Technical Services, IGEM, IGEM House, 28 High Street, Kegworth, Derbyshire, DE74 2DA, and will be submitted to the relevant Committee for consideration and advice, but in the context that the final responsibility is that of the engineer concerned. If any advice is given by or on behalf of IGEM, this does not imply acceptance of any liability for the consequences and does not relieve the responsible engineer of any of his or her obligations.
SECTION 2 : SCOPE

2.1 This Standard covers the design, construction, inspection, testing, operation and maintenance of any PRI installed as below and whose extent is shown in Figures 7(a), (b) and (c).

2.2 This Standard covers any PRI containing Natural Gas that is installed in a Network pipeline, i.e:
- a transmission pipeline (whose design is in accordance with IGEM/TD/1) or
- a distribution main (whose design is in accordance with IGE/TD/3) or
- a service (whose design is in accordance with IGE/TD/4).

This Standard covers any PRI containing LPG or mixtures of LPG and air, that is installed in a distribution main whose design is in accordance with IGE/TD/3 or in service pipework whose design is in accordance with IGE/TD/4.

Note 1: For regulating installations downstream of an emergency control valve (ECV) (which defines the end of the Network as in IGEM/G/1 (Natural Gas) or downstream of a distribution main or service pipework (LPG and LPG/air)), and which are associated with a meter installation, the relevant standards are IGE/GM/4, IGEM/GM/6, IGE/GM/8, BS 6400-1, BS 6400-2 (all for Natural Gas) and BS 6400-3 (for LPG), as appropriate. There are no recognised, equivalent, Standards to the IGE/GM Standards where LPG or LPG/air is used. The principles of the IGE/GM Standards may be applied. Where it is required to install a PRI downstream of an ECV or downstream of a distribution main or service not associated with a meter installation, the principles of this Standard may be applied. See also Figures 1, 2 and 3.

Note 2: Minimum requirements are contained in appropriate normative standards (see Figures 1, 2 and 3).

2.3 This Standard covers PRIs of MOP not exceeding:
- for Natural Gas, 100 bar
  Note: Higher MOP may be accommodated, in which case specialist advice needs to be sought in addition to adopting the principles of the Standard.
- for LPG, 16 bar
- for LPG/air, 2 bar.

2.4 This Standard covers PRIs of operating temperature:
- for Natural Gas, between -20°C and 120°C
- for LPG, between -20°C and 50°C
- for LPG/air, between -20°C and 50°C.

2.5 This Standard covers PRIs containing gases in the vapour phase. This Standard does not address gases in the liquid phase.

2.6 There is no intention that this Standard be applied retrospectively. However, for inspection, testing, operation and maintenance, IGEM/TD/13 Edition 2 can be applied to existing PRIs that were designed and constructed to IGE/TD/13 Edition 1, IGE/TD/9 or IGE/TD/10, but it may be necessary to continue some operations in accordance with those Recommendations.

Note: There are no equivalent obsolete IGEM Standards for PRIs operating on LPG or LPG/air.

2.7 This Standard covers PRIs as shown in Figure 7.

2.8 This Standard covers PRIs handling odorised or unodorised gases.

2.9 All pressures quoted are gauge pressures unless otherwise stated.

2.10 Italicised text is informative and does not represent formal requirements.
2.11 Appendices are informative and do not represent formal requirements unless specifically referenced in the main sections via the prescriptive terms “should”, “shall” or “must”.

**FIGURE 1 - SELECTION OF STANDARDS (NATURAL GAS)**

GS(I&U)R is Gas Safety (Installation and Use) Regulations.
GS(I&U)R is Gas Safety (Installation & Use) Regulations.

**FIGURE 2 - SELECTION OF STANDARDS (LPG)**
GS(I&U)R is Gas Safety (Installation & Use) Regulations.

**FIGURE 3 - SELECTION OF STANDARDS (LPG/AIR)**
SECTION 3 : COMPETENCY AND QUALITY ASSURANCE

Acronyms and abbreviations

PRI = pressure regulating installation

3.1 COMPETENCY

Any person engaged in the design, construction, commissioning, inspection, operation, maintenance or alteration of a PRI shall be competent to carry out such work.

Note: This may be achieved by an appropriate combination of education, training, and practical experience.

3.2 QUALITY ASSURANCE

3.2.1 Materials

3.2.1.1 All materials and equipment shall be selected to ensure safety and suitability for the conditions of use, in accordance with relevant legislation, standards, technical specifications and this Standard.

Note: It is recommended that all materials and components be obtained from suppliers operating a quality system in accordance with BS EN ISO 9000, to ensure that products consistently achieve the required levels of quality.

3.2.1.2 Arrangements shall be made to ensure that materials and workmanship are in accordance with the construction specification.

3.2.1.3 Materials shall be suitable for the anticipated range of operating temperatures.

3.2.2 Inspection

Particular emphasis shall be placed on the inspection of materials, welding, coatings and testing. Any workmanship or materials not in accordance with this Standard or the construction specification shall be rejected.
SECTION 4 : LEGAL AND ALLIED CONSIDERATIONS

Acronyms and abbreviations

- CAD = Chemical Agents Directive
- CDM = Construction (Design and Management) Regulations
- COSHH = Control of Substances Hazardous to Health Regulations
- DSEAR = Hazardous Substances and Explosive Atmospheres Regulations
- EC = European Community
- GB = Great Britain
- GS(M)R = Gas Safety (Management) Regulations
- GT = gas transporter
- HMSO = Her Majesty’s Stationery Office
- HSWA = Health and Safety at Work etc. Act
- HSE = Health and Safety Executive
- MAFF = Ministry of Agriculture, Fisheries and Food
- MHSWR = Management of Health and Safety at Work Regulations
- PED = Pressure Equipment Directive
- PER = Pressure Equipment Regulations
- PRI = pressure regulating installation
- PSR = Pipelines Safety Regulations
- PSSR = Pressure Systems Safety Regulations
- PUWER = Provision and Use of Work Equipment Regulations
- RIDDOR = Reporting of Injuries, Diseases and Dangerous Occurrences Regulations
- SSSI = Sites of Specific Scientific Interest

Units

- barg = bar gauge

The matters dealt with in this section refer to legislation and their application to all aspects of PRI design, planning, construction and operation. Reference to specific legislation in Great Britain (GB) is made in Appendix 2.

4.1 GENERAL

4.1.1 European Community (EC) Legislation

In countries within the EC, it shall be ascertained, at the planning stage, whether the PRI is likely to be subject to EC legislation.

4.1.2 National and local legislation

Consideration must be given to relevant national and local legislation, which may control, regulate or protect, for the PRI:

- its location
- its specification
- the methods and procedures for its construction
- the various authorisations, consents, or permissions, whether from owners or occupiers of land through which the pipeline is laid or from private/public organisations having a function or interest in its construction
- its environmental impact.

4.2 GREAT BRITAIN (GB)

The matters in this sub-section are set out by reference to legislation in force in GB at the time of publication.

4.2.1 Gas Acts

4.2.1.1 Gas Act 1986

The construction of offtakes and pressure reduction stations is an activity which a GT is entitled to undertake under the Gas Act as amended.
In certain circumstances, GTs have powers to place structures and apparatus near houses, in streets.

4.2.1.2 **Gas Act 1995**

The Gas Act 1995 updates provisions in the Gas Act 1986, including licensing arrangements for GTs so permitting competition.

4.2.1.3 **LPG and LPG/air**

GT/MB and GS to provide a paragraph for each.

4.2.2 **Land and planning**

4.2.2.1 It is advisable to obtain legal advice when proposing to develop land for above-ground installations.

4.2.2.2 GTs have power to obtain by negotiation the freehold or leasehold interest in land required for above-ground installations.

4.2.2.3 Whether a GT needs planning permission depends on the size of any structure which houses the PRI and/or on whether it is sited on land. The Town and Country Planning (General Permitted Development) Order provides the requirement. Any non-GT always need planning permission. This Order addresses the installing of a PRI underground.

4.2.2.4 Where an above ground PRI, including buildings housing pipelines, and associated apparatus, are to be constructed, planning permission must, generally, be sought.

4.2.3 **Nature conservation**

4.2.3.1 **Forestry Act**

By the Forestry Act, a licence from the Forestry Commissioners is not required for the felling of trees where the felling is immediately required for the purpose of carrying out permitted development but, where a tree preservation order under the Town and Country Planning Act is in force, the consent of the local authority must be obtained.

4.2.3.2 **Wildlife and Countryside Act**

This act details the protection given to birds, other animals and plants. It states the duties of the County Councils to establish Sites of Special Scientific Interest (SSSIs) to protect flora, fauna, geological or physiographic features and details the procedures to protect these sites.

4.2.3.3 **Countryside Act and The Countryside (Scotland) Act**

These Acts lay a duty on the Government, local authorities and other public bodies to have regard to the desirability of conserving the natural beauty and amenity of the countryside.

4.2.4 **Water**

Under The Water Resources Act, the necessary consents must be obtained from the appropriate authority for the supply and disposal of water for hydrostatic testing, including the time, point and rate at which water may be drawn.
4.2.5 **Pollution**

4.2.5.1 *Environmental Protection Act*

The provisions in Part 111 of this act empower a local authority in England and Wales to control statutory nuisances such as dust, fumes and noise.

4.2.5.2 *Control of Pollution Act*

Part 1 of this act covers the disposal of wastes which are poisonous, noxious or polluting and likely after disposal on land to give rise to an environment hazard. The disposal of waste to which the act applies must be notified to the waste regulation authorities. Regulations have been made exempting from the act the disposal of earth and ordinary construction waste.

Disposal of non-toxic waste water may be subject to special conditions and the advice of the authority responsible should be sought.

Part 111 of this act concerns the control of noise. Local Authorities are empowered to control noise during works of construction.

4.2.5.3 *Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations*

These Regulations cover oil and gas pipeline installations under certain criteria. If covered, development rights are lost and planning permission is needed along with an environmental impact assessment.

4.2.6 **Farm animals**

4.2.6.1 *Disease of Animals Act*

Orders made under this act may regulate operations in infected areas and places, and in relevant cases the Ministry of Agriculture, Fisheries and Food (MAFF) will advise. Special attention is drawn to the rules to be observed in an ‘infected place’ contained in Article 7 of the Foot and Mouth Disease (Packing Materials) Order of 1983.

4.2.6.2 *Foot and Mouth Disease (Packing Materials) Order*

Unsterilized hay and straw must not be deposited on agricultural land and all such packing materials brought onto the site should be certified as sterilised by the supplier.

Further details and advice may be obtained from the Land Use Planning Unit, MAFF.

4.2.7 **The Health and Safety at Work etc. Act (HSWA)**

HSWA sets out general duties which employers have towards employees and members of the public, and employees have to themselves and to each other. It is also the “umbrella” under which safety regulations are made, for example:

4.2.8 **Management of Health and Safety at Work Regulations (MHSWR)**

MHSWR apply to all work activities require, among other things, that employers assess the risks to the health and safety of their employees and of persons not in their employment but who may be affected by their activities and then to make appropriate arrangements for preventative and protective safety measures.
4.2.9  **Construction (Design and Management) Regulations (CDM)**

CDM place a duty on clients, designers, planners supervisors and contractors to take health and safety matters into account and manage them effectively from the planning stage of a construction project through to commissioning and beyond.

4.2.10  **Gas Safety (Management) Regulations (GS(M)R)**

GS(M)R deal with the safe management of gas, whether a single system or a network of connected systems. It is unlawful for gas to be conveyed in a system or network without a safety case being prepared by the GT and accepted by the Health and Safety Executive (HSE).

4.2.11  **Pressure Systems Safety Regulations (PSSR)**

4.2.11.1 PSSR impose duties on designers, importers, suppliers, installers and users or owners to ensure that pressure systems do not give rise to danger. This is done by the correct design installation and maintenance, provision of information, operation within safe operating limits and, where applicable, examination in accordance with a written scheme of examination drawn up or approved by a competent person (as defined by PSSR).

4.2.11.2 Relevant fluids for the purpose of this document would be Natural Gas at a pressure greater than 0.5 bar above atmospheric pressure. A pressure system would include bulk storage tanks, pressure vessels, pipelines and protective devices. Once the pressure in the pipework drops below 0.5 barg, and the user/owner can show clear evidence that the system does not contain, and is not liable to contain, a relevant fluid under foreseeable operating conditions, then that part of the system is no longer covered by PSSR. This is likely to be the case after the pressure relief valve associated with a pressure reducing valve which takes the pressure to below 0.5 barg, for example at the entry to a building.

Note the special requirements placed on protective devices in such systems (see para 110b of HS(L)122). PSSR also apply to pipelines and their protective devices in which the pressure exceeds 2 barg (see Sch 1 part 1 item 5 of HS(L)122).

More information is available in HS(L)122 and in the HSE free leaflets INDG 261 and INDG 178.

4.2.11.3 Inspection is the process that ensures that the installation is suitable for further operation within the design or performance limits specified by the designer or competent person.

4.2.11.4 It shall be determined whether an installation is within the scope of PSSR and, if so, safe operating limits shall be specified and written schemes of examinations must be available prior to commissioning.

4.2.12  **Pipelines Safety Regulations (PSR)**

PSR apply to all pipelines and are designed to ensure that pipelines are designed, constructed, operated, maintained and decommissioned safely. Above-ground installations, including PRIs, are considered to be included in the definition of “pipeline” and are subject to PSR.

4.2.13  **Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)**

RIDDOR require employers to notify certain injuries, diseases and dangerous events. Certain gas and pipeline related incidents are reportable.
Further details, advice and guidance on health and safety matters can be obtained from HSE. Initial contact may be made via the local HSE Area Office (details of which are listed in the published guidance to RIDDOR and local telephone directories).

4.2.14 Dangerous Substances and Explosive Atmospheres Regulations (DSEAR)

These Regulations incorporate:
- ATEX Directive 94/9/EC (ATEX 95) – Safety of Apparatus
- ATEX Directive 99/92/EC (137A) – Safety of Installation
- Chemical Agents Directive (CAD) 98/24/EC.

DSEAR are concerned with protection against risks from fire, explosion and similar events arising from dangerous substances used or present in the workplace. DSEAR require that risks from dangerous substances are assessed, eliminated or reduced. They contain specific requirements to be applied where an explosive atmosphere may be present and require the provision of arrangements to deal with accidents, emergencies etc. and provision of information, training and use of dangerous substances. DSEAR also require the identification of pipelines and containers containing hazardous substances.

The following publications contain details of DSEAR and their application:
- HS(L)138
- HS(L)137
- HS(L)136
- HS(L)135
- HS(L)134
- INDG 370.

4.2.15 Provision and Use of Work Equipment Regulations (PUWER)

4.2.15.1 Work equipment has a wide meaning and includes tools such as hammers, laboratory apparatus, for example Bunsen burners, ladders, photocopiers, lifting equipment and machinery for use at work.

4.2.15.2 PUWER place duties on employers in relation to selection, suitability, maintenance, inspection, installation, instruction and training, prevention of danger and control of equipment.

4.2.15.3 More information on PUWER can be found in HS(L)22. Free leaflets include INDG 291 and INDG 229.

4.2.16 Electricity at Work Regulations

These Regulations apply to a wide range of electrical work, from overhead power lines to the use of office computers and batteries and include work on gas equipment using electrical energy.

They are concerned with the prevention of danger from electric shock, electric burn, electrical explosion or arcing, or from fire or explosion initiated by electrical energy.

They impose duties on every employer, employee and self-employed person and require that persons engaged in electrical work be competent or be supervised by competent persons.
4.2.17 **Control of Substances Hazardous to Health Regulations (COSHH)**

4.2.17.1 COSHH, which reinforce existing statutory obligations under HSWA, impose a duty on employers to protect employees against risks to health, whether immediate or delayed, arising from exposure to substances hazardous to health, either used or encountered, as a result of a work activity. They also impose certain duties on employees.

4.2.17.2 Under COSHH, work must not be carried out which is liable to expose employees to hazardous substances unless the employer has made a suitable and sufficient assessment of the risk created by the work and the steps that need to be taken to comply with COSHH. After assessing the risk, it is necessary to inform employees of the risks and to carry out the appropriate training and instruction to ensure the risks are minimised. In certain cases, control measures such as ventilation or personal protective equipment may be necessary and, where provided, they must be used.

4.2.18 **Pressure Equipment Directive (PED) and Regulations (PER)**

PED applies to the design of pipework of MOP exceeding 0.5 bar which is designed and installed for a site user, for example a factory occupier. PED is implemented in the UK by the Pressure Equipment Regulations (PER) and PSSR. Compliance with PED can be demonstrated by the use of a harmonised standard. BS EN 15001-1 and -2 have been specifically prepared for the gas industry and include a wide range of materials. Systems falling within the scope of PED must display a CE mark and this must be affixed by an approved person or body.
SECTION 5: PLANNING, LOCATION, LAYOUT AND SECURITY

Acronyms and abbreviations

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>CCTV</td>
<td>closed circuit television</td>
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<tr>
<td>DSEAR</td>
<td>Dangerous Substances and Explosive Atmospheres</td>
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<td></td>
<td>Regulations</td>
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<tr>
<td>LPG</td>
<td>liquefied petroleum gas</td>
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<td>MOP</td>
<td>maximum operating pressure</td>
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<td>PRI</td>
<td>pressure regulating installation</td>
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<td>United Kingdom</td>
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Units

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Subscripts

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5.1 PLANNING

5.1.1 Any PRI must be designed, located, constructed, operated and maintained taking into consideration the safety and environmental requirements of applicable legislation.

5.1.2 Consideration shall be given to the layout and other uses of the whole PRI station, for example gas storage, the need for security (see Sub-Section 5.4) and any required housing for the PRI.

Particular consideration shall be given to the possibility of flooding and, in the case of a below-ground or buried PRI, the likelihood of a rising water table.

5.2 LOCATION

5.2.1 All PRIs

5.2.1.1 A risk assessment shall be carried out in which consideration shall be given to the following factors:

- accessibility and security of the site and, in particular;
  - provision of proper means of safe access and egress for maintenance, inspection and dealing with emergencies
  - avoiding areas prone to flooding, subsidence or other naturally occurring hazards
  - below-ground and buried PRIs being located away from any carriageway, for example in the verge or footpath, avoiding traffic hazards and vehicle parking that could make maintenance difficult. A roadway PRI shall not be installed unless there is no alternative and in which case suitable road covers shall be installed and the structure below ground shall be designed to withstand traffic loads
  - vulnerability of sites where traffic accidents, etc. could result in damage to the PRI
  - clearance from overhead power cables and large trees
  - proximity to tall buildings where eddy currents around the building may cause problems with gas dispersal (see IGE/SR/23)
  - where the PRI serves part of a Network or distribution system, its proximity to occupied buildings. Generally, these shall be determined from the building proximity distances given in IGEM/TD/1 or IGE/TD/3 or UKLPG CoP 1 Part 1, as appropriate. In any event, the distance shall not be less than 3 m.
  - where a PRI is installed in a service or service pipework, its location relative to occupied buildings. Generally, proximity shall be determined in accordance with IGEM/TD/4 for pipes.

Note: For all new PRIs in existing pipelines, it is permissible to reduce the proximity distances from those given in the above Standards subject to a robust risk assessment that shows variation to be acceptable.
• avoiding hazardous or potentially hazardous conditions and of any gas venting from regulator relief valves entering property through open windows, airbricks, balanced flues or similar openings in the structure.

Note 1: A hazardous area drawing is required under DSEAR. The extents of the hazardous areas identified in the drawing will influence the location of the PRI in relation to its proximity to properties or potential ignition sources.

Note 2: When selecting a site for a new PRI, or when reviewing the location of an existing PRI near the public highway, the following factors are relevant in a risk assessment:
• distance from the highway and ease of access for construction and maintenance
• speed of traffic
• traffic loading
• overall vulnerability of the PRI
• effect on persons and the environment
• effect on gas supply
• possible future development around the PRI
• ground conditions
• site topography.

The conclusions of the risk assessment may indicate that additional protective measures or re-siting are necessary.

5.2.1.2 Due regard should be taken of the likelihood of the site being flooded, and the effects that any flooding may have on the operation of the unit, and its associated equipment.

In the UK, the information on flooding, and depth of water that could be expected, is available from the local Environment Agency, who can offer advice on this risk.

Where there is no alternative to building on a site at risk of being flooded, mitigation measures shall be considered.

Note: These measures can include raising the breather and vent pipes to a high level, installing electrical equipment on raised platforms within the site, arranging any air inlets to be above expected water levels, etc.

5.2.2 Small PRIs (as defined in Sub-Section 1.5)

In addition to the requirements of clause 5.2.1, for small PRIs, consideration shall be given to:
• the need to ensure any PRI supplying a domestic premises is sited outside buildings and installed in the open, or in surface mounted boxes or housings
• known planned alterations or extensions to buildings which would affect the installation.

5.2.3 PRIs supplying commercial or industrial premises

5.2.3.1 All PRIs

For a PRI installed in a main building, it shall be sited in accordance with the relevant requirements of clauses 5.2.1 and 5.2.2, and in accordance with the following conditions:
• MOPu shall not exceed 2 bar
• the only access to the PRI shall be from outside the main building through outward opening doors
• explosion relief should be provided, either within the doors, or by the doors, or on an outside wall (see clause 6.2.13).

Note: Where it is impractical to provide an explosion relief in the walls or doors, it may be sufficient to provide additional ventilation, for example louvred doors and panels, in the outside wall and to the full height and width of the enclosure.
5.2.3.2 **LPG PRIs**

Any open drain, grille or duct located within 1 m of a PRI or its vent shall be fitted with a water trap or shall be suitably sealed.

5.2.4 **Below-ground LPG PRIs**

Only small LPG PRIs (as defined in Sub-Section 1.5) shall be installed below ground, when the enclosure volume shall not exceed 0.5 m³ and the depth of burial (cover) shall not exceed 0.5 m.

5.3 **PRI STATION LAYOUT**

5.3.1 The area of the PRI station shall be adequate to accommodate the PRI and provide access for maintenance purposes and/or the location of emergency facilities, for example fire extinguishers.

*Note:* It is desirable to provide hard access up to and within the PRI station to accommodate maintenance and emergency service vehicles.

5.3.2 The need for and number of emergency exits shall be determined by risk assessment.

5.3.3 Vulnerable pipework or equipment shall be protected.

5.3.4 Any hazardous area shall be taken into account when determining the PRI station boundary.

5.3.5 The combustion air intake of any gas heater or other burner equipment shall be located so as to minimise any hazard arising from any source of gas leakage or emission, for example from a filter, relief valve vent, etc.

5.3.6 Consideration shall be given to:

- access for pigging operations and equipment
- minimising noise (see Appendix 3)
- gas detection

*Note:* Where gas is not odorised, enhanced arrangements may be needed, such as prominent notices and/or additional detection equipment.

- access for maintenance activities
- access for fire fighting.

5.4 **SECURITY**

5.4.1 Any PRI station should be secured against entry by unauthorised persons.

5.4.2 If a security fence is used, equipment should be sited at a sufficient distance from the fence to prevent interference from outside.

5.4.3 Consideration shall be given to the provision of a locking device for valves, including auxiliary valves located external to a PRI housing.

5.4.4 Consideration shall be given to installing intruder detection devices.

5.4.5 Where the presence of vehicular traffic could cause a hazard, consideration shall be given to the use of safety barriers.

5.4.6 Prominent signs shall be displayed, prohibiting smoking and other ignition sources.
5.4.7 A permanent notice shall be displayed, clearly showing an emergency telephone number which may be used by the public or others.

5.4.8 Where appropriate, due consideration shall be given the vulnerability of the site and the need for a higher standard of security, for example by including electrical fencing, CCTV, etc.
SECTION 6 : HOUSINGS

Acronyms and abbreviations

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<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>GRP</td>
<td>glass reinforced plastic</td>
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<tr>
<td>HSE</td>
<td>Health and Safety Executive</td>
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<td>IP</td>
<td>ingress protection</td>
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<td>MOP</td>
<td>maximum operating pressure</td>
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<td>PRI</td>
<td>pressure regulating installation</td>
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<tr>
<td>SWL</td>
<td>safe working load</td>
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<td>UV</td>
<td>ultra violet</td>
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Units

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<tr>
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<tr>
<td>kg m⁻²</td>
<td>kilograms per square metre</td>
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<td>kN m⁻²</td>
<td>kiloNewtons per square metre</td>
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<td>≤</td>
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This section applies to any of the following housings for all or part of a PRI in:

- a separate building providing weather protection, and sufficient space for maintenance and general access or
- a cabinet providing weather protection, and facility to remove all or part of the cabinet for the purpose of maintenance and general access or
- a pit, i.e. the PRI is located partly or completely below the nominal ground level

Note: Such an installation incurs some additional safety considerations but may be deemed appropriate for reasons of appearance, noise reduction, etc. See also clauses 5.2.1 and 5.2.4.

or

- a buried vessel, designed specifically for the PRI, located partly or completely below the nominal ground level.

Note 1: A PRI may be enclosed in a vessel-type housing designed to be installed as a module between the inlet and outlet pipework. Parts of the housing may contain pressure.

Note 2: A buried vessel incurs some additional safety considerations. See also clauses 5.2.1 and 5.2.4.

A PRI may also be installed in the open air or under a canopy, in which cases the appropriate requirements within this section shall be applied.

6.1 GENERAL

6.1.1 All housings

6.1.1.1 Any vent termination shall be outside the housing except, for Natural Gas only, for a housing volume not exceeding 1.5 m³ and MOP ≤ 7 bar, a relief valve vent may be terminated within the housing (see also clause 6.2.8.4).

6.1.1.2 Any metallic structure shall be earthed.

6.1.1.3 Appropriate warning and procedural notices shall be displayed.

6.1.1.4 Any floor, wall or ceiling separating the PRI from the rest of any building shall be of fire-resistant construction, with a minimum fire rating of 30 minutes, finished with a screed or plaster finish to assist in minimising the leakage of gas through cracks or into any wall cavity. In addition, to prevent gas in-leakage, particular attention shall be paid to the sealing of ventilation openings, pipes, etc., which cross any cavity.
6.1.1.5 The materials used in the construction of any housing/compound shall provide:

- low maintenance requirements
- sound insulation, where necessary
- durability
- weather resistance.

6.1.1.6 Where pipes are to enter and leave a housing above floor level, and unless a sleeve has been fitted during construction/manufacture of the housing, the circular holes required should be made, using a suitable tool (for example, a core drill) at the pipe entry and exit points to accommodate both pipe and sleeve. The annular space between the pipe and sleeve and between the sleeve and the housing wall shall be sealed with an appropriate mastic sealant.

6.1.1.7 Any opening in a housing should be restricted only to those for doors, ventilation, explosion relief, pipework and ancillary services.

Any door or ventilation aperture should be located at a safe distance from any window, door or aperture of another building.

It shall not be possible to create a path of air movement between a space containing a PRI and another space that contains an ignition source, for example by opening an access door, unless the ignition source is at a safe distance or is suitably protected.

6.1.1.8 If access is required on more than one side of the PRI at least two access points shall be provided, each with an adequate and safe means of escape in an emergency (see Figures 5(c) and 5(d), clause 6.2.9).

6.1.1.9 The space containing a PRI shall not be connected directly to a sewer, for example by a floor drain, or any other below-ground service duct or chamber.

6.1.1.10 Items manufactured from aluminium-based light metals, for example door furniture, protection strips etc. should be used only if the magnesium content does not exceed 6% by weight.

Such items shall be protected against electrolytic action occurring where contact with steel is likely to occur, for example by painting; factory applied coating; non-corrosive material, etc.

6.1.1.11 For any glass reinforced plastic (GRP) housing, instrument panel boards or safe area compartments should be pre-fabricated into the housing design.

For other housings, the method of fixing panels and components to interior walls shall be such that the integrity of the housing is not impaired.

6.1.1.12 Access to a PRI shall be directly from outside through outward opening doors.

6.1.2 Glass reinforced plastic (GRP) housings

6.1.2.1 General

6.1.2.1.1 Pipework shall not enter or exit the housing through the side walls unless the facility has been specifically provided and enabling removal of the housing, for example keyhole slots and infill panels. Where a vent pipe is to be fitted, clearly identifiable solid panels, designed specifically for the exit of the pipe, should be provided.

*Note: Usually, these are located at high level and at each end of the housing.*
6.1.2.1.2 The skin should be resin bonded and be of either a single skin or sandwich construction which is cavity-free. Corners, door frames and base frames should be strengthened. Any sandwich structure shall be formed from resin bonded glass fibre inner and outer skins totally encapsulating a suitable core material and meet the criteria and tests in Appendix 4.

6.1.2.1.3 Fixing methods that interrupt the continuity of the GRP surface shall be fully sealed to ensure that ingress of moisture does not occur.

6.1.2.1.4 Where a framework is used, it shall be of wooden construction or metal, suitably treated to prevent corrosion such that it will attain the required design life. The framework shall have a nominal cross section to adequately support the structure.

6.1.2.1.5 All wooden joints shall be glued using appropriate timber adhesives and screwed, and all metal joints suitably welded to attain the required design life.

6.1.2.1.6 The framework shall be totally encapsulated within the GRP structure.

Note: Other materials may be considered to be suitable provided that they meet the test criteria in Appendix 4.

6.1.2.2 Pre-fabricated safe area compartments

6.1.2.2.1 Compartments shall be internally moulded/attached, projecting into the housing but completely sealed from it.

6.1.2.2.2 Access shall be through an external outward-opening door attached to the main housing.

6.1.2.2.3 It shall be possible to mount logging and conversion equipment within the compartment such that it is totally isolated from the main housing.

Note: A safe area compartment is not intended to contain instruments that carry fuel gas.

6.1.2.2.4 The design of the compartment shall be such that all cables have to be routed into the compartment from outside the main GRP housing, without compromising the integrity of either the compartment or the housing.

Note: This is to ensure there is no relief ingress of gas in the safe area compartment.

6.1.2.2.5 All cables and glands shall be matched so as to prevent the ingress of gas or water into the safe area compartment.

6.1.2.2.6 The IP ratings of the external door shall be to BS EN 60529, ingress protection (IP) at least IP 65.

6.1.2.2.7 The compartment shall not be fitted to the same wall as a relief vent pipe.

6.1.3 Safety and safe working access

6.1.3.1 Suitable unobstructed access shall be provided to facilitate construction of the installation and its subsequent maintenance.

6.1.3.2 Where a design incorporates a hinged access roof, it should be fitted with stays to enable it to be held in the open position. The stays should be fitted in pairs and be capable of supporting the weight of the hinged roof while resisting any wind loading that may be applied to the hinged roof while in the open position.

6.1.3.3 Any “walk-in” or “walk-through” housing (see Figure 5) shall have a minimum internal height of 2.1 m.

6.1.3.4 Where vehicle access is required, a roadway or hard standing should be available.
6.1.3.5 Consideration shall be given to preventing other parties from impeding access to the site by such acts as the parking of vehicles, the storage of goods and equipment, fly-tipping, etc.

6.1.3.6 The following shall be provided, as required:

- sufficient clearances for safe working on equipment, also allowing withdrawal of components

  Note: A minimum clearance of 0.5 m is recommended, but significantly more space than this may be required especially where mechanical lifting equipment has to be used within the housing and where large/heavy components may need removing on a trolley. It may be beneficial to make use of a removable roof (even when explosion relief is not required) to facilitate easy access to the installation for the removal of major components.

- where lifting or support equipment is required for safe installation, maintenance or replacement of equipment, as appropriate;
  - a lifting beam or suitable runner at high level, appropriately marked to show its safe working load (SWL), and/or
  - access through the roof for mobile gear and/or provision for removing the housing if pre-fabricated and/or
  - sufficient floor space to enable temporary lifting equipment to be used.

6.1.3.7 Any lift-off housing/cover shall be capable of being easily moved. Where appropriate, lifting eyes shall be fitted.

  Note: Advice is contained in the HSE publication “Getting to grips with manual handling - a short guide”.

Handles, whether fixed or operational, should be positioned for ease of access and operation and be located so that personnel moving a housing/cover will not be in danger of walking into equipment under the housing/cover.

6.1.3.8 Where lifting eyes are fitted, sufficient plugs shall be provided to allow the permanent sealing of the holes if the eyes are to be removed. The sealing method shall ensure that water ingress is permanently prevented.

6.1.3.9 The design of any lifting eye shall be such that the operation of any explosion relief roof will not be affected if they are not removed.

6.1.4 Formal documentation for housings and components

6.1.4.1 The following documents shall be produced, as appropriate:

- planning application, including drawings

  Planning application drawings, whether for a “full planning permission” or approval of a “permitted development” application, are required to show the proposal and should contain sufficient information to demonstrate the general appearance of the housing/compound upon completion. The drawing should contain a location plan, site plan and at least two elevations.

- site layout drawing

  Site layout drawings may also be required for site construction works. These should show sufficient detail to identify the site location, orientation and boundaries, as well as the exact position of any housing/compound to be located on the site.
- general arrangement drawing

General arrangement drawings should provide at least the following information:
- setting out of the housing/compound in plan position
- plans, sections and elevations, as appropriate, showing layout, dimensions and levels of all aspects of the structure
- location of all access doors, holes, chases, pockets, ventilation, fixings and other items
- details of materials to be used, for example brick type, colour and supplier
- details of surface finishes, both internally and externally, including colour
- all other information necessary to permit construction in accordance with design requirements, for example type and location of holding-down fixings.

- detailed fabrication and construction drawings and specifications

Detailed fabrication and construction drawings should indicate any specific manufacturing or construction detail that is not indicated on the general arrangement drawing. Copies of these drawings shall be submitted for acceptance by the project manager prior to commencement of any fabrication or construction work.

- as-built drawings

As-built drawings should indicate the details of the completed construction and should also identify all changes from the construction issue drawings. Copies of the drawings should be provided by the contractor, or supplier, to the project manager on completion of site works.

- design calculations

Calculations for all structural elements and their fixings shall be checked and approved.

**6.2 ABOVE-GROUND HOUSINGS AND BUILDINGS**

**6.2.1 Foundations, bases and floor mounting**

**6.2.1.1 All housings/compounds**

**6.2.1.1.1** Suitable foundations, generally of the slab (raft) or footing type, shall be provided. They shall be designed to take account of any special features of the site, for example, subsidence, local infill, clay, etc., and shall make adequate provision for pipes to enter and leave the housing.

**6.2.1.1.2** Foundations, bases and floors shall be designed and constructed to appropriate standards such as BS 8004, BS 8500-1, BS 8500-2, BS 8110-1 and BS 8110-2. For foundations, the proven nature of the ground and the requirements of the structure to be supported shall be considered.

**6.2.1.1.3** The floor should be finished in a material that has non-sparking and anti-static properties, for example certain grades of concrete.

**6.2.1.1.4** Floors and duct coverings shall be strong enough to take the required point weight loadings of the installation and any additional loadings imposed during construction and maintenance.
6.2.1.1.5 All base fixing points shall be inside the housing, to prevent unauthorised removal once installed.

6.2.1.1.6 The design and location of fixing points shall ensure that accidental stress loading during installation is spread over the body of the housing.

6.2.1.2 Pre-fabricated housings (including GRP)

Sufficient restraining bolts and washers shall be supplied by the housing manufacturer so that, once installed, the housing will meet specified wind loading.

*Note* Normally, at least size M10 bolts and washers will be required.

6.2.1.3 GRP housings

6.2.1.3.1 The base flange shall be suitably reinforced, and shall be provided with an appropriate number of fixing holes. The fixing holes shall be incorporated into the fabric of the base during construction. The pitch of the fixing points shall not exceed 1000 mm.

6.2.1.3.2 The laminate on the underside of the base flange shall have a thickness of not less than 6 mm and be suitably protected to prevent damage to its weatherproofing, in the event of the surface being abraded during installation of the housing.

6.2.1.3.3 Where a housing is designed to fit onto a concrete base, suitable non-setting sealant shall be provided to seal the base to the concrete standing. The sealing kit shall include fitting instructions and detail any safety precautions that may be required.

*Note:* Lift-off housings may have an alternative method of base fixing, allowing for ease of removal without damaging the housing.

6.2.2 Roofs and lift off panels

6.2.2.1 The roof of any purpose-built external housing:

- shall not enclose any unventilated void
- should be of light-weight construction, or so constructed to minimize damage to installed equipment in the event of a roof fall
- should provide the same level of security as the rest of the structure, unless other overall site security measures are taken
- should be of fire resistant material.

6.2.2.2 Where the roof is not required to act as an explosion relief, it shall be securely attached to the walls.

*Note:* It is beneficial that the whole or part of the roof is removable in order to facilitate access to the installation.

6.2.2.3 The roof shall be strong enough to be walked upon safely and be designed to withstand loads imposed by wind, snow, etc.

6.2.2.4 The roof shall be waterproof and shall project sufficiently over the walls as to prevent water entering the ventilators.

6.2.2.5 The roof shall have a minimum fall (gradient) of 1:60 in order to prevent water holding on the roof. Arrangements shall be made to allow rainwater to be shed away from the door access areas and any safe area compartment.

6.2.2.6 Lift off panels and hinged roofs on small moulded housings shall be secured by suitable locking mechanisms.
6.2.2.7 Hinged access roofs shall have hold-open stays that resist wind loading.

6.2.3 **Walls**

6.2.3.1 *All housings*

6.2.3.1.1 Where a new, purpose-built room or building is provided to house an installation, the walls shall be solid without cavity and shall not include openings other than those required for access, ventilation, pipework or other ancillary services.

6.2.3.1.2 Where a new housing makes use of existing walls of cavity construction, those parts of the wall bounding the new housing shall have a screed or plaster finish applied to minimise gas leakage through the wall or into the cavity.

6.2.3.1.3 If an additional room is built onto a housing which may contain potential sources of ignition, the adjoining wall shall have a screed or plaster finish applied to minimize the potential for gas leakage through the wall.

6.2.3.1.4 For a brick-built building, and where an explosion relief is required, the walls should be a minimum 225 mm thick with the bricks fully interlocking. Piers or returns should be provided on long walls.

6.2.3.1.5 The design of any damp proof course should be such as to prevent any tendency for the wall to slide off the damp proof material in the event of an explosion.

6.2.3.1.6 Any wall shall be designed as necessary to withstand specified wind loading.

6.2.3.2 *Pre-fabricated housings (including GRP)*

6.2.3.2.1 Where a housing is of sectional construction, the walls shall be fully formed. The joints shall be positioned to give maximum strength to the housing, and shall be suitably protected and sealed with non-setting sealant. Walls shall not contain cavities.

6.2.3.2.2 Where wall core material is fixed to the frame by means of a lap joint, the depth of the joint shall not be less than two thirds of the thickness of the frame.

6.2.3.2.3 Butt joints shall not be used to form corners or openings.

6.2.3.2.4 For a GRP housing, clearly defined relief vent panels should be incorporated into housings in both walls and through which relief vent pipes may pass. The panels shall be located centrally in the horizontal plane of the wall, and 100 mm below soffit level.

*Note: Normally, panel dimensions of 700 mm long by 100 mm high are sufficient.*

The panels shall consist of solid GRP with no core material, but with any decorative finish to match the rest of the housing.

6.2.4 **Doors**

6.2.4.1 Doors shall conform to BS 459 (wood) or BS 6510 (steel) or an equivalent standard and shall be designed so that warping is minimised during weathering and minor deviations from square during installation will not cause the door to stick. The design shall ensure that rain water is prevented from entering.

6.2.4.2 The design of any door and the door access or housing shall be such as to prevent any direct line of sight into the housing when the door is closed.
6.2.4.3 At least three hinges should be provided on doors that are 2.0 m or greater in height, one each located within 300 mm of top and bottom of the door and the other centrally. Alternatively, a continuous strip-type hinge should be utilized.

Housings with doors that are less than 2.0 m in height shall have at least two hinges fitted.

The hinge design should ensure that any hinge-securing bolts can only be removed from inside the housing or be totally concealed when the door is in the closed position.

Hinges shall be constructed of corrosion-resistant metal and designed so that differential corrosion is minimised.

6.2.4.4 Where an explosion relief is incorporated into the roof or walls of a housing, the doors and locking mechanism shall be strong enough that an explosion would not cause the doors to open.

6.2.4.5 Each door for a “walk-in” or “walk-through” housing shall have a minimum nominal width of 800 mm and a minimum height of 2.0 m.

6.2.4.6 Outward opening doors, of sufficient size to afford access to persons and equipment, shall be provided on the outside wall to accommodate installation and maintenance work.

6.2.4.7 For a “walk-through” housing, an additional emergency exit shall be provided on the opposite side of the building to the main doors (see Figure 5(d) clause 6.2.8.3).

For a “walk-in” housing, at least one set of standard width outward-opening double doors shall be fitted. Two sets of standard width doors are preferred, which should be mounted on opposite ends of the housing for rapid exit in the case of emergency (see Figure 4).

Note: This is to provide an alternative means of escape.

![Preferred arrangement](PRI)

**FIGURE 4 - PROVISION OF EXITS IN LONG “WALK-IN” HOUSINGS**

6.2.4.8 Any means of escape shall be readily operable from inside without the aid of a key.

6.2.4.9 Any door shall have unobstructed access to open fully.
6.2.4.10 Means shall be provided to fasten any door in the open position.

6.2.4.11 For a housing of the cupboard or compartment type, the whole front shall be in the form of a door or an easily removable panel.

6.2.4.12 The left hand door of the double doors designated “front” shall be secured internally.

6.2.4.13 The right hand door of the double doors designated “front” should be secured by means of a hasp and staple to accept a security lock or other, alternative equivalent means of securing with a minimum diameter of 12 mm. The hasp should be positioned at the left hand edge of each right hand door when viewed externally and centrally located.

6.2.4.14 The double doors designated “rear” on “walk-through” housings shall be secured internally to an equivalent standard as the front doors, and shall only be capable of being opened from the inside and without a key.

6.2.4.15 Any double doors designated “rear” on “walk-in” housings (see Figure 5(c)) shall be secured in the same manner as the front doors.

6.2.4.16 Any single door of a “walk-in” housing shall be secured externally.

6.2.4.17 Any rear door used for escape in an emergency shall not be capable of being padlocked.

6.2.4.18 Shooting bolts and locking bars shall locate at the top and bottom of the left hand doors, either behind the door frame against keeper plates or within a suitable, strengthened, sill.

6.2.4.19 Where door sills are fitted, they should be a maximum of 10 mm high and shall be of corrosion-resistant material.

6.2.5 Finish

6.2.5.1 The finish of any housing should allow the removal of graffiti without suffering any damage to coating materials and should be smooth or textured, normally BS 4800 green 14-C-39 or, alternatively, stone, brick or cement rendering or another colour.

6.2.5.2 The finish shall resist the effects of ultra violet (UV) light to ensure minimal degradation over its design life.

Note: For a GRP housing, this will involve UV stabilization.

6.2.5.3 The internal finish of any GRP or other pre-fabricated housing should be white.

6.2.6 Performance

6.2.6.1 All housings

6.2.6.1.1 Any housing shall withstand wind speeds of up to 50 m s$^{-1}$.

6.2.6.1.2 Any explosion relief roof fitted shall operate correctly under the load conditions. Compliance should be verified either by design calculations or by an appropriate test method.

6.2.6.1.3 The roof of the housing shall withstand a uniformly distributed load of 1.25 kN m$^{-2}$. Compliance should be verified either by design calculations or by an appropriate test method.
6.2.6.2  GRP housings

6.2.6.2.1 Housings shall suffer no defects due to temperatures within the ambient temperature range –20°C to +50°C.

6.2.6.2.2 Materials used in construction shall be selected to provide fire resistance for at least 30 minutes when tested to BS 476-6, 7, 12, 21 and 22.

6.2.6.2.3 The criteria of failure for load bearing element capacity, integrity and insulation shall be as defined in BS 476-20.

6.2.6.2.4 Resin used in construction shall be fire retardant and shall conform to BS 476-7, class 2 surface spread of flame.

6.2.6.2.5 The performance test specifications given in Appendix 4 shall be met.

6.2.7  Ventilation of housings

6.2.7.1 Ventilation shall be provided in a PRI housing.

Note: The purpose of ventilation is to:

- ensure that minor gas leakage does not cause the atmosphere within the housing/building to become unsafe
- allow any escape of gas to be smelled or otherwise detected by passers-by
- reduce condensation.

6.2.7.2 The total effective ventilation area (free area) of a housing shall not be less than 2% of the internal floor area of the housing/building or its notional equivalent and should be equally distributed and disposed at high and low levels around at least two walls to outside air.

Note: The notional equivalent floor area is the floor area of an imaginary housing to enclose a PRI which is, in fact, located in a larger open area, for example in the corner of a factory workshop, wall mounted in a shop, in a boiler house etc.

Where only one wall is used, ventilation shall be increased to at least 3% of the internal floor area.

Where a risk assessment indicates that greater ventilation levels are required, this shall be provided.

Note: The hazardous area classification may influence the design and level of the ventilation provided and the required inspection frequency.

The ventilation provided for wall mounted PRIs (see clause 6.2.16) shall not be less than 2% of the floor area for a surface mounted box and be not less than 6% of the floor area for a semi-concealed box. Such ventilation shall be achieved using purpose-designed, non-adjustable louvre type ventilators and/or loose fitting doors/lids.

For a lighter-than-air gas, the low level ventilators should be positioned 150 mm above the floor. The high level openings should be situated as close as possible below, but not more than 10% of the total height below, the roof or ceiling level.

For a heavier-than-air gas, the low level ventilation should be positioned as low as practicable but always at 150 mm or less above the floor. Allowance shall be made for the potential for a vent(s) to be blocked.

6.2.7.3 Where a housing has an apex type roof design, the level of ventilation should be achieved by utilising ridge ventilators. Any ceiling shall not create an unventilated void.
6.2.7.4 Where a relief valve vent is to terminate within a housing (see clause 6.1.1.1), the minimum ventilation shall be 5% of the floor area and this shall be distributed across a minimum of 2 walls and be equally spread between high and low level.

6.2.7.5 A ventilator shall not be located by or near any air in-take duct, thus minimising the possibility of gas entering any building.

6.2.7.6 Any ventilator shall be designed and located to prevent persons tampering with the door restraining fixings.

6.2.7.7 Ventilation openings shall not be into a hazardous area, for example a consumer-generated hazardous area or the hazardous area surrounding a vent pipe termination or drain hole.

6.2.7.8 Where a duct is used, it shall be in accordance with current Building Regulations but, for gas safety reasons, shall not be fitted with a fire damper.

The covers for the duct shall not create an unventilated void.

6.2.7.9 Any ventilator shall be of non-adjustable type (complying with BS 493 Class 1), and should be weatherproof and fire resistant.

6.2.7.10 Any ventilator shall be designed to prevent the ingress of rain and blockage by leaves or snow.

Holes used for the fixing of ventilators shall be fully sealed and designed to ensure that any inner core material will not be exposed to moisture ingress.

6.2.7.11 Any ventilator should be of a circular or square hole, or louvre, design. The openings in the ventilator shall be such that a 9.5 mm diameter sphere cannot pass through.

If the high level ventilator is in the form of a gap(s) between the walls and the roof of the housing, such a gap shall not exceed 9.5 mm.

6.2.7.12 Roof ventilators are more efficient than apertures in the wall but, if installed, they shall provide at least the same effective free area of ventilation as required for high level wall apertures (low level ventilation should be retained).

6.2.7.13 Where a baffle or other design of acoustic ventilation panel is provided within or behind a ventilator, the free area of the aperture as given in clause 6.2.8.2 shall be increased to maintain the required performance of the ventilation system.

6.2.7.14 Ventilation design should take account of the acoustic properties of the building.

6.2.7.15 If a space houses a heating installation, sufficient additional ventilation should be provided to satisfy the appliance combustion requirements.

6.2.8 Access

6.2.8.1 Entry and exit

Exit routes to the outside of the housing should be kept free of obstruction at all times.
6.2.8.2 **Doors**

Any door of a space containing a PRI shall be provided with locks and unless it is not possible to enter the space, shall be capable of being opened from the inside without a key.

Such doors shall open outwards and be capable of being fixed in the open position.

6.2.8.3 **Apertures**

There shall not be any aperture connecting with another closed space.

Any door or ventilation aperture shall be located at a safe distance from any window, door or aperture of another building.

![Access Classification Diagram](image_url)

**FIGURE 5 - ACCESS CLASSIFICATION**

6.2.8.4 **Ignition sources associated with access to a PRI**

It shall not be possible to create a path of air movement between a space containing a PRI and another space that contains an ignition source, for example by opening an access door, unless the ignition source is at a safe distance. Otherwise, the planned position of access doors, ventilation apertures, etc. shall be so as to avoid creating such a path.
6.2.9 **Heating**

6.2.9.1 Where necessary, space heating shall be provided to preserve the fabric of the housing and any electrical, telemetrical or other equipment.

6.2.9.2 If a heating appliance is to be provided in a space in which a flammable atmosphere may be present:
- any combustion chamber shall be isolated from the space
- the surface temperature of any component in direct contact with the space shall not exceed 350°C.

6.2.10 **Ignition sources**

Smoking and other uncontrolled ignition sources shall be prohibited.

6.2.11 **Explosion relief (see Figure 6)**

6.2.11.1 **General**

6.2.11.1.1 For an inlet pressure exceeding 100 mbar and where the housing is of internal volume 1.5 m³ or greater, an explosion relief shall be provided if an explosion within the housing could present a hazard to:
- the general public
- employees, except where a formal working procedure is in place to prevent ignition of any explosive atmosphere.

The relief shall be designed to ensure the integrity of the housing in the event of an explosion within it.

*Note 1: The explosion relief is best provided by the roof of the housing lifting (a correctly designed lifting roof will not compromise the overall security of an installation).*

*Note 2: The pressure developed in a housing during an explosion is dependent on the weight per unit area of the explosion relief (see clause 6.2.13.3), the method of retention of the relief and the vent area created when the relief operates.*

*Note 3: In exceptional cases, for example where an explosion in a meter house could impair the structural integrity of a main building, the provision of explosion relief may be considered for an inlet pressure not exceeding 100 mbar or irrespective of whether the stated criteria are satisfied.*

6.2.11.1.2 If it is not reasonably practicable to provide a lifting roof explosion relief, consideration shall be given to providing relief by the doors or outside walls of the installation, whichever is the more appropriate to the circumstances. The security of the installation shall not be compromised.

6.2.11.2 **Design of a lifting roof explosion relief**

6.2.11.2.1 The restraining fixings of the roof shall be designed such that operation of the explosion relief will not damage any wall of the housing.

6.2.11.2.2 The housing shall be capable of withstanding the maximum internal pressure developed during an explosion and designed such that there would not be any fragmentation sufficient to cause a hazard in the event of an explosion.

6.2.11.2.3 The explosion relief shall be designed so as to prevent damage to equipment within the housing when it reseats following operation.
Note: In practice, it is difficult to achieve a satisfactory design of an explosion relief panel which maintains the acceptable level of security. However, explosion relief panels may be a practical solution where levels of security lower than normal are acceptable or on housings within securely-fenced sites.

6.2.11.2.4 An explosion relief should not provide easier means of access than a locked door, so maintaining the required degree of security.

6.2.11.2.5 An explosion relief shall not be obstructed on the inside or outside of the housing.

6.2.11.2.6 Vent stacks/lines shall not pass through an explosion relief.

6.2.11.3 Internal pressure during explosion

The explosion relief shall be designed to limit the internal pressure in the housing, developed during an explosion, to a maximum of 35 mbar.

6.2.11.4 Design of restraints

6.2.11.4.1 The explosion relief restraining mechanism shall allow free opening of the relief within its excursion limits and should ensure that the roof re-seats properly following any explosion.

Note: A suitable design would consist of a slide rod/slide bracket arrangement or sliding concentric tubes in which the restraint/guide mechanism is attached firmly to the four corners of the roof.

For pre-fabricated housings of steel, concrete or a GRP composite laminate construction, this mechanism may be fixed to either the walls of the building or to the floor. However, for brick-built housings, the roof restraint/guide mechanism needs to be fixed to the floor.

6.2.11.4.2 The lifting roof shall be held in place by virtue of the force of gravity only. Devices to prevent the free vertical movement of the roof shall be incorporated in the roof restraint/guide mechanism only if due consideration has been given to the effects of release tolerances and delays in operation.

6.2.11.5 Design for the housing to accommodate explosion relief measures

The strength of door furniture, including hinges, slide bolts, locking arrangements and method of attachment, shall be such that the doors will not open or be blown out during an explosion.
Cross sectional area of roof \( a \times b \)

Perimeter vent area due to lift \( 2(d \times h) + 2(c \times h) + 2h(d + c) \)

Cross sectional area of lifting plate \( a \times b \)

Area of lifting plate \( c \times d \)

\[
K_{\text{lift}} = \frac{\text{Cross sectional area of roof}}{\text{Perimeter vent area due to lift}} = \frac{a \times b}{2(d \times h) + 2(c \times h) + 2h(d + c)}
\]

\[
K_{\text{roof}} = \frac{\text{Cross sectional area of roof}}{\text{Area of lifting plate}} = \frac{a \times b}{c \times d}
\]

Note: For a lifting roof explosion relief, the maximum pressure developed during an explosion will be limited to 35 mbar (clause 6.2.13.3) or less provided that:

- the weight per unit area of the lifting roof does not exceed 50 kg m\(^{-2}\) which includes the weight of any parts of the roof restraining/guide mechanism that moves with the roof.

Where acoustic attenuation is required, the weight per unit area of the roof may be increased to 100 kg m\(^{-2}\) provided the housing is designed to withstand an internal pressure of 50 mbar (normal brick construction would not be suitable)

- the area of the roof that is lifted is at least 50% of the total roof area i.e. \( K_{\text{roof}} \) as defined above does not exceed a value of 2

- the height of lift of the roof is sufficient to create a vent area around the perimeter of the roof equal to at least 30% of the total roof area, i.e. so that \( K_{\text{lift}} \) as defined above does not exceed a value of 3.3.

In practice, in most cases, the whole roof will lift i.e. \( K = 1 \), and the height of lift of the roof will be such that the value of \( K_{\text{lift}} \) will be nearer to unity than the maximum permitted value of 3.3.

The maximum allowable weights per unit area quoted are adequate to withstand most wind loading but are sufficiently low to allow for a snow loading of approximately 30 kg m\(^{-2}\) while still retaining the effectiveness of the relief.

**FIGURE 6 - HOUSING ROOF AREA/HEIGHT OF LIFT**

6.2.12 **Electrical**

6.2.12.1 Instrumentation and associated electrical equipment associated with a PRI should be housed in a detached building or it should be housed integrally in accordance with Sub-Section 7.6.

6.2.12.2 Special care should be taken with underground connections and the sealing of ducts to ensure a gas-free atmosphere within any separate building or room to which connections are made.
6.2.13 **Fire resistance**

The fire resistance of any wall, roof or door shall comply with an appropriate standard such as BS 476 -20 to -23.

6.2.14 **Wall mounted PRIs**

It is permitted to install a small PRI as defined in Sub-Section 1.5 in a surface-mounted or semi-concealed box.

The above requirements apply in general for such boxes, except as amended below.

6.2.14.1 The design of the box shall be to a bespoke design that achieves:

- robust, secure construction using durable materials
- sufficient access for replacement and maintenance of installed equipment
- provision for sealing the box at the points where inlet, outlet and vent pipes pass through the box.

6.2.14.2 The siting of the box shall be such that:

- the edge of the box/housing is at least 0.18 m from any opening into the property and
- at least 0.33 m away from any electrical equipment and
- when installed, the outlet of the regulator relief vent is at least 1 m from any opening into the property and at least 1.55 m away from any electrical equipment.

6.2.14.3 Any rear knockout of the box shall be “intact” and a spigot shall not be fitted.

6.2.14.4 Any installed outlet pipework shall not enter the building directly from the back of the box or near the vent termination point.

6.2.14.5 There shall be no openings on the back of the box that would permit gas to track into the building.

6.2.14.6 A box shall not be built into the outer skin of an external wall.

6.3 **BELOW-GROUND HOUSINGS**

6.3.1 **General**

Any below-ground housing shall comply with the relevant requirements of Sub-Section 6.2 together with the following additional/more stringent requirements.

Where an LPG PRI is to be located in the turret of a below-ground LPG vessel, the volume of the turret shall not exceed 0.5 m$^3$ and the turret shall not be buried deeper than 0.5 m.

6.3.2 **Access and egress**

A permanent ladder or steps shall be provided for access to, and egress from, any pit vault having a depth greater than 750 mm.

6.3.3 **Construction**

The housing shall be designed to withstand foreseeable superimposed loads and forces exerted by ground water.

*Note: Guidance is provided in UKLPG CoP 1 Part 4.*
Any constructional material subject to corrosion shall be protected fully prior to in-ground installation.

The housing shall be watertight as far as is practicable.

6.3.4 **Cover**

6.3.4.1 Any cover shall be designed to withstand foreseeable imposed loads. If a cover is not designed to withstand traffic, it shall be protected from intrusion by vehicles by adequate and permanent barriers. However, LPG vessels shall not be positioned under any roadway or drive and, hence, the turret shall be protected from intrusion by vehicles by adequate and permanent barriers.

6.3.4.2 Any cover shall be readily removable and replaceable and be designed such that the risk of damage to the PRI due to its mishandling is minimised.

6.3.5 **Ventilation**

6.3.5.1 It is not necessary to provide ventilation for housings with an internal free volume of 0.5 m³ or less. In such cases, the cover of the housing shall not be airtight but shall prevent the ingress of water. Temporary (removable) means of reducing the free volume, including for maintenance, shall not be used.

6.3.5.2 The requirements for minimum levels of ventilation for PRIs carrying a lighter-than-air gas are given below. However, the inclusion of electrical equipment, either permanently or temporarily, has implications with respect to hazardous area classification. Where such equipment is to be present, a hazardous area classification shall be carried out in accordance with clause 7.9.2.

*Note 1:* The internal free volume of an LPG turret is limited to 0.5 m³ (see clause 6.3.1).

*Note 2:* The hazardous area classification may influence the design and level of the ventilation provided and the required inspection frequency.

*Note 3:* UKPLG CoP 1 Part 4 classifies the LPG turret as Zone 1.

Where there is no option, an LPG regulator limited relief valve may vent into the turret when the rate of discharge shall not exceed 0.3 m³ per hour and the turret shall be above nominal ground level (see clause 6.3.9).

*Note:* UKPLG CoP 1 Part 4 requires a minimum 3 m distance from a turret to a building, boundary or fixed source of ignition. This distance can be reduced to 1.5 m if a gas dispersion wall is used.

If a decision is taken to provided additional ventilation, the ventilation requirements shall be checked to ensure they attain or exceed the levels given below and be provided in accordance with the following requirements.

6.3.5.3 The ventilation system should consist of 2 ducts starting at both high and low levels in the housing. The low level duct should terminate at least 3 m above ground level and the high level duct should terminate at least 1 m above the low level duct. The combined free area of the ventilation apertures, as a percentage of the floor area of the housing, shall be as shown in Table 3, where the free area can be less if vent lines are installed on all equipment.
<table>
<thead>
<tr>
<th>MOP$_U \leq$ 7 bar</th>
<th>MOP$_U \succ 7$ bar</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VENTILATION AS A PERCENTAGE OF FLOOR AREA</strong></td>
<td><strong>VENTILATION AS A PERCENTAGE OF FLOOR AREA</strong></td>
</tr>
<tr>
<td>with vent lines</td>
<td>without vent lines</td>
</tr>
<tr>
<td>1.5%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Note: Sub-Section 7.5 provides requirements for the installation of vent lines.

**TABLE 3 - MINIMUM FREE AREA FOR VENTILATION APERTURES FOR BELOW-GROUND HOUSINGS (> 0.5 m$^3$ volume)**

6.3.5.4 The termination of ventilation ducts shall be resistant to obstruction, such as by snow, and consideration shall be given to fitting a flame arrester to any ventilator opening that is less than 3 m above ground level. Arresters shall not restrict the designed capacity of the ventilators and shall be protected from blockage and water ingress.

6.3.6 **Dimensions**

6.3.6.1 Any volume that, potentially, could be occupied by an air/gas mixture shall be kept to the minimum possible, consistent with reasonable access by operatives.

6.3.6.2 Wherever possible, the depth of a housing shall be such that operatives undertaking maintenance work can have their head and shoulders above the level of the surrounding ground.

6.3.7 **Through-wall sealing**

Any pipe or conduit passing through a wall of a housing shall be sleeved and the annulus sealed to maintain a gas-tight and watertight seal.

6.3.8 **Drainage/pumping/breather lines**

6.3.8.1 Special consideration shall be given to avoid locations that are subject to flooding, for example in areas with a high water table.

6.3.8.2 A sump shall be constructed in the base of the pit or vault. The sump shall be drained adequately.

6.3.8.3 There shall not be a connection via an open duct or pipe between a housing and a drain or other enclosed space.

6.3.8.4 If adequate drainage cannot be provided, a pumping pit for the removal of water shall be provided and/or breather and vent lines shall be installed on the regulators and be routed to a high level.

6.3.9 **Ground water**

6.3.9.1 Locations shall be chosen free of surface water or flooding. High water tables should be avoided.

6.3.9.2 For a non-roadway installation, consideration shall be given to slightly raising the housing to prevent ingress of water.

6.3.9.3 For a LPG turret, the installation shall be semi-moulded if the turret is 500 mm or more above the nominal ground level.

If required, drainage shall be constructed from the base of the turret to provide adequate drainage.
For a LPG turret, if adequate drainage cannot be provided, the PRI shall be installed above ground and in a suitable enclosure.

6.3.10 Explosion relief

The requirements for the provision of explosion relief as given in clause 6.2.13 do not have to be applied but shall be considered.

6.4 VESSEL-TYPE HOUSINGS

Any vessel-type housing shall comply with the relevant requirements of Sub-Section 6.2, except for ventilation when clause 6.3.5 shall be applied together with the following additional and/or more stringent requirements.

Where a vessel-type housing is classified as a pressure vessel, it shall comply with PD 5500 or BS EN 13445.

6.4.1 Installation and external loading

6.4.1.1 The housing shall be installed on a suitably-prepared footing giving a similar amount of support as given to the pipework.

6.4.1.2 If the housing is installed in a roadway or other location where high surface loading may occur, the outer cover shall be supported independently to prevent surface loading being transmitted down to the pipework or housing.

6.4.1.3 The vessel shall have a closure constructed such that it can be operated safely.

6.4.2 Corrosion protection

6.2.2.1 Any housing subject to corrosion shall be suitably protected.

6.4.2.2 Consideration shall be given to anti-corrosion coating and to reinforcement by additional protection, for example by wrapping, prior to installing the vessel in the ground.

6.4.3 Vent stacks

The vessel shall include a vent stack to contain vent lines and breather lines.

6.4.4 Ground water

6.4.4.1 Locations should be chosen free of surface water or flooding. High water tables should be avoided.

6.4.4.2 For a non-roadway PRI, consideration shall be given to slightly raising the housing to prevent ingress of water.

6.4.4.3 For a fully buried housing, the housing shall be watertight.
SECTION 7 : DESIGN OF A PRI

Acronyms and abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNE</td>
<td>combined neutral earth</td>
</tr>
<tr>
<td>CP</td>
<td>cathodic protection</td>
</tr>
<tr>
<td>DP</td>
<td>design pressure</td>
</tr>
<tr>
<td>MIP</td>
<td>maximum incidental pressure</td>
</tr>
<tr>
<td>MOP</td>
<td>maximum operating pressure</td>
</tr>
<tr>
<td>NDE</td>
<td>non-destructive examination</td>
</tr>
<tr>
<td>NDT</td>
<td>non-destructive testing</td>
</tr>
<tr>
<td>PE</td>
<td>polyethylene</td>
</tr>
<tr>
<td>PME</td>
<td>protective multiple earthing</td>
</tr>
<tr>
<td>PRI</td>
<td>pressure regulating installation</td>
</tr>
<tr>
<td>PRIIV</td>
<td>PRI inlet valve</td>
</tr>
<tr>
<td>PRIOV</td>
<td>PRI outlet valve</td>
</tr>
<tr>
<td>SMYS</td>
<td>specified minimum yield strength</td>
</tr>
<tr>
<td>SSV</td>
<td>slam-shut valve</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
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</table>

Units

<table>
<thead>
<tr>
<th>Symbol</th>
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<tr>
<td>lb</td>
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<tr>
<td>m</td>
<td>metres</td>
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<td>mbar</td>
<td>millibars</td>
</tr>
<tr>
<td>mm</td>
<td>millimetres</td>
</tr>
<tr>
<td>m s⁻¹</td>
<td>metres per second</td>
</tr>
<tr>
<td>N mm⁻²</td>
<td>Newtons per square millimetre</td>
</tr>
<tr>
<td>Ω</td>
<td>ohms</td>
</tr>
<tr>
<td>°</td>
<td>angular degrees</td>
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Subscripts

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<tbody>
<tr>
<td>d</td>
<td>downstream</td>
</tr>
<tr>
<td>pri</td>
<td>pressure regulating installation</td>
</tr>
<tr>
<td>u</td>
<td>upstream</td>
</tr>
</tbody>
</table>

Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;</td>
<td>greater than</td>
</tr>
<tr>
<td>≤</td>
<td>less than or equal to</td>
</tr>
<tr>
<td>d</td>
<td>internal diameter</td>
</tr>
<tr>
<td>D</td>
<td>outside diameter</td>
</tr>
<tr>
<td>f</td>
<td>maximum design factor</td>
</tr>
<tr>
<td>p</td>
<td>pressure</td>
</tr>
<tr>
<td>P</td>
<td>design pressure</td>
</tr>
<tr>
<td>s</td>
<td>SMYS</td>
</tr>
<tr>
<td>t</td>
<td>design wall thickness</td>
</tr>
<tr>
<td>t₀</td>
<td>nominal wall thickness</td>
</tr>
<tr>
<td>X</td>
<td>overpressure factor</td>
</tr>
<tr>
<td>Ø</td>
<td>diameter</td>
</tr>
</tbody>
</table>

7.1 GENERAL PRINCIPLES

7.1.1 The design pressure of the upstream part of any PRI (DP_{upri}) shall be greater than or equal to the maximum operating pressure of the upstream system (MOP_u).

The design pressure of the downstream part of the PRI (DP_{down}) shall be greater than or equal to the maximum operating pressure of the downstream system (MOP_d).

7.1.2 A PRI shall be designed:

- as part of a system which may comprise other installations and connected pipelines

  Note: A system may include compression or other means of inducing flow, monitoring and controlling, as well as communications systems.

- taking into account its complete life-cycle through concept design, detail design, material and equipment procurement, fabrication, installation, testing, commissioning, operation, maintenance, modification and final decommissioning

- specifying fabrication methods for construction together with any heat treatment, non-destructive testing (NDT), non-destructive examination (NDE) and inspection; the methods and procedures being in accordance with appropriate standards

- so that it does not, at any time, present an unacceptable risk to any person nor adversely affect the environment. Any hazard associated with a PRI shall be identified, risks evaluated and measures taken to reduce risk to as low as reasonably practicable (see IGE/SR/24)

- to allow piping systems, plant and equipment to be isolated safely, inspected, maintained and tested

- with sufficient safety systems to protect the downstream system(s) in the event of failure of the pressure regulating system (see Sub-Section 8.5)

- with sufficient isolation valves and valved purge and vent points to enable depressurisation and subsequent testing
• so that all plant and equipment is capable of withstand ing the most severe conditions of coincident pressure, temperature, chemical action and mechanical loading that may occur during normal operation and reasonably-foreseeable adverse conditions, for example the elevated temperature immediately downstream of a compressor station
• to achieve the required level of reliability, taking into account the requirements for the safe operation of the system, continuity of supply, plant and equipment failure characteristics and redundancy, for example by the inclusion of multiple streams, etc.
• to minimise the effect on the environment of gas venting through the operation of control devices, etc.

7.1.3 Due account shall be taken of:
• range of flow rate required
• range of design temperature
• range of inlet and outlet pressures related to flow rate
• special characteristics of the load, for example when the PRI is to supply an industrial or commercial consumer
• cleanliness of the gas in respect of both solid particle and liquid entrainment
• odorisation and other treatment

Note: Gas detection equipment may be required for sites with unodorised gas.
• any need for protection against reverse flow
• any need for pre-heating prior to pressure reduction
• any need for metering
• any need for noise control
• any requirements for telemetered information and remote control
• the need for maintenance, especially to;
  • enable safe and easy access to operating components
  • permit safe and simple operation by maintenance staff
  • allow for safe and easy dismantling and reassembly of all or part of the operating components.
• any requirement for inspection periods.

7.1.4 Where a PRI is constructed in modular form and fabricated off-site, an appropriate lifting facility should be provided by the manufacturer. The total weight shall be marked clearly.

7.2 PIPEWORK SIZING

7.2.1 Pipework should be sized such that the gas velocity will not exceed 20 m s\(^{-1}\) for unfiltered gas and 40 m s\(^{-1}\) for filtered gas, at the outlet of the PRI under conditions of maximum flow and lowest operational pressure.

7.2.2 Installation outlet headers should be designed to have a cross-sectional area of at least 1.5 times the sum of the cross-sectional areas of all working inlet connections, to ensure that impulse points for regulator control systems are representative of the pressure in the downstream network. Pipework between the outlet header and the PRI outlet valve should be at least the same diameter as the header pipework.

7.2.3 Where a PRI serves a network of MOP ≤ 75 mbar, the pipework between the outlet header and the PRI outlet valve should be designed for a pressure loss of not exceeding 1.25 mbar.
Note 1: Diameter changes may influence the performance of the system in respect of noise, turbulence and vibration. A change in diameter can be achieved by the use of forged fittings or taper pieces to provide a smooth transition. On the downstream side of a regulator, it is recommended that consideration be given to the use of taper pieces with an included angle not exceeding 15°.

Note 2: Where it is essential to the PRI design requirements, gas velocities within the PRI streams may exceed the required filtered gas velocity subject to the system design capability, noise levels and good engineering practice.

7.3 DESIGN PRESSURE BOUNDARIES

7.3.1 DP of components and pipework should be compatible with their location in relation to pressure boundaries.

7.3.2 For regulator streams, the design pressure boundary shall be at the outlet connection of the regulator stream outlet isolation valve.

7.3.3 Plant and equipment (including pilot bodies) up to the outlet valve of each stream should be designed to withstand anticipated inlet pressure but, where this is not reasonably practicable, measures shall be incorporated to prevent unsafe pressures occurring in any part of the PRI.

7.3.4 Where a pressure-bearing part of a differential strength regulator will need to be protected from inlet pressure, for example a diaphragm chamber, the chamber shall be impulsed downstream of the stream outlet isolation valve.

7.3.5 If differential strength regulators are used, components shall comply with BS EN 334.

7.4 ISOLATION OF PRIS AND COMPONENTS

7.4.1 Principles of isolation

Figures 7(a) to 7(c) provide examples of PRI isolation methods and define the design boundaries applicable to IGEM/TD/13, the extremities of the PRI being shown as the outlet of the upstream pipeline/PRI isolation valve A and the inlet of the downstream PRI/pipeline isolation valve B.

Note 1: Other valves (C, D, E, F) shown in Figures 7(a), 7(b) and 7(c), may be included either as required by IGEM/TD/13 or by the design specification.

Note 2: The physical boundary of a PRI station may extend beyond the location of the valves defining the pressure boundary. In such cases, arrangements will need to be in place between the respective operators of the PRI and the pipeline, for access to valves and pipe considered part of the pipeline. However, for the purposes of IGEM/TD/13, note, from Figure 7(c) that the fence is not intended to represent a boundary.

A is the upstream pipeline isolation valve that may also serve as a PRI isolation valve
B is the downstream pipeline isolation valve that may also serve as a PRI isolation valve
C is an “optional” PRI inlet valve (PRIIV)
D is an “optional” PRI outlet valve (PRIOV)

Figure 7 (a) - PRI equipment only

FIGURE 7 - EXAMPLES OF PRI ISOLATION
A is the upstream pipeline valve that may also serve as a PRI isolation valve
B is the downstream pipeline isolation valve that may also serve as a PRI isolation valve
C is an "optional" PRIIV
D is an "optional" PRIOV
E are pipeline by-pass valves
F is the main pipeline valve

See Notes to clause 7.4.1.

**Figure 7 (b) - Offtake with PRI**

**Figure 7 (c) - Off takes with PRI and showing security fence**

**FIGURE 7 - EXAMPLES OF PRI ISOLATION (cont)**
7.4.2 **Provision of isolation valves** (see Figure 7)

Pipeline/PRI and PRI/pipeline isolation valves (Figure 7, valves A and B), considered to be part of the pipeline (see IGE/TD/1, TD/3 and TD/4 respectively) are assumed to be installed by the pipeline operator.

Reference shall be made to the HS(G)253.

7.4.2.1 In addition to the respective pipeline isolation valves, isolation valves shall be installed in a PRI, as follows:

- where required, a PRIIV at the inlet of the PRI, downstream of the upstream pipeline isolation valve (Figure 7, Valve C)
- where required, a PRIOV at the outlet of the PRI, upstream of the downstream pipeline isolation valve (Figure 7, Valve D)
- at the inlet and outlet of each stream of the PRI
- at any other location where it is foreseeable that plant or equipment may need to be isolated, for example for maintenance or replacement.

Pressure points shall be fitted to both sides of PRIIVs and PRIOVs where the valve is greater than 80 mm nominal size.

**Note 1:** On PRIs of MOP \(\leq 7\) bar, supplying discrete networks, the PRIOVs (items B and/or D in Figure 7) may be omitted.

**Note 2:** The provision of a PRIIV and/or a PRIOV (items C and D in Figure 7) is not a requirement, provided that the upstream and downstream pipeline isolation valves (items A and B in Figure 7) can be readily operated, i.e. in an emergency, by persons working on the PRI.

**Note 3:** On PRIs with inlet pressures > 2 bar, each regulator stream inlet isolation valve has to be of flanged or weld end construction on its inlet connection.

7.4.2.2 Any branch connection to main stream pipework, including any sensing pipe, shall have an isolation valve installed as close as practicable to the point of attachment.

**Note:** In some instances, it may not be appropriate to install an isolation valve on pipework serving a safety device.

The required level of isolation, for example using single seat valves, double seat valves, block and vent, double block and bleed, etc., shall be determined by an assessment of the hazards and risks which shall take into account factors such as the:

- nature and duration of work to be carried out on any isolated plant, for example the inspecting and changing of filter elements, maintaining pressure regulating equipment, removing equipment, hot work, etc.
- gas pressure and the consequences of breakdown or failure of the means of gas isolation
- duty, reliability, sealing and operating characteristics of selected valves.

The process and decisions, with their justification, leading to the selection of the chosen method(s) of isolation, shall be documented and records retained in an appropriate manner.

7.4.3 **Location and identification of isolation valves**

7.4.3.1 Any isolation valve shall be provided in a safe position, protected from damage and interference.

7.4.3.2 The distance between the upstream pipeline isolation valve, or the PRIIV if installed, and the PRI it isolates should be kept to a minimum commensurate with the level of risk and the need for safe access in an emergency.
Note: Recommended clearances are a minimum of 4 m from operational equipment for MOP > 7 bar, and a minimum of 2 m with a maximum of 10 m for MOP ≤ 7 bar.

7.4.3.3 Any isolation valve shall be identified clearly at its location, either by marking the valve itself or by a permanent notice fitted near the valve.

7.4.3.4 Valve identification shall be unique to the valve.

7.4.4 Selection of isolation valves

7.4.4.1 The following shall be taken into account when deciding on the type of valve to be used:

- necessity for effective sealing at all anticipated operational pressure levels

  Note: Some non-return flow control valves and certain other valves are not suitable for providing gas-tight isolation. In some circumstances, this may mean having to check the failure history of valves but, in any event, verification of the potential performance of the valve is recommended.

- anticipated duty, for example operating with filtered or unfiltered gas, expected differential pressure, need for throttling, etc.

- ability to obtain a tight seal, aided, for example, by use of soft seats, lubricant, sealant, valve adjustment, seat adjustment or by venting body cavities.

Where isolation is by a single ball or gate valve, of 50 mm nominal bore and greater, this shall be designed to seal on both the upstream and downstream faces and the space between shall be constructed with the facility for installing a vent. Body vents shall be valved and plugged.

Where isolation is by twin valves, a valved connection shall be fitted so that the space between the valves may be vented.

Note: Body cavities of double seated isolation valves need to be fitted with a suitable vent valve during manufacture or before the valve is tested and put into service. Vent plugs not having a pressure-bleed device are potentially hazardous in situations where, when unscrewed from a valve body, the pressure contained is high.

- any requirement for minimising pressure loss through the valve

  The differential pressure across regulator stream isolation valves in the open position at minimum operating pressure and maximum design flow rate should not exceed:

  - for OP ≤ 75 mbar; 20 mbar
  - for 75 mbar < OP ≤ 2 bar;
  - for OP > 2 bar; 100 mbar

- requirements for mechanical strength
- torque characteristics or ease of operation
- need for actuation, the provision of an energy source and means of manual operation
- speed of operation
- maintenance requirements, including ease of in-line maintenance

Note: In general, valves that do not require maintenance are preferred.

- special requirements for valves near a meter, when reference shall be made to BS 6400 - 1, 2, 3, IGE/GM/4, IGEM/GM/6 or IGE/GM/8, as appropriate.

Note: BS 6755 - 1 provides guidance on the tightness testing of valve seats, during manufacture.
7.4.4.2 Valves shall comply with, as appropriate:
- BS 1552
- BS 5353
- BS EN 331
- BS EN 593
- BS EN 13774
- BS EN 15761
- BS EN ISO 10497
- BS EN ISO 17292
- API 6D
- GIS/V7-1.

7.4.5 Features of valves and their actuators

7.4.5.1 Any valve shall carry clear indication of the direction of operation to open and close the valve.

Any valve shall close when the direct operating actuator is turned in a clockwise direction.

7.4.5.2 Facility shall be provided to drain liquids from the body of any valve.

7.4.5.3 On a small bore valve, i.e. \(\varnothing \leq 25\) mm, where the valve incorporates a “ball”, the valve shall be constructed such that the ball cannot be released by unscrewing any part of the body.

7.4.5.4 Where it is necessary to lubricate a valve for continued satisfactory operation, seals or check valves shall be provided to minimise the amount of excess lubricant passing into the gas stream.

7.4.5.5 A force lubricated valve shall not be used immediately upstream of a meter.

7.4.5.6 Any actuator shall be correctly matched to its valve both in terms of required torque and mechanical attachment. The conditions under which the valve is required to operate, including speed of operation, shall be specified.

7.4.5.7 Where a valve is supplied with an actuator, stem extension, gear-box etc., it shall be matched and fitted to ensure that each assembly functions correctly in the intended attitude(s). Removal of an actuator should not affect the pressure-tightness of the valve.

7.4.5.8 Actuators shall be weatherproof.

7.4.5.9 Means shall be provided to:
- enable safe manual operation of any actuated valve
- prevent local or remote automatic operation while the hand-operated drive of an actuated valve is engaged.

7.4.5.10 For any buried valve requiring periodic injection of lubricant or sealant, consideration shall be given to extending injection points to a suitable point above ground.

7.5 GAS CLEANING

7.5.1 If there is any possibility that dust or liquid could be present in the upstream gas system, consideration shall be given to incorporating an extraction system which,
if adopted, should not be more stringent than is necessary to protect downstream equipment.

### 7.5.2 Any filtration system shall:
- be designed to permit maximum design gas flow at the minimum inlet pressure
- be provided with local visual means, such as a differential pressure gauge with slave pointer, to register the maximum differential pressure which has occurred across each main filter. The differential pressure gauge shall be connected to the tappings provided by the filter manufacturer for this purpose
- for liquid contaminants, be provided with a manual or automatic discharge device, with a collector if necessary
- be constructed such that filter baskets are sufficiently robust as to contain any rupture of the filtering elements
- where classified as a pressure vessel, comply with PD 5500 or BS EN 13445
- for OP ≤ 7 bar and ≥ 80 mm nominal size, comply with the requirements of GIS/E13.1
- have any closure constructed such that it can be opened safely
- be designed such as to avoid contaminants falling into the downstream system during cleaning.

### 7.5.3 The pressure drop across clean filters at maximum design flow should not exceed the levels indicated in Table 4.

<table>
<thead>
<tr>
<th>OP</th>
<th>Differential Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 75 mbar</td>
<td>≤ 0.6 mbar</td>
</tr>
<tr>
<td>&gt; 75 mbar ≤ 2 bar</td>
<td>≤ 20 mbar</td>
</tr>
<tr>
<td>&gt; 2 bar</td>
<td>≤ 100 mbar</td>
</tr>
</tbody>
</table>

**TABLE 4 - MAXIMUM DIFFERENTIAL PRESSURE ACROSS CLEAN FILTERS**

### 7.5.4 Filters for main regulators shall have cut off levels as indicated in Table 5.

<table>
<thead>
<tr>
<th>OP</th>
<th>Filtration Cut Off Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 75 mbar</td>
<td>≤ 250 µm</td>
</tr>
<tr>
<td>&gt; 75 mbar ≤ 2 bar</td>
<td>≤ 200 µm</td>
</tr>
<tr>
<td>&gt; 2 bar ≤ 7 bar</td>
<td>≤ 50 µm</td>
</tr>
<tr>
<td>&gt; 7 bar</td>
<td>2 µm*</td>
</tr>
</tbody>
</table>

Note: Filtration cut off Levels less stringent than 2 µm may be justified following a detailed impact analysis.

**TABLE 5 - FILTRATION CUT OFF LEVELS FOR MAIN REGULATORS**

### 7.5.5 Filtration shall be provided within individual regulator streams or as a separate facility, i.e. multiple filter units in a filter bank arrangement with suitable valving. Multiple units should permit the design throughput to be maintained with one unit out of operation.

In-line strainers, either closed or open ended, shall not be used to provide permanent filtration on installations.

Note: Filtration may be omitted if the installation is on the immediate outlet of a higher-pressure installation which itself incorporates filtration and there is no secondary feed into the pipework between the two installations.

### 7.5.6 Any filtration system shall permit compliance with clause 7.2.1 regarding velocity.
7.5.7 Account shall be taken of the design pressure loss of the cleaning system when the inlet pressure to the PRI is at its lowest.

7.5.8 Temporary open ended strainers shall be installed on the inlet of the first regulator in each stream in the following circumstances:

- on new installations where the main filters are not on the immediate inlet of the equipment they protect, for example where there are heating and metering streams before the regulator streams.

- on existing installations where modifications are undertaken on the main pipework between the main filters and any meter or regulator, where the modification could result in debris occurring in the length of the pipework between the main filter unit and the equipment to be protected.

Such temporary strainers shall be removed having been in service for one winter period.

The presence of such a strainer should be indicated on the relevant section(s) of pipework (and be removed when the strainer is removed).

7.5.9 Any auxiliary system should itself include a filtration system.

7.5.10 Filters for gas supplies to pilots and auxiliaries shall have cut off levels as indicated in Table 6.

<table>
<thead>
<tr>
<th>OP</th>
<th>PILOT ORIFICE DIAMETER</th>
<th>FILTRATION CUT OFF LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 7 bar</td>
<td>≥ 3.2 mm (1/8&quot;)</td>
<td>≤ 50 µm</td>
</tr>
<tr>
<td>≤ 7 bar</td>
<td>&lt; 3.2 mm (1/8&quot;)</td>
<td>≤ 10 µm</td>
</tr>
<tr>
<td>&gt; 7 bar</td>
<td>All</td>
<td>≤ 10 µm</td>
</tr>
</tbody>
</table>

**TABLE 6 - FILTRATION CUT OFF LEVELS FOR GAS SUPPLIES TO PILOT AND AUXILIARIES**

7.6 HEATING OF GAS

A reduction in pressure creates a reduction in temperature which may necessitate the installation of pre-heaters to avoid unacceptably-low temperatures on the outlet of pressure regulating equipment.

*Note:* Normally, it is not necessary to provide pre-heating where the pressure differential across a PRI is less than 15 bar.

7.6.1 Where it is determined that gas pre-heating is required, and except where contractual requirements dictate otherwise, the minimum outlet temperature should be 0°C.

7.6.2 It may be possible to operate at lower outlet temperatures, thereby reducing or eliminating the cost of preheating, but consideration shall be given to the effects of sub-zero operation such as:

- ability of the downstream pipe material to retain satisfactory physical characteristics at any reduced temperature of operation
- detrimental effects on pilot control systems
- the possibility of hydrate or liquid formation which could influence the operation of PRI and downstream equipment
- the soil type surrounding the downstream system
• the effect of frost heave on adjacent plant, buildings, roads and other services
• the effect of low temperatures on mains subject to gas conditioning
• potential damage caused to arable and cereal crops
• low temperatures on pipeline coatings
• low temperature effects on agricultural irrigation systems.

Where the effects of low temperature operation could have a detrimental effect on pilot control systems, consideration shall be given to the provision of an independent pilot heating system.

Note 1: This may be provided by methods such as trace heating, vortex heating, small capacity electric heaters or secondary heat exchanger loops in the main heating system.

Note 2: Consideration may be given to the provision of pre-heating to improve the operating condition of equipment by reducing the likelihood of condensation occurring and, hence, reducing corrosion.

7.6.3 Pre-heating should be provided by one, or more, of the following methods:
• waterbath heaters
• package/modular boilers and heat exchanger system
• electrical heaters.

Note: Alternative methods of pre and post pressure reduction heating methods may be considered.

7.6.4 The sizing of the heating system shall be determined by calculating the amount of heat required to maintain the desired installation outlet temperature. Account shall be taken of the maximum pressure drop across the system, the flow through the system and any other heat losses associated with the system.

Care shall be taken when sizing a heating system. Oversizing, to meet the unlikely event of maximum projected (1:20) demand conditions occurring simultaneously with maximum differential pressures, can result in poor reliability of the heating system and rapid deterioration of condensing boilers due to cycling in non-condensing mode.

7.6.5 The heat input shall be calculated to meet the particular duty. The full calculation shall take into account the composition of the gas to be heated and the influence of pressure on the specific heats of its various constituents.

7.6.6 The number of heaters, capacity, configuration and the level of standby provision should be determined by the criticality of the installation with respect to its requirement for heating and the probability of failure of a unit occurring simultaneously with a period of extreme demand.

Note: If this possibility is low, the provision of standby heater capacity to meet the extreme condition may not be necessary.

7.6.7 Consideration shall be given to the reliability of the system in operation, taking into account its dependence on other services.

Note: It may be necessary to provide standby water and electricity supplies where continuous operation under all fault conditions is essential.

7.6.8 Where waterbath heaters are utilised, the heater air intake and flue stack shall be sited in a safe area of the PRI, as determined in accordance with IGE/SR/25. Particular care should be taken with the siting of the heater control system to ensure that any hazardous areas associated with it do not encroach into the vicinity of the heater air intake and flue stack.
7.6.9 Package/modular boiler installations shall be sited in a safe area of the PRI as determined in accordance with IGE/SR/25 and installed to comply with the requirements of BS 6644 and IGEM/UP/10.

7.6.10 The fuel gas supply pipework, between the fuel gas supply pressure regulating installation and the inlet to the boiler housing, shall be sized to ensure a stable pressure is available at the inlet of the boilers under all operating conditions.

7.6.11 The fuel gas supply for heating installations should, wherever possible, be taken from the point of lowest pressure within the PRI consistent with the requirements of the heater burner system and, in the case of waterbath heaters, downstream of the waterbath heater.

7.6.12 Any heater installation shall be equipped with a meter for measuring its fuel consumption and a control system which minimises the energy consumed by the pre-heaters. Measures shall be taken to protect water-based heating systems from freezing and internal corrosion.

7.6.13 Precautions shall be taken to prevent interchange of the gas with the heating medium.

7.6.14 Consideration shall be given to the effects of thermal stress which may occur in heat exchangers due to the cyclic nature of some heating control systems.

7.6.15 Measures shall be taken to protect water-based heating systems from freezing and internal corrosion.

7.6.16 Any material used in a PRI, in particular polymeric and elastomeric types, shall be capable of withstanding the maximum temperature that the pre-heating source can attain.

Note: It may be necessary to limit the maximum temperature of the pre-heating source to avoid exceeding the safe operating temperature of such materials in any meter or regulator valve seat.

7.7 NOISE AND VIBRATION

A PRI can generate noise and vibration which, if untreated, may:

- create an environmental nuisance in the locality of the site
- create a hearing hazard to personnel working on the site
- result in component failure.

7.7.1 Environmental noise

7.7.1.1 Consideration shall be given to the incorporation of noise control features to limit noise to an acceptable level at the site boundary and near inhabited buildings.

Note: The level of noise permitted may be dictated by local requirements.

7.7.1.2 Consideration shall be given to installing equipment that produces a low noise level.

If the noise level is not sufficiently low, ear defenders shall be worn by operatives and prominent warnings signs shall be displayed at the access point to the area.

7.7.2 Vibration and acoustic fatigue

7.7.2.1 Account shall be taken of the damaging effects of acoustic fatigue caused by high frequency vibration.
Vibration can affect components installed within pipework, particularly the elements within silencers, the pipework itself and small bore instrument connections. Specific precautions to secure pilots, gauges and small-bore pipework against vibration, or even to alter natural excitation frequency, may be necessary to avoid damage to compression-type fittings.

Reference should be made to Appendix 9.

7.7.2.2 Relief valve vent stacks are susceptible to vibration. Steps shall be taken to prevent damage to any stack and relief valve when in use.

7.8 BREATHERS, VENT LINES AND RELIEF VENT STACKS

7.8.1 General

7.8.1.1 Any vent or relief system shall have adequate support and anchorage, to minimise induced stresses in the relief valve and its associated pipework.

7.8.1.2 Materials for vent stacks shall be as used in the main PRI pipework.

7.8.1.3 For any vent or relief system of MOP > 7 bar, pipework should be hydrostatically tested to the same level as the main PRI pipework.

Note: It is not necessary to test vents of MOP \(\leq 7\) bar.

7.8.2 Breathers

7.8.2.1 Gas escaping through breathers in ancillaries can result in a flammable mixture in an enclosed space which shall be avoided.

7.8.2.2 One or more of the following provisions shall be made:

- fit apertures with vent lines to outside the enclosed space
- include restrictions in breather connections, provided the operational performance is not impaired
- provide extra ventilation in the space.

7.8.2.3 If a vent line is fitted to an aperture serving diaphragms in regulators or safety devices, it shall be of sufficient capacity to permit gas to escape freely. The functioning of any associated pressure regulator and/or safety device shall not be affected adversely by pressure build-up in the line.

7.8.3 Vent lines

7.8.3.1 Vent lines working at the same pressure may be combined but gas flow through one or more shall not affect the operation of any equipment.

7.8.3.2 Dedicated vent and depressurising lines shall not be combined with breather lines in a manifold.

7.8.3.3 If a manifold is used for a type of vent line, this shall not impair the proper functioning of the connected units.

7.8.3.4 Any termination of a vent line shall be located at a safe distance from any source of ignition. The termination shall be designed to suit the local conditions.

7.8.3.5 Suitable precautions shall be taken to prevent blockage of the outlet of any vent line and to protect it against the ingress of foreign material, for example water, dirt, insects, etc.
7.8.4 **Relief vent stacks**

*Note: Further guidance on relief vent stacks is given in IGE/SR/23.*

7.8.4.1 Any termination of a relief vent stack shall be located at a safe distance from any source of ignition. Any vent termination shall be designed to suit the local conditions (see also clause 6.1.1).

7.8.4.2 Suitable precautions shall be taken to prevent blockage of the outlet of any relief stack and to protect it against the ingress of foreign material, for example water, dirt, insects, etc.

7.9 **PIPE AND FITTINGS**

7.9.1 **General**

7.9.1.1 Welded joints should be used in preference to flanges, screwed connections or flexible connections, where reasonably practicable and economic, to eliminate potential leakage sources and fugitive emissions.

7.9.1.2 Main pipework and fittings, for use above ground, shall be of fire resistant material such as steel. PE pipe and fittings shall not be used above ground nor above floor level inside housings.

*Note 1: Copper as a material for fittings is not, generally, preferred because of strength and requirements for protection against theft. However, it does have applications (see clause 7.10.3).*

*Note 2: The use of other materials may be considered for some buried pipework.*

7.9.1.3 Steel pipework should be used for critical applications, particularly above ground, and non-metallic pipework shall not be used.

*Note: Steel or stainless steel pipe and fittings are recommended for critical pipework. Copper is a less preferred material for critical pipework such as sensing and auxiliary lines. This is for strength considerations and because of the possibility of vandalism and theft.*

7.9.1.4 Pipework shall be designed to allow the removal and replacement of equipment without the need to distort pipework.

7.9.2 **Steel pipe for main PRI pipework**

7.9.2.1 Pipe shall be seamless or longitudinally welded.

7.9.2.2 Pipe shall comply with appropriate standards to suit the required duty, such as:

- API 5L
- ASTM A 106
- BS EN 10208
- BS EN 10216
- BS EN 10217
- BS EN ISO 3183-2 ?.

7.9.2.3 The selection of pipe shall be qualified with respect to its yield strength, brittle and ductile fracture toughness and weldability in accordance with a suitable standard such as ANSI/ASME B31.8.

*Note 1: Minimum fracture toughness levels ensure, at the appropriate test temperature, safe operation without risk of propagating brittle or ductile fractures. The requirements are to ensure high quality construction under field welding conditions.*

*Note 2: Historically, API 5L is the most commonly specified pipe standard. In Europe, increasing use is being made of BS EN 10208 (BS EN ISO 3183-2?). Company standards, for example those of GTS, may specify additional requirements to these national and international specifications.*
7.9.2.4 The minimum wall thickness shall be selected by using the largest of the values determined in the formula given in clause 7.9.2.10 and those in Table 8.

*Note 1:* Table 8 values will be found to apply at relatively low pressures and the formula will be found to apply at higher pressures.

*Note 2:* Greater wall thickness may need to be specified following any specialist stress calculation made in accordance with additional requirements such as those in IGE/TD/12.

7.9.2.5 The following formula for determining minimum wall thickness shall be used:

\[ t = \frac{PDX}{(20fs)^{-1}} \]

- \( t \) = design wall thickness of pipe (mm)
- \( P \) = design pressure (bar)
- \( D \) = outside diameter of pipe (mm)
- \( f \) = maximum design factor determined from Table 7
- \( s \) = specified minimum yield strength (SYMS) (N mm\(^{-2}\))
- \( X \) = maximum incidental pressure (MIP) divided by MOP and is an overpressure factor. This factor is unique to PRIs and is not used for pipelines (IGEM/TD/1, IGE/TD/3 or IGE/TD/4) or for stress analysis (IGE/TD/12).

Note: Appendix 3 provides example calculations.

<table>
<thead>
<tr>
<th>SITE DESCRIPTION AREA</th>
<th>MAXIMUM f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location manned</td>
<td>All 0.67</td>
</tr>
<tr>
<td>Location protected against external interference and unmanned</td>
<td>R 0.67, S 0.5, T 0.3</td>
</tr>
</tbody>
</table>

*Note:* Type R - Rural areas with a population density not exceeding 2.5 persons per hectare.

Type S - Areas intermediate in character (between Types R and T) in which the population density exceeds 2.5 persons per hectare and which may be developed extensively with residential properties, schools, shops, etc.

Type T - Central areas of towns or cities, with a high population density, many multi-storey buildings, dense traffic and numerous underground services.

### TABLE 7 - SELECTION OF MAXIMUM DESIGN FACTOR (f)

<table>
<thead>
<tr>
<th>NOMINAL DIAMETER OF PIPE (mm)</th>
<th>MINIMUM WALL THICKNESS (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>3.9</td>
</tr>
<tr>
<td>80</td>
<td>4.78</td>
</tr>
<tr>
<td>100</td>
<td>4.78</td>
</tr>
<tr>
<td>150</td>
<td>4.78</td>
</tr>
<tr>
<td>200</td>
<td>6.35</td>
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<tr>
<td>250</td>
<td>6.35</td>
</tr>
<tr>
<td>300</td>
<td>6.35</td>
</tr>
<tr>
<td>400</td>
<td>6.35</td>
</tr>
<tr>
<td>450</td>
<td>6.35</td>
</tr>
<tr>
<td>500</td>
<td>7.92</td>
</tr>
<tr>
<td>600</td>
<td>7.92</td>
</tr>
<tr>
<td>750</td>
<td>9.52</td>
</tr>
<tr>
<td>900</td>
<td>9.52</td>
</tr>
<tr>
<td>1050</td>
<td>11.91</td>
</tr>
<tr>
<td>1220</td>
<td>12.7</td>
</tr>
</tbody>
</table>

*Note:* At lower pressures, these minimum wall thicknesses are still necessary to withstand handling during construction and while in service.

### TABLE 8 - MINIMUM WALL THICKNESS OF STEEL PIPE
7.9.3 **Fittings**

7.9.3.1 Fittings shall be of a material compatible with selected pipe and with each other and be of the appropriate strength for the proposed test pressure.

7.9.3.2 The selection of fittings shall be qualified with respect to yield strength, brittle and ductile fracture toughness and weldability.

7.9.3.3 Any NDT of flanges, fittings and branches shall be carried out after all manufacturing, processing, heat treatment and stress relieving have been completed. Methods appropriate to specific components, and to particular areas such as seam welds, shall be determined.

7.9.3.4 Welds shall not be closer to each other than 150 mm or one pipe diameter, whichever is the smaller, excepting connections provided for impulse and instrumentation purposes. Branches shall be positioned on pipes so that the edges of branch welds are at least 50 mm away from any other weld.

7.9.3.5 Fabricated branches (Figure 8 type D) should be used in preference to stub junctions (Figure 8 type A).

7.9.3.6 The inside of butt welds on fabricated tapers shall be aligned. The minimum wall thickness and material grade of the tapered section should be at least equal to the wall thickness of the pipe attached to the larger end. Taper pieces intended to reduce turbulence should have concentric ends.

7.9.3.7 Bolting and gasket material for flanged joints shall be in accordance with appropriate standards.

7.9.3.8 It may be necessary for some components and fittings to be stress-relieved during fabrication and, possibly, after installation. The requirements shall be determined by reference to an acknowledged standard such as PD 5500, Appendix D.

7.9.3.9 Where fittings are fabricated to other than BS 1640, the fittings should be of the appropriate strength for the proposed test pressure. They should be qualified with respect to strength, fracture toughness and weldability in a similar manner to pipe.

7.9.3.10 Mechanical testing shall be carried out after hot forming and final heat treatment. Tensile testing for forged components should be carried out in accordance with an appropriate standard on specimens taken transverse to the direction of rolling of the original piece. Fittings shall be qualified with regard to fracture toughness by notch ductility testing, for example Charpy testing.

*Note: Suitable sampling rates from a given batch of fittings, specimen extraction procedures and acceptable test results are suggested in BS and ANSI/ASME codes.*

7.9.3.11 The weldability of fittings of a specific type and from a specified source of supply should be assessed on a full size production sample, preferably a complete butt weld to a pipe pup.

7.9.3.12 Unless otherwise specified, all NDT of fittings shall be carried out after all processing, heat-treatment and final stress relief, if possible.

7.9.3.13 Fittings shall be selected in accordance with Table 9 and Figure 8.
<table>
<thead>
<tr>
<th>FITTING TYPE</th>
<th>MATERIAL</th>
<th>LIMITATIONS</th>
<th>CONSTRUCTION IN ACCORDANCE WITH</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bends, branches, tees</td>
<td>PE</td>
<td>To relevant standard</td>
<td>BS EN 1555-3 GIS/PL2 Parts 4 or 6</td>
<td></td>
</tr>
<tr>
<td>Bends, branches, tees</td>
<td>Non-metallic but not PE</td>
<td>Not preferred</td>
<td></td>
<td>See clause 7.13.3</td>
</tr>
<tr>
<td>Bends, branches, reducers, tees</td>
<td>Copper</td>
<td>ø ≤ 22 mm p ≤ 2 bar</td>
<td>BS EN 1254-2 BS 2051</td>
<td>Restricted use.</td>
</tr>
<tr>
<td>Bends, tees, reducers, plugs etc.</td>
<td>Malleable iron</td>
<td>ø ≤ 50 mm/ 2 in screwed p &gt; 7 bar</td>
<td>BS 143 and 1256</td>
<td>Commonly used in screwed form for small PRIs</td>
</tr>
<tr>
<td>Compression fittings</td>
<td>Brass Carbon steel Stainless steel</td>
<td>ø ≤ 40 mm</td>
<td>BS 4368</td>
<td>See clause 7.13.3</td>
</tr>
<tr>
<td>Forged or extruded bends, tees, reducers, caps etc</td>
<td>Steel</td>
<td>None</td>
<td>BS EN 10253 BS 1640 for ø &gt; 600 mm MSS SP 75 for ø &gt; 600 and ø ≤ 900 mm</td>
<td>Preferred type especially for p &gt; 7 bar</td>
</tr>
<tr>
<td>Wellolet branches</td>
<td>Steel</td>
<td>d/D ≤ 0.5 p ≤ 7 bar d/D ≤ 0.3 p &gt; 7 bar</td>
<td>ANSI/ASME B 31.11 BS EN 10253</td>
<td>Normally available up to ø = 200 mm/8 in pipe size</td>
</tr>
<tr>
<td>Threadolet branches</td>
<td>Steel</td>
<td>ø ≤ 50 mm/ 2 in screwed</td>
<td>ANSI/ASME B 31.11</td>
<td></td>
</tr>
<tr>
<td>Welloflange branches</td>
<td>Steel</td>
<td>ø ≤ 50 mm</td>
<td>BS EN 10222</td>
<td>Note 6.</td>
</tr>
<tr>
<td>Other screwed branches</td>
<td>ø ≤ 25 mm screwed p &gt; 7 bar</td>
<td>Note 7.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweepolet branches</td>
<td>Steel</td>
<td>d/D ≤ 0.75 p ≤ 7 bar d/D ≤ 0.6 p &gt; 7 bar</td>
<td>BS 1640 or ANSI/ASME B 31.11</td>
<td>Also called &quot;easy sweep&quot; or curved branch. Note 5.</td>
</tr>
<tr>
<td>Full encirclement branches</td>
<td>Steel</td>
<td></td>
<td>PD 5500 or ANSI/ASME equivalent BS EN 13445</td>
<td>Wrapper plate to completely encircle the pipe</td>
</tr>
<tr>
<td>Other fabricated branches (stub junctions)</td>
<td>Steel</td>
<td>p ≤ 7 bar</td>
<td>BS EN 13445 ANSI/ASME B 31.11</td>
<td>Notes 2 and 3.</td>
</tr>
<tr>
<td>Mitre bends</td>
<td>Steel</td>
<td>p ≤ 7 bar</td>
<td>Note 4.</td>
<td></td>
</tr>
<tr>
<td>Cast bends</td>
<td>Steel</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fabricated tapers</td>
<td>Steel</td>
<td>p ≤ 7 bar p &gt; 7 bar</td>
<td>BS EN 13445 PD 5500</td>
<td></td>
</tr>
<tr>
<td>Cast tapers</td>
<td>Steel</td>
<td>p ≤ 7 bar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forged components</td>
<td>Steel- according to relevant flange standards</td>
<td>p ≤ 16 bar &gt; PN16 ø ≤ 600 mm &gt; PN16 ø &gt; 600 mm</td>
<td>BS EN 10222-1 to 5 BS 1560 ISO 7005 (NEQ) ANSI/ASME B 16.5 BS 3293</td>
<td>Forgings which form the whole or part of a component</td>
</tr>
<tr>
<td>Transition fittings</td>
<td>Metal to PE</td>
<td>To relevant standard</td>
<td>GIS/PL3</td>
<td>Note 6. To the relevant pressure rating. Preferred for &gt; PN16</td>
</tr>
</tbody>
</table>

Note 1: Steel used to manufacture fittings require at least equivalent wall thickness and physical and chemical properties to those of the pipe.

Note 2: Branches made from linepipe for use in modular constructions etc. where external loadings at the tee are not significant.

Note 3: Branches made from pipe that is thicker than the respective line pipe where a significant external load may be applied to the tee.

Note 4: Mitre bends are acceptable providing that the angle of each mitre does not exceed 11.25° and the minimum axial distance between welds is half the pipe diameter.

Note 5: Where d/D exceeds 0.5, it is recommended that the proposed location in the line pipe be examined for defects, especially laminations.

Note 6: Flanges for alternative material, for example SG iron or aluminium, are permitted where they form an integral part of the equipment fitted as part of the module, for example a regulator body, provided they are dimensionally compatible.

Note 7: Commonly fabricated from up to 3000 lb. screwed fittings, care is required to ensure the fitting and junction are of sufficient strength to withstand the connecting and loadings that may be imparted by the branch pipework.

Note 8: Small diameter "set-on" flanged branches, subject to fatigue or vibration under operational conditions, have to be one-piece "welloflange" forgings.

**TABLE 9 - LIMITATIONS ON THE SELECTION AND USE OF FITTINGS**
7.9.4 **Gaskets**

7.9.4.1 Compressed fibre gaskets to an appropriate standard such as BS 7531 shall be used. Gaskets containing asbestos shall not be used.

7.9.4.2 Jointing paste or compounds shall not be used to seal flanged connections.

7.9.4.3 Gaskets shall conform to the dimensions given in BS 1560 or BS EN 1514, as applicable, and to the materials in BS 6956 or BS 7531.

7.9.4.4 Joint rings for ring type joint (RTJ) flanges, and spiral wound gaskets shall conform to suitable standards such as BS 3381, API 5A (RTJ), ASME B16.20 and BS EN 12560.

7.9.5 **Bolting, studs, nuts and washers**

7.9.5.1 Bolts and nuts shall comply with BS EN 1515-1, BS 3692, BS 4190 or BS 4882, as appropriate.

7.9.5.2 The correct length of bolt, with 3mm thick washer(s), shall be used.

7.9.5.3 Stud bolts shall comply with a suitable standard such as BS 4882 Grade B7, BS EN 1515-1, ASTM A320 L7, ASTM A193 B7.

---

**FIGURE 8 - TYPES OF BRANCH FITTINGS**

- (a) Branch from line pipe
- (b) Weldolet type
- (c) Full encirclement
- (d) Other fabricated branches

$\varnothing = $ nominal external diameters
7.9.5.4 Nuts and washers for stud bolts shall comply with a suitable standard such as BS 4882 Grade 2H, ASTM A194 2H or BS EN 1515-1 with washers at least 3 mm thick. Two washers per stud bolt shall be used and shall be chamfered 30°.

7.9.6 Flexible connections and joints

7.9.6.1 Flexible connections and joints should, generally, not be used. However, where they are found to be necessary, the following constraints shall apply:

- have OP restricted up to and including 2 bar
- be capable of being dismantled
- incorporate elastomeric seals to BS EN 682
- have positive means provided to prevent separation of the pipes.

7.9.7 Sensing, instrument and auxiliary pipework

7.9.7.1 General

7.9.7.1.1 Auxiliary and impulse lines shall be positioned to reduce the risk of mechanical damage and shall not impede access for maintenance of the module components.

7.9.7.1.2 The design of auxiliary and impulse pipework should allow for commissioning, testing and purging without breaking any fittings.

7.9.7.1.3 Copper and plastic tubing shall not be used in critical applications. Critical pipework is defined as that which provides a primary safety, sensing or control function such as:

- sensing pipework to safety devices (slam-shut or slam-open valves), direct acting regulators, monitor regulators or pilots, outlet pressure limiting pilots or controllers
- auxiliary pipework connecting control systems to inlet or outlet pipework.

7.9.7.1.4 Where plastic tubing is used, it shall be nylon conforming to one of the standards listed in Table 10.

7.9.7.1.5 Sensing, instrument and auxiliary pipework steel be designed to BS 6739 and conform with appropriate national standards for the material and duty involved, for example as shown in Table 10.
7.9.7.2 Metallic pipework

Pipe wall thickness, especially of stainless steel pipe, should be chosen to be compatible with the compression fittings to be used.

Note: Typical wall thickness for imperial pipe is 1.6 mm and for metric pipe is 1.5 mm.

7.9.7.2.2 Where compression fittings are used, they shall not be used on copper pipe of diameter exceeding 28 mm and for steel and stainless steel they should be in outside diameter (O.D.) sizes and not larger than ¾” or 22 mm O.D.

Compression fittings for steel or stainless steel may be either single or twin ferrule, where single ferrule fittings are used they shall conform to the requirements of GIS/F/9.

7.9.7.2.3 The mixing of fittings of different manufacturers and outside diameters on a site should be avoided.

7.9.7.2.4 Compression fittings for use with stainless steel pipe shall be stainless steel

Note: Carbon steel fittings are not suitable.

7.9.7.2.5 Compression fittings shall be assembled in accordance with the manufacturer’s instructions.

7.9.7.2.6 Auxiliary and impulse pipework should be suitable sized and adequately supported using anti-vibration supports as indicated in Table 11.
TABLE 11 - PIPING AND TUBING SUPPORTS

7.9.7.2.7 The effects of vibration shall be considered when designing auxiliary control system pipework and the following factors should be taken into account:

7.9.7.2.8 Where heavy items such as control pilots are included in the auxiliary and impulse pipework, careful attention shall be given to ensure they are adequately supported. Whenever necessary, control pilots should be supported independently from the auxiliary and impulse pipework.

7.9.7.2.9 Flexibility shall be incorporated into the auxiliary and impulse pipework.

7.9.7.2.10 Auxiliary and impulse pipework shall not touch other pipework, fittings or components.

7.9.7.2.11 Formed bends shall not be used in close proximity to compression fittings.

7.9.7.3 Nylon tubing

7.9.7.3.1 Nylon tubing should be protected from mechanical damage.

7.9.7.3.2 MOP shall not exceed 7 bar.

7.9.7.3.3 Manufacturers’ recommendations regarding minimum internal bend radius shall be adhered to and the limitations given in Table 12 applied.

<table>
<thead>
<tr>
<th>TUBE O/D (mm)</th>
<th>TUBE I/D (mm)</th>
<th>MINIMUM INTERNAL BEND RADIUS (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2.5</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>3.0</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>4.0</td>
<td>30</td>
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<td>8</td>
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<td>14</td>
<td>11.0</td>
<td>80</td>
</tr>
<tr>
<td>16</td>
<td>12.0</td>
<td>95</td>
</tr>
</tbody>
</table>

TABLE 12 - MINIMUM INTERNAL BEND RADIUS FOR NYLON TUBE

7.9.7.3.4 On permanent installations, only compression fittings should be used.

Note: Push fit fittings may be used for temporary connections for maintenance purposes only (for example pressure gauges etc.).

7.9.7.3.5 An internal tube support ferrule shall always be used, to support the tube wall, in conjunction with an external ferrule designed for use on plastic tube.
7.9.7.3.6 Fittings with combined internal and external olives/ferrules or fittings that incorporate an integral tube support may also be used. In some cases, the manufacturer may recommend the use of a plastic olive/ferrule in conjunction with a metal internal ferrule.

7.9.7.3.7 In all cases, the individual manufacturer's instructions regarding joint assembly and tightening shall be strictly adhered to as the procedure varies between manufacturers.

7.9.7.3.8 Where it is necessary to install sensing pipework underground, it shall be constructed in steel or stainless steel and be suitably protected against corrosion. Consideration shall be given to providing additional protection from interference damage.

Note: Consideration may also be given to the use of plastic for such pipework, but only where additional protective measures are taken to safeguard it from interference damage.

7.9.8 Screwed pipework and fittings

7.9.8.1 Pipe and fittings should conform to the standards listed in Table 9.

7.9.8.2 For PRIs of MOP_u > 2 bar, screwed pipe and fittings shall not be used for main inlet pipework upstream of any stream inlet isolation valve.

7.9.8.3 The use of screwed connections should be limited to OP as given in Table 13.

<table>
<thead>
<tr>
<th>OPERATING PRESSURE (OP)</th>
<th>NOMINAL BORE (NB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OP &lt; 75 mbar</td>
<td>&lt; 80 mm</td>
</tr>
<tr>
<td>75 mbar &lt; OP &lt; 2 bar</td>
<td>&lt; 50 mm</td>
</tr>
<tr>
<td>2 bar &lt; OP &lt; 7 bar</td>
<td>&lt; 50 mm</td>
</tr>
<tr>
<td>7 bar &lt; OP &lt; 100 bar</td>
<td>&lt; 25 mm</td>
</tr>
</tbody>
</table>

TABLE 13 - LIMITATION ON THE USE OF SCREWED CONNECTIONS

7.9.8.4 Threads shall be in accordance with BS 21.

7.9.8.5 Care shall be taken to ensure that connecting male and female threads are compatible.

7.9.8.6 For MOP ≤ 7 bar, threads shall be specified as either taper male/parallel female or taper male/taper female.

7.9.8.7 For MOP > 7 bar, threads shall be specified as taper male/taper female.

7.9.8.8 Joints should be sealed with an appropriate thread sealant suitable for the pressure and temperature at which it will be used.

7.9.8.9 Joints should not be turned back for alignment purposes, but rather dismantled and re-made.

7.9.9 Pre-testing

When a PRI is to be tested in accordance with Section 12, pre-installation testing of pipe and fittings used for construction is not, normally, required.

However, if any part designed to operate at stresses in excess of 30% SMYS is in close proximity to existing operational plant which it is not possible to protect during the tests to Section 12, the pipe and fittings used shall:

- be pre-installation tested as described in IGEM/TD/1 or
be of such additional wall thickness to ensure a maximum hoop stress of 45% SMYS when subjected to the main test pressure.

7.10 WELDING

7.10.1 Preparation

Prior to welding, the welding procedure specification shall be agreed and welding procedure tests and welder qualification tests shall be completed satisfactorily.

7.10.2 MOP > 7 bar

Welding shall be carried out to BS 4515 (for pipe welding) or BS 2633 (for steel pipework). Where components of different material specifications are to be jointed, the welding procedure shall comply with that specified for the material with the higher yield.

7.10.3 MOP ≤ 7 bar

Welding and inspection shall be carried out to BS 2971.

7.10.4 Post-weld stress relieving

In certain circumstances, for example where the pipe wall is exceptionally thick, heat treatment of site fabrications may be necessary. Where this is required, reference shall be made to an appropriate standard such as PD 5500 (for welded pressure vessels) and treatment should be to appropriate standards such as the procedures laid down in BS 4515 (for welding pipelines) or BS 2633 (for steel pipework), where appropriate.

7.10.5 PE jointing

PE pipe jointing shall be carried out in accordance with IGE/TD/3.

7.11 STRESS ANALYSIS

A PRI will be subject to internal and external forces such as ground movement and changes in temperature and pressure.

7.11.1 General

Attention shall be given to the design in the following circumstances:

- where movement of an underground pipeline may impose stresses on an above ground connection
- where large changes in temperature are possible
- where adequate flexibility is difficult to obtain, for example in a long meter run or similar straight run of above ground pipe
- where fatigue stressing caused by regular pressure and/or temperature changes or vibration may occur.

Reference shall be made to IGE/TD/12, which gives detailed guidance and a method for comprehensive analysis.

7.11.2 Supports

Primarily, supports serve to retain PRI streams and equipment level and at the desired height, and to allow safe removal of equipment for maintenance or replacement.
7.11.2.1 Supports shall be located to contain the bending stresses in any stream within allowable limits. The location of supports shall be such as to ensure that other stresses also remain within allowable limits.

7.11.2.2 Sufficient supports shall be provided to avoid excessive deflections and high stresses caused by the additional weight of fluid contained during hydrostatic testing.

7.11.2.3 Where appropriate, heavy components shall be supported to prevent bending or torsional loading of adjacent pipework.

7.11.2.4 Supports not intended specifically to anchor pipe shall be designed to minimise interference during pipe expansion.

7.11.2.5 Supports shall be designed to cope with any mechanical or noise-excited vibration.

7.11.2.6 Supports welded directly to pipe shall be of the full encirclement type. Local welding stresses shall be minimised, for example by using thick-walled pipe and controlled welding onto the pipe longitudinally.

7.11.2.7 Anchor supports shall be located so as to minimise stresses and be designed to withstand the loads indicated by stress analysis. The possibility of the reversal of forces shall be considered.

7.11.2.8 Buried pipework and headers shall not be considered as anchors unless specifically designed for that purpose.

7.11.2.9 Supports shall incorporate electrical insulation to meet the requirements of any CP system.

7.11.2.10 Corrosion shall be prevented at the point of contact of the support and the pipework by effectively sealing the interface.

7.11.2.11 Where it is considered necessary, pipe supports shall be designed to be removable for maintenance work and for inspection purposes.

7.11.2.12 Sensing and auxiliary pipework shall be adequately supported to cater for its small diameter and inherent vulnerability.

7.12 METERING

7.12.1 General

For associated metering, reference should be made to the following, as appropriate for the pressure and meter type:

- IGE/GM/4
- IGEM/GM/5
- IGEM/GM/6
- IGEM/GM/7A
- IGEM/GM/7B
- IGE/GM/8
- IGE/UP/6 (for a meter associated with a large compressor).

Note: Reference may also be made to other international metering standards such as BS EN ISO 5167 and AGA 3 for orifice meters.
7.12.2 Pipework

7.12.2.1 Pipework immediately upstream/downstream of any meter shall at least comply with the meter manufacturer’s guidelines.

7.12.2.2 Pipework shall not impose any undue strain on the meter and shall be designed such as to accommodate any thermal expansion and contraction.
SECTION 8 : PRESSURE AND FLOW CONTROL

Acronyms and abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>accuracy class</td>
</tr>
<tr>
<td>AG</td>
<td>accuracy group</td>
</tr>
<tr>
<td>LPG</td>
<td>liquefied petroleum gas</td>
</tr>
<tr>
<td>MIP</td>
<td>maximum incidental pressure</td>
</tr>
<tr>
<td>MOP</td>
<td>maximum operating pressure</td>
</tr>
<tr>
<td>nom</td>
<td>nominal</td>
</tr>
<tr>
<td>NRV</td>
<td>non-return valve</td>
</tr>
<tr>
<td>OP</td>
<td>operating pressure</td>
</tr>
<tr>
<td>PRI</td>
<td>pressure regulating installation</td>
</tr>
<tr>
<td>PSSR</td>
<td>Pressure Systems Safety Regulations</td>
</tr>
<tr>
<td>SIL</td>
<td>safety integrity level</td>
</tr>
<tr>
<td>SP</td>
<td>set point</td>
</tr>
<tr>
<td>SSV</td>
<td>slam-shut valve</td>
</tr>
<tr>
<td>STP</td>
<td>strength test pressure</td>
</tr>
<tr>
<td>TOP</td>
<td>temporary operating pressure</td>
</tr>
</tbody>
</table>

Units

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>mbar</td>
<td>millibar</td>
</tr>
<tr>
<td>mm</td>
<td>millimetres</td>
</tr>
</tbody>
</table>

Subscripts

<table>
<thead>
<tr>
<th>Subscript</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>downstream</td>
</tr>
<tr>
<td>pri</td>
<td>pressure regulating installation</td>
</tr>
<tr>
<td>o</td>
<td>outlet</td>
</tr>
<tr>
<td>u</td>
<td>upstream</td>
</tr>
</tbody>
</table>

Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;</td>
<td>less than</td>
</tr>
<tr>
<td>≤</td>
<td>less than or equal to</td>
</tr>
<tr>
<td>&gt;</td>
<td>greater than</td>
</tr>
<tr>
<td>P</td>
<td>pressure</td>
</tr>
<tr>
<td>Q_max</td>
<td>maximum flow rate</td>
</tr>
</tbody>
</table>

IGEM/TD/13 applies to new and replacement PRIs. Usually, it is not necessary to apply IGEM/TD/13 retrospectively to existing PRIs. Some IGEM/TD/13 requirements were not contained in IGE/TD/9 and IGE/TD/10, for example on accuracy classes (ACs) and accuracy groups (AGs) (but these were addressed in IGE/TD/13 Edition 1). However, existing installations designed to IGE/TD/9 or IGE/TD/10 may benefit from appraisal and review in accordance with IGEM/TD/13 in all respects, including AGs and ACs.

8.1 GENERAL

8.1.1 The control system shall be designed to maintain the volume flow or pressure conditions in the downstream system within the required limits.

Note: If a PRI is designed to this Standard, and control is not actioned by the use of programmable electronic devices, then a Safety Integrity Level (SIL) assessment is not normally required.

8.1.2 Reference should be made to Appendix 4 for information on typical available and suitable control methods.

8.1.3 Figure 9 and Table 14 show the relationship which shall be applied between MOP, peak level operating pressure (peak level OP), temporary operating pressure (TOP), MIP and the strength test pressure (STP).

![FIGURE 9 - PRESSURE CRITERIA](image-url)

**FIGURE 9 - PRESSURE CRITERIA**

- SP Nom3 = Maximum set point of, typically, a SSV
- SP Nom2 = Maximum set point of, typically, a monitor regulator
- SP Nom1 = Maximum set point of, typically, the active regulator
- AC applies to regulators
- AG applies to SSVs.
### TABLE 14 - RELATIONSHIP BETWEEN DOWNSTREAM SYSTEM MOP, PEAK LEVEL OP, TOP AND MIP

<table>
<thead>
<tr>
<th>PRESSURE (bar)</th>
<th>PEAK LEVEL OP</th>
<th>TOP</th>
<th>MIP&lt;sup&gt;1,4,5&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOP ≤ 0.1</td>
<td>1.125 MOP</td>
<td>1.35 MOP</td>
<td>0.2 bar&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>0.1 &lt; MOP ≤ 1.0</td>
<td>1.125 MOP</td>
<td>1.35 MOP</td>
<td>1.75 MOP</td>
</tr>
<tr>
<td>1.0 &lt; MOP ≤ 2.0</td>
<td>1.1 MOP</td>
<td>1.2 MOP</td>
<td>1.35 MOP</td>
</tr>
<tr>
<td>2.0 &lt; MOP ≤ 7.0</td>
<td>1.05 MOP</td>
<td>1.1 MOP</td>
<td>1.2 MOP</td>
</tr>
<tr>
<td>7.0 &lt; MOP ≤ 100</td>
<td>1.025 MOP</td>
<td>1.05 MOP</td>
<td>1.1 MOP</td>
</tr>
</tbody>
</table>

Note 1: Where MOP of a network is declared as being less than 75 mbar for reasons of integrity, MIP may be less than 0.2 bar.

Note 2: The table indicates the maximum pressure values permitted in the downstream system. Equipment settings may need to be lower to take into account equipment setting tolerances and multiple streams. See also Appendices 3 and 4. Example calculations are given in Appendix 3.

Note 3: MIP is not to exceed STP for any part of the downstream system.

Note 4: Where a safety device is not required (see Table 9) TOP<sub>d</sub> and MIP<sub>d</sub> are not relevant.

Note 5: For systems subject to PSSR (see clause 14.2.6) it is possible to establish a safe operating limit for the downstream system from the pressure test at 1.5 MOP. Consequently, for 2 to 7 bar systems, subject to such a satisfactory test, MIP may exceed 1.2 MOP but is limited to a maximum of 1.33 MOP.

### 8.2 PRESSURE REGULATING SYSTEMS

8.2.1 The pressure regulating system shall maintain the pressure within limits which are acceptable for the downstream system under all flow conditions and at the minimum inlet pressure.

8.2.2 The set point should not exceed MOP.

*Note: It is recognised that OP may exceed the set point due to the dynamic nature of the regulating system.*

8.2.3 The active regulator should not allow the downstream OP to exceed the values given for peak level OP in Table 8.

8.2.4 The AC and lock-up performance of any active regulator or control system, controlling a fixed outlet pressure, shall be selected taking into consideration the AG/AC of any other device installed to prevent interaction (see Figure 9).

8.2.5 The design capacity for any PRI should be determined for the defined planning horizon.

*Note: Typically, the planning horizon would be 5 to 10 years.*

8.2.6 The PRI should be designed for the working stream to supply the capacity required under 1 in 20 demand conditions and at the minimum predicted inlet pressure and maximum outlet pressure.

*Note: Where predicted loads at the planning horizon are significantly higher than those expected at the commissioning stage, this can result in regulators and/or control valves being oversized – possibly causing poor or erratic control.*

8.2.7 Where continuity of supply is required, duplicate streams shall be installed unless the minimum safe network pressure can be maintained from another source.

8.2.8 When selecting regulators or control valves for use in PRIs, and determining the number of streams required, a detailed analysis of the equipment duty and
maintenance requirements shall be conducted on all regulators and control valves with a nominal diameter larger than 200 mm. Consideration shall be given to ensure there is sufficient safe access, ascertain if any special facilities are required, for example craneage and to reduce ongoing maintenance costs to a minimum.

8.3 AUXILIARY SYSTEMS

Auxiliary systems provide power for operation of main regulators and, generally, provide more accurate outlet pressure control and positive "lock up" facilities. By the addition of components into the auxiliary system, variations in outlet pressure and or flow can be effected either locally or remotely.

8.3.1 Each auxiliary system shall be fitted with an inlet and outlet valve. Isolation valves for auxiliary systems shall be plug or ball type to a recognised standard, requiring 90° operation from fully open to fully closed. Isolation valves shall be of a tamperproof design or the operating handles shall be removable. The inlet valve shall be followed by a filter. The filter shall be suitably sized having regard to the condition of the supply mains system, particular attention being paid to the possibility of entrainment of liquids.

8.3.2 All components included within the auxiliary system, and the parts of the main regulator to which the control signal is applied, shall be designed to withstand MOPu. Where this is not reasonably practicable, measures shall be taken to prevent unsafe pressures occurring in any part of the installation.

Note: Where applicable, this may be achieved by the inclusion of a suitably positioned pressure relief valve within the auxiliary system.

8.3.3 Where sudden outlet pressure changes are possible, for example clock control, consideration shall be given to the effect of a pressure surge in the near vicinity of the PRI due possibly to constraining outlet mains. Such a surge could trip SSV systems in high flow rate conditions. In these circumstances, consideration shall be given to the inclusion of an additional control pilot which is sensed at a point adjacent to the SSV sensing point and set at a pressure below the SSV setting.

8.4 SENSING AND CONTROL PIPEWORK (see Appendix 4)

8.4.1 Auxiliary and impulse lines shall be provided with their own separate valved connections.

8.4.2 Impulse lines shall be positioned to reduce the risk of mechanical damage and shall not impeded access for maintenance of the module components.

8.4.3 The design of impulse pipework shall allow for commissioning, testing and purging without breaking any compression fittings.

8.4.4 Consideration shall be given, where appropriate, to each device being provided with its own sensing pipe. Sensing connections shall not be used for any other purpose.

8.4.5 The sensing point selected for any regulator or relief valve should be reasonably free from turbulence and effects resulting from changes in the gas velocity and high gas velocities through the PRI such that a truly representative pressure condition is imposed on the control equipment at all times.

Particular regard should be paid to the proximity of concentric taper pieces.

Note: Pressures fall below regulator control pressures, at most flow rates, due to the velocity effect.

8.4.6 Wherever possible, sensing lines should be taken from pipework within the confines of the housing/enclosure.
8.4.7 Where truly representative pressure conditions cannot be located within the pipework layout of the PRI, an alternative arrangement may be provided i.e.:
- an adequately-sized connection and manifold, to which independent sensing connections are made, may be provided downstream of the PRI or
- where accurate pressure control is required, independent sensing connections may be connected to the PRI outlet to avoid excessive pressure loss and high velocity effects.

Where such a course is contemplated, provision shall be made for protection against over pressurisation resulting from mechanical damage. Suitable protection may be achieved by fitting of an outlet pressure limiting pilot separately sensing from the immediate outlet of the main regulator.

8.4.8 Care shall be taken with all sensing pipework to reduce risk of mechanical damage and consideration should be given to the likely result of such damage.

8.4.9 All sensing pipework shall be protected against corrosion.

8.4.10 Sensing lines may be connected upstream or downstream of the stream outlet isolating valve.

When connected downstream:
- the pressure sensed is more representative of the line pressure
- when commissioning the PRI, the regulator can be set to match the prevailing line pressure.

When connected upstream:
- the pressure sensed is less representative of the line pressure due to pressure drop across the outlet isolating valve and any fittings
- the stream may be fully isolated thereby simplifying testing of the regulator lock up
- inadvertent closing of the outlet valve prior to closing the inlet valve (under flow conditions) would be less likely to cause inadvertent closing of the SSV.

8.5 PRESSURE SAFETY SYSTEMS

8.5.1 General

8.5.1.1 Any safety system shall be designed such that, in the event of a fault condition, the downstream pressure will not exceed the lower of:
- safe operating limits (see Table 15)
- any specific regulatory limit that may apply.

Note: Circumstances which might cause such excess conditions include the failure of the regulator system to effectively control pressure.

8.5.1.2 Any pressure safety system shall take into account the limitations of the downstream system. Particular attention shall be paid to relevant pipeline design standards regarding time limitations on operating at pressures exceeding MOP.

Note: Guidance on pressure warning systems is given in clause 8.5.4.

8.5.1.3 Any non-venting pressure safety system shall utilize one or more of the following principles:
- slam-shut valve (SSV)
- overpressure cut-off device (actuated valve)
- monitor regulator.
Note: A SSV may be either a self contained, spring operated, diaphragm-type SSV or actuated valve with an associated control system.

Where more than one safety device is required (see Table 15) at least one shall be either a SSV or an overpressure cut-off device.

Note: Guidance is provided in clause 8.5.6.

8.5.1.4 Any venting pressure safety system shall utilize a relief valve.

The environmental effect of the release of large volumes of gas to atmosphere shall be considered before choosing a relief valve as a pressure safety device.

8.5.1.5 If a monitor regulator is used, it shall be the first acting device in the pressure safety system.

8.5.1.6 The minimum number of safety devices, as shown in Table 15, shall be provided to protect, independently and in series, each stream of the downstream system from pressure in excess of permitted operating limits.

Note: A decision algorithm is shown in Figure 10.

8.5.1.7 At least two safety devices should be used where:

- MOPu is greater than 2 bar but less than or equal to 16 bar; or
• MOP, is greater than 16 bar and the difference between MOP, and MOPd does not exceed 16 bar;

Note 1: It is permitted to use a single safety device if the results of a risk assessment of the downstream system show that the levels of risk are acceptable with such an arrangement.

Note 2: IGE/SR/24 provides general guidance on risk assessment techniques and the steps to be taken when determining the required level of safety and number of safety devices.

8.5.1.8 Any risk assessment shall include a careful study that identifies factors that could affect the level of risk to the downstream system, for example:

• for the downstream system as a whole;
  • its function – i.e. mainly domestic or industrial supply, etc. and the number of people who could be affected by overpressure
  • the maximum pressure that could be sustained by the downstream pipelines, mains, services, meter/regulators, etc.
  • the design standard and materials used in the system
  • histories of pressure test, failure and maintenance
  • the maximum pressure at the inlet of the PRI regulating streams
  • gas velocity effects
  • the volume and capacity of the downstream system and whether other PRIs are connected to it.

• for the PRI:
  • the overall security and protection (against damage, weather and flooding) of the PRI and its equipment
  • the number of regulator streams and configuration
  • the capacity of regulating streams
  • the reliability of regulators, control systems and safety devices
  • levels of vibration and stress to which equipment (including pilots and sensing lines) may be subjected
  • the presence of stream discrimination devices
  • the approach to maintenance, for example reliability/risk based maintenance etc.
  • the speed of response of safety devices, particularly with regard to the capacity and dynamics of the downstream system. For example, monitor regulators and overpressure cut off devices usually react more slowly than slam-shut devices, etc.

Note: Typically, activated valve-type SSVs close at 1 second per 25 mm of valve diameter.

8.5.2 Design of non-venting pressure safety systems

8.5.2.1 General

8.5.2.1.1 Any SSV or overpressure non-venting cut off system shall be designed such that:

• it has a dedicated sensing line taken from downstream of the regulator(s)
• the set value for cut-off does not exceed [MIP – AG]
• if activated, it remains closed until opened by local manual intervention unless, when the maintenance of supply is essential in the event of more than one stream system closing, a control system is included to allow automatic opening or closing of safety devices between set pressure limits
• its operation is entirely independent of other plant
• operation of a SSV in one stream does not affect any SSV in another stream
• any non-return valve (NRV) is sized such that the main regulator outlet pressure, at the sensing point of the SSV, meets the requirements of clause 8.5.2.5
• no valves are incorporated in impulse lines, except where the SSV is impelled from the common outlet manifold when it shall be of a design that prevents the SSV impulse from being isolated while the stream is operational, for example a locked open valve and, on SSV control cabinets, an interlock mechanism

• the point of sensing selected for any SSV is reasonably free from turbulence and effects resulting from changes in the gas velocity and high gas velocities through the PRI, such that a truly representative pressure condition is imposed on the control equipment

• there will be no detrimental movement of the SSV’s trip mechanism at flows \( \leq 120\% Q_{\text{max}} \) of the PRI stream with any combination of inlet and outlet pressure for which the PRI is designed.

Note 1: The pipework will have to be correctly sized to ensure that the pressure generated at the slam-shut sense point is not so high as to cause detrimental movement of the SSV’s mechanism.

Note 2: SSV sense pressures approaching the SSV’s AG limit could cause movement of the SSV mechanism. Such movement needs to be avoided as it can lead to subsequent spurious operation of the SSV. The preferred AG of SSVs is:

- 5% for \( OP \leq 7 \) bar
- 1% for \( OP > 7 \) bar.

High velocities, for example as caused by a regulator fault, can cause low or negative pressure at the slam-shut sense point. Consequently, consideration shall be given to ensuring the pressure at the slam-shut sense point is not so low as to prevent the SSV operating if \( MIP_{\text{pri}} \) is reached at the regulator pressure sense point.

Note 1: Generally, regulator sense pressure is the outlet pressure local to the PRI.

Note 2: Short term high gas velocities can occur when systems have “step” control action for example “clocking”. An additional overriding control may be needed if these high velocities would result in an unacceptable pressure at the SSV sense pressure point.

8.5.2.1.2 Any self contained SSV for \( OP \leq 7 \) bar shall comply with GIS/V9-1. Where a spring-operated diaphragm type SSV is incorporated into a PRI with \( OP > 7 \) bar, the performance requirements of GIS/V9 1 should be applied.

8.5.2.1.3 Any multiple stream PRI with SSV protection supplying networks, shall have a stream discrimination system fitted as standard.

This requirement shall also apply to single stream installations on multi-feed networks where the failure of the PRI could result in loss of supply.

8.5.2.2 Stream discrimination systems

8.5.2.2.1 Any stream discrimination (protection) system shall be designed to protect the SSV(s) in healthy streams being fired by the failure of any regulator in any other stream.

Note 1: This can be achieved, for example, by fitting a NRV downstream of the active regulator in each stream, positioned so as to close in the event of reverse pressure being applied to the stream and the SSV(s) in the stream sensing pressure between the active regulator and the NRV.

Note 2: Staggered set points alone are not considered to constitute stream discrimination.

Note 3: On PRIs supplying commercial or industrial customers and service regulator installations, stream discrimination will only be applied when there is an overriding need to maintain continuity of supply.

8.5.2.2.2 Where NRV stream discrimination is fitted to PRIs of \( MOP \leq 7 \) bar, the following considerations apply:
• the impulse point for the SSV shall be taken from a point on the outlet pipework, upstream of the device
• where the PRI serves a network of MOP ≤ 75 mbar, the outlet pipework shall be designed such that the pressure at the SSV impulse point complies with the following limits for flow rates up to 1.5 times the maximum design flow rate for the stream ($Q_{\text{max}}$), see Figure 11:
  • not greater than 30 mbar above the regulator outlet pressure ($P_o$);
  • not greater than 10 mbar below the regulator outlet pressure ($P_o$);

  Note: If the pressure limits on the SSV impulse pressure stated cannot be guaranteed, an alternative method of limiting the pressure needs to be adopted. This can be achieved by methods such as a flow or pressure limiting pilot.

FIGURE 11 - SSV IMPULSE PRESSURE LIMITS

• on installations supplying networks of MOP > 75 mbar, the outlet pipework shall be designed so that at normal operating conditions the pressure at the SSV impulse point shall not exceed the pressure at which the SSV trip mechanism starts to move
• the NRV shall be installed in horizontal pipework and have a minimum of one pipe diameter of straight pipe immediately upstream and downstream and shall be positioned such that its operation is not affected by the position/size of downstream equipment, pipework or fittings
• a valved tapping shall be provided in the stream pipework between the stream discrimination device and stream outlet isolation valve
• the NRV should conform to the performance requirements of Appendix 9.
• a creep relief valve shall be fitted upstream of the NRV and sized according to Sub-Section ??, Table ??.
• where a NRV stream discrimination device is fitted to PRIs of OP > 7 bar, the requirements of clauses 8.5.2.5.1 and 8.5.2.5.3 to 8.5.2.5.6 shall be applied
• where no stream discrimination device is fitted in a PRI, the pressure at the SSV impulse point shall comply with the requirements of clause 8.5.2.5.3.
8.5.2.3 **Creep relief valves**

8.5.2.3.1 The use of creep relief valves should be avoided wherever possible. However, where they are considered necessary, such as where a stream discrimination NRV is fitted (see clause 8.5.2.5), the volume of gas released to atmosphere should be limited to the lowest practicable level. The volume of gas vented by the creep relief should not exceed 1% of the stream design capacity. For PRIs of OP $\leq 7$ bar, the values stated in Table 16 should not be exceeded.

<table>
<thead>
<tr>
<th>INSTALLATION OUTLET PIPEWORK DIAMETER (Ø) (mm)</th>
<th>CREEP RELIEF CAPACITY (m³h⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\leq 25$</td>
<td>2.5</td>
</tr>
<tr>
<td>$25 &lt; \text{Ø} \leq 50$</td>
<td>10</td>
</tr>
<tr>
<td>$50 &lt; \text{Ø} \leq 80$</td>
<td>15</td>
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<tr>
<td>$80 &lt; \text{Ø} \leq 100$</td>
<td>20</td>
</tr>
<tr>
<td>$100 &lt; \text{Ø} \leq 150$</td>
<td>25</td>
</tr>
<tr>
<td>$150 &lt; \text{Ø}$</td>
<td>31</td>
</tr>
</tbody>
</table>

*Note: Where the minimum demand on the downstream system exceeds 1% of the stream design capacity, the creep relief may be omitted except where a NRV stream discrimination device is fitted*

**TABLE 16 - CREEP RELIEF CAPACITY (OP < 7 BAR)**

8.5.2.3.2 Creep relief valves should be of the progressive opening type.

8.5.2.3.3 For ease of maintenance, an isolation valve may be fitted immediately upstream of the relief valve. This valve shall be capable of being locked in the open position.

8.5.2.3.4 Vent pipes from creep relief valves shall not be combined.

8.5.2.3.5 Hazardous areas associated with vent pipes shall be sized in accordance with IGE/SR/25.

8.5.2.3.6 A full capacity pressure relief valve shall not be used as the first acting safety device and, if needed as a second acting safety device, it shall be in conjunction with a first acting non-venting device.

8.5.2.4 **Actuated valve SSVs**

8.5.2.4.1 For an actuated valve SSV which utilizes upstream pressure as a power source, the power gas supply shall be taken from the inlet/header arrangement.

Where reduced pressure is required for the power gas supply, this shall be provided by either:

- an individual regulator arrangement with full capacity relief or
- a twin stream regulator arrangement, with full capacity relief, to supply multiple valves.

8.5.2.4.2 SSVs shall not be installed in the slam-shut power gas supply line.

8.5.2.5 **Monitor regulator systems**

8.5.2.5.1 The AC and lock-up performance of any active or monitor regulator or control system, controlling outlet pressure, shall be selected taking into consideration the AC/AG of any other device, to prevent interaction (see Figure 9).
8.5.2.5.2 If a monitor regulator system is to be installed, the following points shall be considered:

- pressure surges can occur in the time between the active regulator failing and the monitor regulator taking control
- the downstream system needs to be examined to ascertain if it is capable of absorbing any pressure surge
- using the monitor as part of a two stage pressure breakdown improves the speed of response in the event of failure of the active regulator.

8.5.2.5.3 If a monitor regulator is used as the only pressure safety device, it shall:

- be direct acting
- be designed such that the set point for the monitor to be such that TOP cannot be exceeded. If, by means of an alarm system or frequent inspection of the PRI, the situation where a monitor has taken over control from the active pressure regulator can be detected within a short time period, MIP (instead of TOP) may be taken into account for the determination of the set point
- be designed such that, if instruments such as transmitters or control instruments are used without a back-up, loss of signal results in a safety action
- ensure that a failure of the active regulator has no adverse effect on the proper function of the pressure safety system
- be used only having given due regard to noise levels (see Appendix 5).

8.5.2.5.4 The AC of any monitor regulator shall not allow the outlet pressure to exceed the set point of the AC of any relief valve or MIP less the AG of any SSV.

8.5.2.5.5 Loss of auxiliary power shall fail safe unless:

- pressurized gas from the system itself is used as auxiliary power and the supply of this gas is continuous
- auxiliary power (electricity, air or hydraulic fluid) from an external source is supported by gas from the system as auxiliary back-up power and the supply of this gas is continuous.

8.5.3 Design of venting pressure safety systems

Any relief valve installed as a pressure safety system shall be designed such that:

- it is sized correctly to meet its duties
- volumes of gas released are minimised
- sensing signals are not affected adversely by the operation of other plant
- required actuating gas supplies utilize upstream pressure without being influenced by the operation of other plant
- reaction time ensures operation is sufficient to protect downstream pipework and equipment
- any valve re-seats cleanly when normal pressure is restored
- proximity to adjacent buildings or proposed buildings is considered
- due regard is given to noise levels (see Appendix 5).

8.5.4 Pressure warning systems

Where a pressure safety system allows operation at a pressure exceeding peak level OP, a pressure warning system or other suitable measure shall be in place to alert the operator. The design shall ensure that such conditions occur infrequently
and, when they do, their duration is limited to that which ensures safety is maintained.

8.5.5 **Pressure Safety System Instrumentation**

8.5.5.1 Pressure safety instrumentation shall be independent of any other instrumentation.

8.5.5.2 The siting of the control system forming part of the pressure safety system shall be fixed, where necessary.

8.5.5.3 Isolation of the pressure detection components of the pressure safety system from the system it protects shall not be permitted unless it leads to a safety action.

8.5.6 **Arrangement of equipment when safety devices are required** (see Appendix 4)

8.5.6.1 **General**

The arrangement of equipment should be the most suitable for the particular application. Some basic arrangements are given below.

8.5.6.2 **Monitor regulator and active regulator**

8.5.6.2.1 The monitor regulator shall be positioned upstream of the active regulator. 

*Note 1: The monitor is set at a slightly higher pressure than the active, and takes over in the event of its failure. This arrangement has a wide application throughout distribution installations, but the maximum capacity of the combination is reduced to approximately 70% of each individual regulator capacity.*

*Note 2: In many cases, a pressure surge may take place in the time between failure of the active regulator and the monitor taking over full control position.*

8.5.6.2.2 Where this configuration is utilized on installations where MOP_u exceeds 100 mbar, the regulators shall be of the open at rest type.

8.5.6.2.3 The capacity of the downstream system to absorb the surge shall be examined and, in cases where this is inadequate, alternative systems shall be considered.

8.5.6.3 **Active regulator with upstream SSV**

8.5.6.3.1 This arrangement offers positive means of guarding against excess downstream pressure resulting from failure open of the regulator to which it is attached.

8.5.6.3.2 The SSV sensing point shall be protected against over pressurisation caused by failure in another stream or system (see clauses 8.5.2.3 and 8.5.2.4).

8.5.6.3.3 Where this configuration is utilized on installations where MOP_u exceeds 100 mbar, the regulators shall be of the fall open at rest type.

8.5.6.4 **Monitor regulator and active regulator with SSV**

8.5.6.4.1 The monitor regulator shall be positioned upstream of the active regulator.

*Note: The monitor is set at a slightly higher pressure than the active and takes over in the event of its failure. The SSV is the final safety device.*

8.5.6.4.2 The SSV sensing point shall be protected against over pressurisation caused by failure in another stream or system (see clauses 8.5.2.3 and 8.5.2.4).

8.5.6.5 **Two stage pressure reduction with SSV**
8.5.6.5.1 Failure of the second stage regulator shall be compensated for by the incorporation, in the control system of the first stage regulator, of an override pilot regulator to prevent stream outlet pressure from rising to first stage regulator setting.

*Note: The SSV is the final safety device.*

8.5.6.5.2 The SSV sensing point shall be protected against overpressurisation caused by failure in another stream or system (see clause 10.2.1.8).

8.5.6.6 *Active regulator with two SSVs*

This arrangement offers positive means of guarding against excess downstream pressure resulting from failure open of the regulator to which it is attached.

8.5.6.6.1 Where two SSVs are used, they shall be of differing designs to ensure any design fault is not duplicated.

8.5.6.6.2 The SSV sensing point should be protected against overpressurisation caused by failure in another stream or system (see clauses 8.5.2.3 and 8.5.2.4).

8.6 **BY-PASSES**

8.6.1 *By-passes for equalization and testing*

If a by-pass is used for the equalization of pressure across an ancillary or for testing purposes, a valve shall be installed which shall close automatically if it is not held open manually.

8.6.2 *By-passing the regulating equipment and/or the safety system*

8.6.2.1 Any regulator stream or safety system shall not be provided with a facility to be by-passed unless a means of pressure control is incorporated and safety systems are included within the by-pass, as given in Sub-Section 8.5.

8.6.2.2 A pressure indicator shall be fitted downstream of any by-pass and should be readable from the point of application of any manual pressure control method.
SECTION 9: PROTECTION AGAINST CORROSION

Acronyms and abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Abbreviation</th>
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<tbody>
<tr>
<td>ac</td>
<td>alternating current</td>
</tr>
<tr>
<td>CP</td>
<td>cathodic protection</td>
</tr>
<tr>
<td>dc</td>
<td>direct current</td>
</tr>
<tr>
<td>PE</td>
<td>polyethylene</td>
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Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Cu</td>
<td>copper</td>
</tr>
<tr>
<td>CuSO₄</td>
<td>copper sulphate</td>
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Units

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<td>mV</td>
<td>millivolts</td>
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<tr>
<td>V</td>
<td>volts</td>
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9.1 CATHODIC PROTECTION (CP)

9.1.1 General

9.1.1.1 As soon as possible following construction, CP shall be applied to all buried steel pipework and components, designed and installed in accordance with appropriate standards such as BS 7361.

9.1.1.2 The structure to be protected shall be coated with a good electrical - insulating material that has strongly adherent properties that match the design life of the structure to minimise the CP current and maximise efficiency of the application.

9.1.2 Technical considerations

9.1.2.1 In particular, attention shall be paid to the following:

- the surveillance of ground conditions to determine the resistivity and whether carbonaceous material or stray currents are present
- the provision of permanent monitoring facilities
- possible secondary effects such as coating disbondment or electrical interference with adjacent buried structures
- the need to insulate the PRI CP system from adjacent pipelines, pipework and structures by means of insulating flanges or couplings

Note 1: Flange insulation kits are not recommended for use below ground.

Note 2: Where a PRI is connected directly to PE pipework, an insulation joint is not required.

- avoidance of inadvertent earthing of the CP system through such items as pipe supports, instrument connections, electrically operated valve actuators, concrete reinforcement remaining after construction etc.
- the minimising of any shielding effects from concrete pit walls and other structures by careful positioning of anodes or groundbeds
- the need to maintain polarised potentials (with respect to Cu/CuSO₄) in the range -950 mV to -1250 mV for all new installations

Note: For existing installations, -850 mV may be acceptable subject to continued satisfactory performance.

- positioning groundbeds and anodes to avoid electrical interaction causing damage to other metallic equipment
- the need to include pipework interconnections, including sensing pipework and auxiliary fittings in the design of CP
- avoidance of unintended bridging of insulating joints
- in areas of high incidence of lightning or electrical faults, insulation joints may need protection by fitting polarisation cells or surge diverters.
9.1.1.3 CP cable connections shall be made with either welded or pin-brazed fittings which should be re-coated to avoid accelerated corrosion.

9.1.1.4 A close interval potential survey of the buried pipework within the PRI shall be considered and, if undertaken, be as soon as possible after complete commissioning of the CP system, in order to fully validate and provide a fingerprint of the system.

9.1.3 Types of systems

9.1.3.1 Sacrificial anode systems

Sacrificial anode systems are associated with:
- smaller installations or installations without an electrical power supply
- installations having discreet or isolated sections of pipework
- installations where the high current characteristic of an impressed current scheme may otherwise cause damage to neighbouring plant.

The quantity of anodes to be used shall be determined and dependent upon the total current requirement for the installation, the size and type of anode material and the ground resistivity.

9.1.3.2 Impressed current systems

Impressed current systems are associated with larger sites where current demand or ground resistivities preclude the use of sacrificial anodes.

Impressed current systems require a direct current (dc) power source, usually in the range of 10 to 50 V and 1 to 10 A. Normally, this is provided from an alternating current (ac) powered transformer rectifier or from solar power/battery installations where lower power consumption is required.

For an alternating current (ac) power source, reference shall be made to BS 7671.

9.2 METHODS OF PROTECTION AGAINST EXTERNAL CORROSION, OTHER THAN CP

9.2.1 General design considerations

9.2.1.1 Suitable protection against external corrosion shall be provided, unless the material is, in itself, resistant to corrosion (for example, stainless steel).

Note: Corrosion of internal surfaces of plant carrying dry Natural Gas will not occur under normal operating conditions.

9.2.1.2 Any coating shall be specified in accordance with the design requirements of the PRI and its environment.

9.2.1.3 Where different coatings are used, joints between the coating systems shall be made by overlapping one coating with another.

9.2.1.4 Where a PRI is to be built in an area of contaminated ground or in harsh environmental conditions, consideration shall be given to the use of specialised, high performance, coatings.

9.2.1.5 Safety-related issues shall be considered, for example particular surface preparation requirements and the storage, handling and application of all materials and equipment.
9.2.2 Surface preparation for coating

Pipework and other structures shall be prepared for coating in accordance with an appropriate standard such as BS 5493, BS 7079, etc.

Note: Any coating material will be provided with the manufacturer’s instructions for surface preparation and application to ensure the design performance of the coating is achieved. Most high-performance coatings require a blast-cleaned surface with a specific profile range achieved after preliminary degreasing. Other, less onerous, preparations may specify manual cleaning methods as suitable for some coating systems.

Surface preparation is a key stage in achieving coating performance. Inspection shall be implemented during the initial phase of the work to ensure compliance with the appropriate standards.

9.2.3 Coating of above-ground pipework and components

A suitable coating system shall be used. These include:
- solvent-based epoxy systems
- water-borne acrylic systems.

Different colours shall be used for multi-layer coating systems.

Where thermal or acoustic cladding is installed, care shall be taken to ensure that coating is undertaken prior to cladding.

Note: Specialised, high performance, coatings may be utilized where removal of cladding for inspection cannot easily be achieved.

Special coating measures shall be undertaken to protect the bearing surfaces of pipe supports as these are often the source of corrosion on pipework.

Where a moving metal-to-metal contact is inherent in the design, for example on a valve spindle, pipe support jack, vessel door, etc., a semi-firm wax-oil coating shall be considered.

Gaps in flanged joints are difficult to coat and maintain. Consideration shall be given to filling such a gap with an inert or anti-corrosive material and fitting purpose-made flange protectors.

9.2.4 Coating of below-ground pipework

The coating system shall afford an enduring electrical insulation from its environment. The coating shall adhere strongly to the metal surface and resist cathodic disbondment at holidays.

Note: The complex shape of some components may require the use of different materials and application methods to maintain a uniformly high standard of coating throughout the installation.

A suitable coating system shall be used. These include:
- epoxy resin powder
- multi-component urethane
- polyethylene cladding and,

for field applied coatings:
- two-pack epoxy systems
- multi-component urethanes
- brush-applied mastics
- cold-applied laminate tapes.
9.2.5 **Backfilling**

9.2.5.1 During backfilling, care shall be taken to avoid damage to the finished coating.

9.2.5.2 Where excavated material contains carbonaceous or other matter that may damage the coating, it shall be substituted by suitable material of an appropriate particle size.

9.2.5.3 The material shall be placed and compacted to ensure that there are no voids and that the pipework is supported adequately.

9.2.5.4 Where backfill contains ballast or rocks, consideration shall be given to appropriate methods of preventing damage. Consideration shall be given to sheathing the pipework and components with a perforated plastic sheet.

*Note 1: Further advice on backfilling is provided in IGEM/TD/1 and IGE/TD/3.*

*Note 2: If considered necessary, a post-construction Pearson Survey may be carried out to determine if coating damage has been sustained during backfilling.*

9.2.6 **Inspection**

An inspection regime shall be put in place to control:

- surface cleanliness
- surface profile
- temperature
- relative humidity
- adhesion
- holiday detection
- wet and dry film thickness
- other tests recommended by the manufacturer
- backfilling.

Where the coating application is proved to be outside the required specification, it shall be removed and repaired.
SECTION 10 : ELECTRICAL INSTALLATION AND INSTRUMENTATION

### Acronyms and abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>CNE</td>
<td>combined neutral earth</td>
</tr>
<tr>
<td>CP</td>
<td>cathodic protection</td>
</tr>
<tr>
<td>PME</td>
<td>protective multiple earthing</td>
</tr>
<tr>
<td>PRI</td>
<td>pressure regulating installation</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
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### Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
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<tr>
<td>≤</td>
<td>less than or equal to</td>
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</table>

## 10.1 ELECTRICAL INSTALLATION

### 10.1.1 General

10.1.1.1 Fuses shall be of the high-rupturing-capacity type.

10.1.1.2 Any metallic part, including a stairway and its supports, shall be earthed.

10.1.1.3 Electrical equipment must be designed, manufactured, installed and maintained in accordance with statutory requirements and shall comply with relevant standards.

10.1.1.4 Any cable shall be installed on a cable tray or in a duct.

### 10.1.2 Hazardous areas

Areas that may become hazardous as the result of the presence of flammable gas are classified in the UK as Zone 0, 1 and 2 and are defined in IGE/SR/25 and IGEM/GM/7B.

10.1.2.1 The installation, testing and maintenance of any equipment within such specified zones shall comply with the requirements of the appropriate parts of BS EN 60079 or IGE/SR/25. For MOP $\leq$ 2 bar the principles of IGEM/GM/7A and IGEM/GM/7B may be applied.

*Note:* Some information on equipment selection is given in BS EN 1127.

10.1.2.2 A zoning diagram, as illustrated in IGE/SR/25, should be produced and maintained as a permanent record to enable the correct selection and siting of electrical equipment (and other potential sources of ignition) to be undertaken for both initial installation and future modifications.

*Note:* It may be desirable to install Zone 1 equipment in both Zone 1 and Zone 2 areas, to avoid proliferation of types of electrical equipment in small installations.

10.1.2.3 Due regard shall be paid to the effects of any foreseeable extensions to the PRI itself and to other plant in its vicinity.

### 10.1.3 Electrical isolation

10.1.3.1 Electrical isolation shall be as specified in BS EN 60079 and BS 7671.

10.1.3.2 Means of isolation shall be provided to disconnect incoming power supplies from certain sections of plant, as required for maintenance for normal and emergency purposes.

10.1.3.3 The position and duty of any isolating switch shall be clearly identifiable on site.

10.1.3.4 Any circuit isolator supplying apparatus located in a hazardous area shall disconnect the neutral as well as the phases.

10.1.3.5 Automatic or remotely-controlled equipment shall be provided with immediately-adjacent stay-put-stop buttons or equivalent safeguards, including arrangements...
for padlocking in order to prevent accidental starting during maintenance or inspection. Where isolation is required for long periods, main isolating switches shall be used and padlocked. Either an isolator shall interrupt all control and monitoring circuits, main phase and neutral connections, or suitable provision shall be made for multiple isolations.

10.1.4 **Lightning**

Consideration shall be given to installing lightning protection (which shall be to a suitable standard).

10.1.5 **Earthing**

10.1.5.1 The whole of the electrical installation must be earthed adequately and effectively and in accordance with statutory instruments and shall comply with appropriate standards.

*Note: In the UK, the supply authority has statutory obligation to supply the user with an earthing terminal (with the exception of protective multiple earthing (PME) systems).*

10.1.5.2 The following shall be taken into account when designing earthing:

- where the supply is taken directly from the local distribution system by means of an underground cable, the electricity supply authority will usually permit connection of the user’s earthing conductor to the sheath of that cable
- where the supply is taken directly from the local distribution system by means of an overhead line, it may be necessary for the user to provide an earth
- where the supply is taken from a local transformer, the user’s earth connection usually will be made at the same electrode as that to which the transformer secondary neutral is connected.

10.1.5.3 Care shall be taken to avoid interactions between the electrical earthing, instrumentation earthing and cathodic protection (CP) systems.

10.1.5.4 The design and siting of electrical earthing electrodes should be given specialist attention. Such electrodes shall be manufactured from stainless steel, austenitic steel or other CP-compatible materials.

*Note: Copper or any other incompatible electrodes are not suitable as the buried steel pipework may corrode preferentially with respect to the electrode.*

Carbonaceous materials, for example coke, shall not be used as part of the electrode system.

10.1.5.5 Sites supplied from PME or combined neutral earth (CNE) systems present certain problems on which specialist advice should be sought.

*Note: In particular, this is important where intrinsically safe circuits are employed and the impedance of earth return paths from safety barriers are to be kept below 1 Ω.*

10.1.6 **Lighting**

10.1.6.1 Continuous illumination may be unnecessary in many plant areas, but consideration shall be given to the installation of permanent fixed lighting points, with separate switching at positions where light is frequently required to carry out routine maintenance.

*Note: In many cases, the need for flameproof lighting can be avoided by the provision of floodlighting equipment sited outside the hazardous area or mounted at a sufficient height to eliminate the possibility of the flammable mixture approaching the fittings.*

10.1.6.2 All lighting switches should be readily accessible and located in a non-hazardous area wherever practicable.
Where location in a hazardous area is required, the equipment shall be certified for the position of use.

Note: In "classified safe" areas, supplementary lighting for occasional use can be provided by portable equipment.

10.1.6.3 In hazardous areas where portable lighting equipment is used, the equipment shall be correctly certified for the position of use.

10.2 INSTRUMENTATION

10.2.1 General

10.2.1.1 A PRI shall be equipped with instrumentation, including gauges and recorders, to enable both control and monitoring to be achieved.

Consideration shall be given to the consequences of failure of instrumentation and control equipment during telemetry, power or communication failures.

All instrumentation requirements shall be established at the earliest possible stage of design in order that the necessary tappings and straight pipe lengths for metering can be accommodated in the design.

10.2.1.2 Consideration shall be given to locating sensing points so that readings such as pressure, temperature and flow, as well as control devices such as regulators and slam-shut valves, will not be affected by any turbulence in the gas stream.

10.2.1.3 The design shall ensure that any system can fail only to a safe condition.

10.2.1.4 The possibility of interaction between electrical earthing and any CP system shall be considered.

10.2.1.5 Arrangements shall be made to monitor the following, on site:

- PRI inlet pressure
- PRI outlet pressure
- filter differential pressure
- flow (if required)
- inter-stage pressure on multi-stage pressure regulating systems (where required)
- PRI inlet temperature (if required)
- PRI outlet temperature (if required).

Where appropriate, these values shall be recorded.

10.2.1.6 The provision of electrical power shall be considered in relation to electronic instrumentation. Housing for the power source (mains, battery or locally generated) shall be provided.

10.2.1.7 Care shall be taken to ensure that gas or air used for instrumentation and control is free of dust, water or hydrocarbons and condensates.

10.2.1.8 Where an electricity supply is required to operate an instrument, due regard shall be taken of appropriate standards.

10.2.1.9 The source of supply of power gas to the pilot control of certain types of regulator and to any actuator of a slam-shut valve (SSV) shall be determined carefully to ensure its pressure and temperature range is compatible with the operating requirements of the control device being served.
10.2.2 **Gas instrumentation pipework**

10.2.2.1 Pipework should be designed and installed to a standard, for example BS 6739 and be:
- compatible with that of the main pipework
- routed to minimise the number of joints
- protected from impact
- located so as not to interfere with plant maintenance.

10.2.2.2 Pipework should slope upwards, at least 1 in 20, from the tapping to the instrument.

*Note: This avoids creating dirt and moisture traps.*

10.2.2.3 Where equipment causes continual or frequent discharge of gas, the pipework shall discharge to a safe place.

*Note: These arrangements may not be effective during maintenance (see Section 13).*

10.2.2.4 Pipework shall not be run within the same duct as electrical power and electrical instrument cables.

10.2.2.5 Any instrument shall be installed in such a way that its removal and replacement can be undertaken without distorting pipework.

10.2.2.6 Any pressure sensing point shall be located at a point in the flowing gas stream where it is least likely to be affected by turbulence or jetting.

10.2.2.7 Valves shall be installed to permit the safe isolation of pipework and be of such a size and in such a position as to resist mechanical damage.

10.2.2.8 Small-bore sensing pipework shall be supported securely to minimise vibration that might lead to mechanical failure and leakage.

10.2.2.9 Undue stresses shall not be imposed on any instrument by its pipework.

10.2.2.10 Pipework shall be fitted with sufficient isolation valves and valved purge and vent connections to enable de-pressurisation and subsequent testing using a local or external signal source.

*Note: In some instances, it may not be appropriate to install an isolation valve on pipework serving a safety device.*

10.2.2.11 Pipework shall be connected to the main pipework above its centre line and should be fitted with an isolation valve as close as possible to the point of attachment.

10.2.2.12 Where pipework is connected to two sections of the PRI operating at different potentials for CP purposes, it shall be fitted with electrically insulating joints.

10.2.2.13 Pipework shall be readily identifiable according to its duty, for example by colour coding, labelling, on-site drawing, etc.

10.2.2.14 Pipework shall not be connected to main pipework at a point where debris or liquid could accumulate.

10.2.3 **Telemetry**

Telemetry provides the capability, from a distance, to monitor only, or to both monitor and control, features of a PRI. Radio, telephones, landlines, cellphones or
other signalling and communications systems may be used to achieve this. Monitoring may be carried out in real-time or retrospectively.

10.2.3.1 For a remotely monitored or controlled installation, consideration shall be given to providing remote readings, alarms, and controls in addition to those given in clause 7.14.1.5, for example:

- filter status
- overpressure and underpressure device status
- status of other equipment, especially pre-heaters, reliefs and SSVs
- status of the telemetry system
- valve position indication adjustments
- outlet pressure adjustments
- facility to switch from set point control to direct valve control and vice-versa
- inlet, outlet and inter-stage pressure measurements and alarms
- flow measurements
- temperature measurements
- meter readings
- security
- mains electricity failure alarms, including phase change and the status of back-up power supplies.

*Note: In some cases, these may be provided by “software” alarms incorporated within control systems.*

10.2.3.2 Provision shall be made to allow local control of individual items of equipment.

The design shall include appropriate tappings, ducts, supports, power supplies, etc. for transducers, actuators and related equipment and for test instruments.

10.2.3.3 Tapping points shall be provided for use of any portable instrument where permanent indication and records are not required, but where some monitoring facilities are needed, particularly for maintenance purposes.

10.2.3.4 The accuracy of any instrument shall be adequate to perform its intended duty.

10.2.3.5 The size and location of any sensing point shall be such that any instrument measures the bulk condition of the stream and not a local disturbance.

10.2.3.6 Any pressure sensing point shall be fitted with isolation valves and with a test pressure injection point downstream of those valves.

10.2.3.7 A pressure sensing point shall be provided on the inlet and outlet of any PRI to facilitate fitting pressure recorders.

10.2.3.8 Consideration shall be given to the provision of permanent flow rate recording instruments for large installations. Where flow recorders are not installed permanently, consideration shall be given to the need to make provision for use of an insertion meter.

10.2.3.9 Any instrument should be sited so that it can be read and maintained easily.

10.2.4 **Selection of equipment**

10.2.4.1 **General**

10.2.4.1.1 Any instrument should be selected in accordance with the hazardous area in which it is to be sited.
10.2.4.1.2 Any instrument should be as simple and robust as the requirements of accuracy and repeatability allow.

10.2.4.1.3 The size and range of any instrument shall allow for the maximum and minimum operating conditions and the normal range of operating conditions.

10.2.4.1.4 Care shall be exercised in locating instruments that have pressure relief within their casings.

10.2.4.1.5 Where a window is required for viewing the gauge, it shall be of non-splintering material.

10.2.4.2 Pressure measurement

10.2.4.2.1 Pressure measurement equipment shall be selected from:
- digital pressure indicators
- electronic instruments
- manometers
- bourdon tube instruments.

10.2.4.2.2 Where a pressure differential gauge is installed, a re-settable slave pointer shall be incorporated to indicate the maximum pressure differential experienced since reset.

10.2.4.2.3 Means shall be provided to enable gauges to be isolated for testing or their removal.

10.2.4.2.4 Care shall be taken to avoid errors due to the slow response of manometers which should be considered as “steady state” instruments.

*Note 1: Manometers will not respond accurately to fluctuating pressures or to short duration (less than 1 second) peaks due to the inertia of the liquid column itself.*

*Note 2: Water, or other liquid-filled U tubes are only suitable for the measurement of low pressures.*

10.2.4.3 Flow measurement

The design of any flow metering system shall be in accordance with appropriate standards such as IGE/GM/4, IGEM/GM/6, IGE/GM/8, BS 1042 and BS EN ISO 5167.

*Note: Further requirements are contained in Sub-Section 7.16.*

10.2.4.4 Temperature measurement

10.2.4.4.1 Temperature measurement shall be achieved either by the installation of thermowells with measuring probes inserted into the gas stream or by the attachment of temperature sensors to the pipe wall.

10.2.4.4.2 Temperature sensing devices shall be installed in positions where turbulence in the gas stream, solar gains or any other external conditions are unlikely to affect adversely the measurement.

*Note: This may necessitate the use of insulation and protection around the temperature sensors and pipework to protect against ambient conditions.*

10.2.4.4.3 When choosing between thermowells and surface temperature measurement devices, account shall be taken of the effects of water on any insulation used with
surface measuring devices, especially where the measuring point is located below ground or in a pit which could be liable to flooding.

10.2.4.4 Where pipe wall sensors are utilized, care shall be taken to ensure good thermal contact is made between the sensor and the pipe wall.

10.2.4.5 Thermowells shall:
- be designed to BS 2765
- be of non-welded construction and should be forged and manufactured in stainless steel to BS EN 10222-1.

Note: Thermowells for use at MOP ≤ 7 bar may be of lightweight corrosion-resistant stainless steel fabrication.

- be designed to minimise stress concentration at the root of the stem caused by resonance

Note: Resonant conditions may occur due to a combination of gas velocity, the design features of the individual thermowell and their configuration in multiple arrays.

- be positioned in straight pipe away from branches, bends, tees or any other source of turbulence. Multiple thermowell installation, i.e. sense and test, in the same section of pipe shall not be fitted in a straight line, but be staggered radially

- protrude into the pipework to about one third of the nominal bore and where possible, at least 75 mm, to ensure good temperature measurement

Note: On large bore pipe, for example exceeding 300 mm diameter, where resonant vibrations of the thermowell are known to be a problem, the design of the thermowell may restrict the depth of immersion. In such cases, little accuracy will be lost provided that the thermowell protrudes at least 75 mm into the pipe bore.

- be protected against the ingress of water
- be filled with oil or conductive paste to improve thermal conductivity, prevent corrosion and exclude water.

10.2.4.6 Consideration shall be given to fitting a spare thermowell(s) for calibration purposes.

10.2.4.7 Spare thermowells shall have their open ends sealed.

10.2.4.8 Thermowells shall not be fitted directly upstream of a gas meter. Thermowells associated with meters, for example flow conversion to standard conditions, should be located downstream of the meter. However, for an orifice meter, reference shall be made to BS 1042-1, Section 1.1).
SECTION 11 : CONSTRUCTION

Acronyms and abbreviations

HSC = Health and Safety Commission
NDE = non-destructive examination
NDT = non-destructive testing
PE = polyethylene

11.1 SITE SAFETY

11.1.1 Steps shall be taken to ensure the safe construction, installation, inspection and examination of works for PRIs shall be ensured. All necessary notifications should be made and measures taken for the protection of personnel, members of the public, property and the environment that might be affected by the construction work. Appropriate supervision shall be provided to ensure that all necessary safety precautions are taken.

Arrangements shall be made to obtain authorisations and permits-to-work, where required.

*Note:* Guidance on permits to work is provided in “Guidance on permit-to-work systems in the petroleum industry” published by the Health and Safety Commission (HSC).

11.1.2 Attention must be paid to relevant regulatory requirements.

11.1.3 The health and safety at work of all personnel shall, so far as is reasonably practicable, be ensured by the provision of suitable instruction, training and equipment.

11.2 SITE ENVIRONMENT

11.2.1 General

Work must be conducted within the framework of relevant environmental legislation, and shall be in accordance with appropriate guidance and codes of practice.

Consideration shall be given to the identification and minimisation of emissions to air, surface and ground water courses and also the disturbance of all land involved in the works. Efforts shall be made to minimise disturbance to natural resources, ecologically sensitive habitats and archaeological sites.

11.2.2 Noise abatement

A certain amount of noise is inherent in all construction operation. The best practicable methods shall be employed to minimise noise emissions to levels acceptable to site personnel and third parties and to comply with regulations.

Special consideration shall be given to:

- designing out noise-generating operations before construction starts
- siting and possible screening of plant and equipment
- use of acoustically-attenuated powered tools, compressors and generators
- avoidance of operations outside normal working hours
- controlling noise related to venting operations.

Appendix 3 provides guidance on noise assessment and control.
11.2.3 **Chemicals and fluids**

 Fuels, lubricants and chemicals shall be stored, used and disposed of in such a way as to minimise the possibility of any injury or ill health to workers or the public, or environmental impact.

11.2.4 **Traffic**

 Where necessary, consideration shall be given to implementation of a Traffic Management Plan agreed with the controlling authority in order to minimise the nuisance and damage caused to public roads and footpaths.

11.3 **MATERIALS, WORK PROCEDURES AND RECORDS**

11.3.1 Before any work commences, it shall be established that all materials, components and work procedures are in accordance with the design specifications and that satisfactory material certificates have been provided.

11.3.2 Procedures shall be adopted to control and record the transport, receipt, storage, issue and use of materials and components.

11.3.3 When transporting, storing and installing plant and equipment, steps shall be taken to minimise damage or loss due to:

- ingress of moisture and dust
- impact
- vandalism
- mishandling,

and to prevent injury or ill health to workers.

11.3.4 Pipework fabrications and components shall be protected adequately during handling, transport and storage. They shall be inspected before use and, if any are found to be damaged or defective, they shall not be incorporated unless repairs can be carried out as agreed by those responsible for the design and construction.

11.3.5 Temporary closures and other protective measures shall be retained in position until the component or equipment is ready for installation.

11.4 **CIVIL ENGINEERING**

11.4.1 **Site assessment**

 Prior to the commencement of work:

- an inspection and survey of the intended site shall be made to assess the practicability of all aspects of construction work, including temporary access, working areas and support for structures and excavations.
- where heavy items of plant are to be located, consideration shall be given to exploratory work by means of trial holes and/or the employment of specialists.

*Note: Guidance is given in BS 1377 (for testing soils), BS 5930 (for site investigations) and BS 6031 (for earthworks).*

- the location of buried pipelines, cables, services and other plant shall be established prior to commencement of work.

*Note 1: Special precautions may be required if the works are in the vicinity of existing gas pipelines, installations and other plant.*
Note 2: IGE/SR/18 provides requirements on working in the vicinity of pipelines and IGE/SR/10 provides requirements on locating underground plant.

HS(G)47 outlines safe practices to avoid dangers from underground services.

- consideration shall be given to the possibility of flooding.

11.4.2 **Alignment and levels**

The datum point and co-ordinates shall be indicated clearly on the drawing and, before site work commences, these items shall be established securely and identified on site. Regular checks shall be made thereafter to ensure that all measurements are made relative to these references.

11.5 **FABRICATION AND WELDING OF PIPEWORK AND COMPONENTS**

11.5.1 The requirements of Sub-Section 7.13 shall be applied.

11.5.2 Radiography shall be carried out in accordance with BS EN 1435. During construction, arrangements shall be made for the scrutiny of all radiographic film.

All other NDE and NDT shall be witnessed and recorded.

11.5.3 The external surfaces of all pipework and fittings shall be inspected to ensure that they are free from imperfections, for example notches, weld burns and corrosion.

11.5.4 The bores of pipework and fittings shall be inspected to ensure freedom from weld protrusions, slag and extraneous material. If there is any doubt about the cleanliness and freedom from scale of pipework, consideration shall be given to internal blasting-cleaning followed by the application of a protective coating.

11.5.5 For lifting equipment, consideration shall be given to:

- the prevention of damage to overhead services
- the proximity of overhead cables
- the load-bearing characteristics of the ground and the susceptibility of underground services to damage
- maximum safe working loads and radius of operation
- the use of slings or other equipment designed to avoid damage to pipes, equipment or coatings,

Note: IGem/TD/1 Supplement 1 provides guidance on handling of steel components. IGE/TD/3 Supplement 1 provides guidance on handling PE pipe and fittings.

11.5.6 The piping system shall be assembled and erected in such a manner that the completely erected piping conforms to the specified requirements of the engineering design.

11.5.7 Steps shall be taken to ensure that undue stresses caused by welding and/or bolting of flanges are not induced during erection.

In particular:

- pipework shall be assembled away from “fixed” points
- final bolting-down and grouting of large items of plant and supports shall not take place until all pipework has been erected
- jacks, pulley blocks and similar practices shall not be used to force pipework into line.

11.5.8 Thread forms on stud bolts shall be kept free from mechanical damage or corrosion.
Note: A suitable thread lubricant will reduce the torque necessary to produce a gas-tight joint. Care is needed in the storage of ring-type joints and raised-face gaskets to ensure they are in an acceptable condition prior to installation.

11.5.9 Bolts shall be tightened carefully in the correct sequence to achieve an equally distributed force on all joints and gaskets. Stud-bolts shall be of such length as to give at least one thread free of each nut.

11.5.10 The faces of raised-faced flanges shall be to an acceptable standard, with regard to both flatness and surface finish, to match the gasket chosen. For ring-type joints, rust shall not be evident on either the ring or the mating surfaces of either flange.

11.5.11 After successful testing has been carried out (see Section 12), flanged joints may have joint protectors or mastic fill with flexible tape applied to the rim to protect the interface and bolts. Both these protective measures may be fitted or cavities should be filled with grease or suitable anti-corrosion mastic.

11.5.12 In the construction and fittings of supports, care shall be taken to obtain accurate location and alignment to prevent stresses being imposed on the pipework. Precautions shall be taken to prevent corrosion at the point of contact of the support and the pipework by effectively coating and insulating the interface.

11.5.13 On completion of construction, a Peason-type survey shall be carried out to locate any areas of coating damage on buried components. Any damage found shall be repaired.

Above-ground pipework shall be inspected and any coating damage repaired.
SECTION 12 : TESTING

Acronyms and abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP</td>
<td>design pressure</td>
</tr>
<tr>
<td>LDF</td>
<td>leak detection fluid</td>
</tr>
<tr>
<td>MOP</td>
<td>maximum operating pressure</td>
</tr>
<tr>
<td>NDT</td>
<td>non-destructive testing</td>
</tr>
<tr>
<td>OP</td>
<td>operating pressure</td>
</tr>
<tr>
<td>PPE</td>
<td>personal protective equipment</td>
</tr>
<tr>
<td>PRI</td>
<td>pressure regulating installation</td>
</tr>
<tr>
<td>SMYS</td>
<td>specified minimum yield strength</td>
</tr>
<tr>
<td>STD</td>
<td>strength test duration</td>
</tr>
<tr>
<td>STP</td>
<td>strength test pressure</td>
</tr>
</tbody>
</table>

Units

<table>
<thead>
<tr>
<th>Unit</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>m</td>
<td>metres</td>
</tr>
<tr>
<td>mbar</td>
<td>mbar</td>
<td>millibar</td>
</tr>
<tr>
<td>min</td>
<td>min</td>
<td>minutes</td>
</tr>
<tr>
<td>mm</td>
<td>mm</td>
<td>millimetres</td>
</tr>
<tr>
<td>N mm⁻²</td>
<td>N mm⁻²</td>
<td>Newtons per square millimetre</td>
</tr>
<tr>
<td>°C</td>
<td>°C</td>
<td>degrees Celsius</td>
</tr>
</tbody>
</table>

Symbols

≤    = less than or equal to
≥    = greater than
D    = outside diameter of pipe
S    = SMYS
tn   = nominal wall thickness

12.1 GENERAL

12.1.1 All new PRIs shall be strength and tightness tested before being purged and commissioned.

A tightness test shall be applied to all PRIs where alterations and repairs have been carried out that could affect the gas tightness of the PRI.

12.1.2 Where a PRI has been pre-tested and not subsequently modified and has appropriate certificates of conformity available, a strength test need not be undertaken but a visual examination of joints, general condition, suitability etc. shall be conducted prior to installing and subsequent tightness testing.

Note: Permanent marking, for example be manufacturer’s badging/stamping may be deemed as certification of conformity.

12.1.3 Any component or such sub-assembly that was installed after strength and/or tightness testing shall be tested for tightness at MOP using leak detection fluid (LDF).

12.1.4 LDFs shall comply with BS EN 14291 and be selected so as not to cause corrosion or failure of pressure parts. The fluid should always be removed by thoroughly washing and drying.

12.2 PLANNING FOR STRENGTH AND TIGHTNESS TESTING

12.2.1 A detailed site-specific method statement and risk assessment shall be produced including, as a minimum:

- responsible persons
- STP and the test duration
- acceptance criteria
- the testing procedure and specifications to be followed
- safety precautions to be followed
- details of the design and supply of any test fittings and an accurate description of the equipment to be tested
- for complex configurations, an engineering drawing. Such drawings should, ultimately, form part of the final test documentation
- location of pressure test ends and test equipment
- proposed location of any test cabin, pumps and other test equipment
- means of filling and pressurising including, for hydrostatic testing, water sources, and test connections and vent points
• means of de-pressurising and, for hydrostatic testing, emptying (including details of drainage connections and method of disposal of water)
• a detailed test program, giving proposed dates
• an emergency procedure to be carried out in the event of a test failure through rupture, including washouts
• requirements for permits and notifications to regulatory bodies
• a comprehensive procedure for repairs and NDT.

12.2.2 The test area shall be specified, approved and defined clearly to all personnel.

12.3 TEST ENDS

12.3.1 Closed valves shall not be used as end caps. All valves shall be tested in the open position. Valves fitted at extremities shall be securely blanked using a correctly designed blank flange and anchored to prevent movement.

*Note: The insertion of a correctly designed spade at a flange acts as a physical isolation.*

12.3.2 The full number of appropriate studs or bolts provided for blank (test end) flanges shall be used. Any studs or bolts with worn or damaged threads shall be replaced.

12.3.3 Welded test ends shall only be fitted by means of an approved welding procedure. All such fitting welds shall be subjected to a full NDT examination, equivalent to that employed on the PRI to be tested.

12.3.4 Each test end shall be identified uniquely and consideration shall be given to the frequency of its use. Such information shall be recorded carefully, that periodic independent re-testing may be carried out.

12.3.5 The design of attest end shall state the maximum number of operating cycles prior to revalidation or disposal.

12.3.6 Any test end shall be subject to a strength test of not less than 1.25 STP.

12.4 SAFETY PRECAUTIONS

12.4.1 The safety of personnel and the general public is of paramount importance and measures to ensure safety shall be specified/included in the test procedure.

12.4.2 Safety precautions must comply with statutory and other relevant regulations. The precautions should be approved.

12.4.3 All persons engaged on strength testing or tightness testing work, or any work associated with pressure testing shall be suitably qualified and be aware of the possible consequences of a pipe, component or test fitting failing under pressure test conditions.

12.4.4 During testing and subsequent pressure-reducing operations, all construction or operational work in the test area or on the pressurised sections shall cease and all persons not involved directly should be evacuated from the test area.

12.4.5 Before commencing a pneumatic strength test, suitable adjusted regulators and a full flow safety valve(s) shall be incorporated (in the connection of the pressurising system to the PRI) to prevent the PRI being pressurised above STP.

12.4.6 Test equipment shall be situated in a safe location, away from public highways, other inhabited areas, depots and sites.
12.4.7 It shall be ensured that the PRI and components subject to the strength test have been designed, installed and anchored to withstand STP.

12.4.8 Suitable precautions shall be taken to protect any adjacent pipework or equipment from the potential effects of failure of the pipework under test.

12.4.9 During testing using media other than air or water, precautions shall be taken to prevent personnel from entering areas, for example pump pits, where dangerous concentrations of nitrogen or other test fluids may be present.

12.4.10 Warning notices, for example stating “WARNING – PIPEWORK UNDER TEST”, “NO PARKING”, “NO ACCESS”, “RESTRICTED ACCESS” AND “ACCESS BY PERMIT ONLY” shall be placed at appropriate locations and as required, for the duration of the test.

12.4.11 It shall be ensured that, from the start of pressurisation, during the test period and until de-pressurisation, no person approaches within the safety distances given in Table 17.

<table>
<thead>
<tr>
<th>TEST PRESSURE</th>
<th>NOMINAL PIPE DIAMETER (mm)</th>
<th>MINIMUM SAFETY DISTANCE (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PNEUMATIC TEST</td>
</tr>
<tr>
<td>≤ 1 bar</td>
<td>All</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 1 bar ≤ 3 bar</td>
<td>All</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 3 bar ≤ 7 bar</td>
<td>≤ 50</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 3 bar ≤ 7 bar</td>
<td>&gt; 50</td>
<td>5</td>
</tr>
<tr>
<td>&gt; 7 bar ≤ 16 bar</td>
<td>≤ 50</td>
<td>7.5</td>
</tr>
<tr>
<td>&gt; 7 bar ≤ 16 bar</td>
<td>&gt; 50</td>
<td>20</td>
</tr>
<tr>
<td>&gt; 16 bar</td>
<td>All</td>
<td>See clause 12.4.12</td>
</tr>
</tbody>
</table>

Note: It may be impractical to apply these safety distances to points of access to the general public, for example roads. In these instances, all reasonable measures need to be taken to ensure that the public do not dwell at these locations, by way of “NO PARKING” signs and regular patrols etc.

TABLE 17 - MINIMUM SAFETY DISTANCES DURING STRENGTH AND TIGHTNESS TESTING

12.4.12 Where the minimum safety distance is not given, the following formula may be used to determine the minimum safety distance for a pneumatic test:

\[ L_{vg} = 3 \times 10^{-4} D \left[ D \left( P_t - P_t^{0.714} \right) \right] \]

\( L_{vg} \) is the minimum safety distance (m)
\( P_t \) is the test pressure (bar)
\( D \) is the nominal pipe diameter (mm)

12.4.13 The test pressure shall be reduced to a safe level before any work is permitted within the safety distance. For hydrostatic testing, the safe pressure level shall be not greater than static head plus 1 bar, and for pneumatic testing the safe pressure level shall not exceed 1 bar unless specified otherwise.

12.4.14 Hoses shall be anchored securely using an approved method to reduce the risk of injury to personnel in the event of failure.

12.4.15 Test hoses shall be:
- visually checked for damage prior to use
- certified within a 6 month period preceding the test.
There is a risk of injury from particles of dirt and high velocity jets at the time of pressure testing. Personal protection equipment (PPE), including eye protection, shall be worn by all persons required to work within the test area.

The test shall be conducted by an appropriate number of competent persons relative to the test being undertaken. A person shall be present at the pressurising source and an additional person(s) should be at, or able to clearly see, each extremity of the installation being tested.

A certain amount of noise is inherent in all testing operations. Best practice should be employed to minimise noise emissions to levels acceptable to site personnel and the general public.

Special consideration shall be given to:
- siting and possible screening of plant and equipment
- use of acoustically-treated power tools, compressors and generators
- avoidance of operations outside normal working hours.

**STRENGTH TESTING**

**12.5.1 General**

Strength testing is used to identify any major flaw in the construction of the PRI fabrications, prior to tightness testing.

**12.5.1.1** Small bore connections i.e. of diameter ≤ 25 mm, impulse lines and components such as regulators, meters, non-return valves, automatic isolation valves, safety shut-off valves etc, or a sub-assembly, that could be internally damaged by STP or exposure to water (for hydrostatic testing), shall be removed and replaced with spool pieces or sealed off with an appropriate fitting prior to carrying out the strength test.

Such a component or sub-assembly shall be, or proved to have been, tested separately to an appropriate standard.

**12.5.1.2** The test should be undertaken using appropriate certificated and calibrated instruments, for example pressure gauges, pressure recorders.

**12.5.1.3** Following a successful hydrostatic strength test, the PRI fabrication should be immediately drained and dried thoroughly.

**12.5.1.4** The pipework should be pressurised slowly and a brief check for general integrity should be undertaken at 350 mbar.

**12.5.1.5** If STP exceeds 2 bar, then, after reaching 2 bar, the pressure shall be increased in 10% increments up to STP leaving a short period between each increase in pressure.

**12.5.1.6** The pressure in the PRI should be maintained at STP over the stabilization period.

**12.5.1.7** At the end of the stabilization period, the pressure source shall be disconnected from the PRI and the STD shall commence. The gauge should be monitored for the full test period.

**12.5.1.8** If the PRI fails the strength test, the pressure shall be reduced to no greater than 1 bar prior to allowing personnel into the exclusion zone to check the PRI for leakage using LDF.

Once any repairs are complete, a further strength test should be carried out.
12.5.2 Determination of test method, STP and duration

12.5.2.1 The test method, STP, stabilization period and strength test duration (STD) shall be as given in Table 18.

No pressure drop is allowed.

<table>
<thead>
<tr>
<th>MOP</th>
<th>TEST METHOD</th>
<th>STP</th>
<th>STABILIZATION PERIOD (mins)</th>
<th>STD (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 75 mbar</td>
<td>Pneumatic</td>
<td>350 mbar</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>&gt; 75 mbar ≤ 2 bar</td>
<td>Pneumatic</td>
<td>3 bar</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>&gt; 2 bar ≤ 7 bar</td>
<td>Hydrostatic</td>
<td>10.5 bar</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>&gt; 7 bar</td>
<td>Hydrostatic</td>
<td>The lower of Z and 1.5 DP</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Z = pressure that corresponds to a hoop stress of 90% SMYS in the PRI under test.

\[ Z = \frac{20 \times t_n \times 0.9 \times s}{D} \]

\( t_n = \) nominal wall thickness (mm)  
\( s = \) specified minimum yield strength (N mm\(^{-2}\))  
\( D = \) outside diameter of pipe (mm)

**TABLE 18 - DETERMINATION OF STRENGTH TEST METHOD, STP AND STD**

12.5.3 Small bore pipework and equipment (≤ 25 mm nominal bore)

12.5.3.1 Small bore pipework and equipment with MOP ≤ 7 bar should not be subject to a strength test. It shall be tightness tested at MOP.

12.5.3.2 Small bore pipework and equipment with MOP > 7 bar shall be pneumatically strength tested, to the pressures detailed in Table 11, for a minimum test duration of 15 minutes.

12.6 TIGHTNESS TESTING

12.6.1 A thorough survey of the PRI, to detect any major integrity defect, shall be carried out before testing, including inspection of certificates, NDT, etc.

12.6.2 The tightness test shall be undertaken at MOP and shall be for a minimum duration of 15 mins and there shall be no leak.

12.7 RECORDING AND DOCUMENTATION

12.7.1 General

12.7.1.1 A documentary record of all tests shall be compiled and retained for the life of the PRI.

12.7.1.2 Care shall be exercised in the identification of test documentation to ensure that it can be identified accurately in the future.

12.7.3 The documentary record shall include:

- test or calibration certificates for all instruments and equipment used in the measurement of the test
- the records produced during the test
12.7.2 Test certificate

On completion of each test, a test certificate shall be compiled which should include, but is not limited to, the following information:

- an accurate description of the PRI to which the test relates
- a detailed description of test start and finish points
- details of all pipework tested including diameter, wall thickness, grade, manufacturer and external coating
- STP in the test section, together with details of its derivation or source
- the test pressure achieved at the maximum, minimum and test control point locations, together with their relative locations
- the procedure, Edition and Section with which the test complies
- date and time of test start and finish.
SECTION 13 : COMMISSIONING AND DE-COMMISSIONING

Acronyms and abbreviations

CP = cathodic protection
PRI = pressure regulating installation
SP = set point

13.1 GENERAL

13.1.1 Purging and commissioning shall only be undertaken if the PRI has passed strength and tightness tests (see Section 12). When a PRI is to be first brought into service, additional requirements may apply. Following any hydrostatic testing of the pipework on site, any residual water should be removed. Suitable drain points should be incorporated within the site pipework for this purpose. Any remaining water should be removed by either air drying the pipework, or it may be necessary to run the site pre-heating equipment at a higher level for a period, to ensure removal of any remaining water vapour, which could cause icing within the pressure reduction equipment.

13.1.2 Before commissioning or decommissioning, procedures shall be prepared and issued for each operation. The procedures shall be carried out whenever a PRI is commissioned or decommissioned, wholly or in part.

Note 1: Guidance on a PRI re-commissioning after maintenance is given in Section 14.

Note 2: Additional guidance on commissioning a new PRI in a new pipeline is given in IGEM/TD/1.

Interested parties should be notified of the date on which commissioning is to be carried out.

13.1.3 As-built drawings, test reports, procedures and any other documentation required for operation of the installation should be in the possession of the operator of the installation, at the time of hand over after commissioning (see IGE/GL/5).

13.1.4 Purging shall be in accordance with an appropriate standard such as:

- IGE/UP/1
- IGE/UP/1A.

Note: The scopes of IGE/UP/1 and IGE/UP/1A do not extend to the pressure limits covered by IGEM/TD/13. However, for direct purging, this is irrelevant and the procedures in IGE/UP/1 (but not necessarily IGE/UP/1A) may be applied for any PRI.

13.1.5 Gas mixtures shall not be exhausted from any position other than a properly designed vent ejector designed in accordance with IGE/SR/22 and IGE/SR/23, except when purging in accordance with IGE/UP/1 or IGE/UP/1A when those Standards apply.

13.2 GAS SYSTEMS

13.2.1 Commissioning and de-commissioning procedures shall take into account the requirements of any downstream equipment, for example meters, gauges, etc. and ensure that:

- the correct functioning of all components is verified by the operator in accordance with the manufacturer’s instructions for the individual component
- pressure safety systems are set and tested before commissioning regulators
- the regulators are shown to be in full control before the outlet valves are opened
- the SPs of all pilots, controllers and regulators are checked for each stream on load, if possible under all flow conditions
13.2.2 Following initial commissioning of the installation after a hydrostatic test on the site pipework, a check should be made on the dew point levels within the site, to ensure any residual water has been effectively removed.

13.3 **CP SYSTEMS**

13.3.1 As soon as possible, the CP system shall be commissioned in accordance with BS 7361-1.

13.3.2 Where an impressed current system is used, electrical checks shall be made to verify the correct output polarity.

13.3.3 A close interval potential survey of the entire system shall be undertaken as soon as possible after complete commissioning of the CP system in order to:
- fully validate that protection levels are adequate
- provide a fingerprint of the protection levels achieved.

13.3.4 The continued effective operation of a CP system is totally dependent upon a satisfactory level of monitoring and maintenance, and this shall form part of the installation management system.

13.4 **ELECTRICAL EQUIPMENT**

Commissioning of the electrical equipment shall ensure that:
- the installation is as specified and designed and is installed correctly
- where appropriate, equipment is suitable for the hazardous areas as specified
- all earthing and isolation of the equipment is checked and verified
- all personnel safety systems and cut outs are functioning
- all communication and warning systems are switched on and operational
- mechanical safety systems cannot be overridden.

13.5 **INSTRUMENTATION**

13.5.1 Commissioning of instrumentation shall ensure that:
- instrumentation is as specified and designed and is installed correctly
- where appropriate, instrumentation is suitable for the hazardous areas as specified
- power is switched on (from within a safe area for instrumentation in a hazardous area)
- instruments are pressurised safely and in the correct order
- there are no gas leaks
- instruments are calibrated as required.

13.5.2 Any site instrumentation equipment should be removed or physically isolated during hydrostatic testing. Following hydrostatic testing, the equipment should not be reconnected to the site pipework until it is certain that all residual water has been removed from the pipework upstream of the equipment.

Where instrumentation forms part of a control or metering system, it is protected properly during commissioning.

13.5.3 Where instrumentation forms part of a telemetry system, full "end to end" checks shall be undertaken between the PRI and the remote monitoring or control centre to ensure correct operation of the system.
SECTION 14 : OPERATION AND MAINTENANCE

Acronyms and abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>CP</td>
<td>cathodic protection</td>
</tr>
<tr>
<td>FMECA</td>
<td>failure mode, effects and criticality analysis</td>
</tr>
<tr>
<td>MOP</td>
<td>maximum operating pressure</td>
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<tr>
<td>PPE</td>
<td>personal protective equipment</td>
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<tr>
<td>PRI</td>
<td>pressure regulating installation</td>
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<tr>
<td>RCM</td>
<td>reliability centred maintenance</td>
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<td>SSV</td>
<td>slam shut valve</td>
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Units

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<thead>
<tr>
<th>Symbol</th>
<th>Unit</th>
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<tbody>
<tr>
<td>mm²</td>
<td>square millimetres</td>
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Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
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<tr>
<td>f</td>
<td>minimum design factor</td>
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The aims of operation and maintenance are to ensure that the PRI:

- operates in a safe and environmentally sound manner
- offers sufficient reliability for the operating conditions within which it is used and will continue to operate until its next maintenance
- is in sound mechanical condition
- operates at the appropriate set points
- is installed correctly.

14.1 GENERAL

14.1.1 Operation and maintenance shall be designed to maximise the availability of the associated gas supply. Contractual arrangements for gas supply, with 3rd parties, should be taken into account.

14.1.2 The risks and consequences of failure associated with operating and maintaining a PRI shall be considered from design and through installation, commissioning and operation.

Note: The modes of failure associated with the PRI will be governed largely by the plant design and the operating method used. Using this knowledge, in addition to a good maintenance history, an effective maintenance strategy can be devised to reduce the risk of failure to an acceptable level.

Consequences shall include failure to supply gas and damage to the downstream system by overpressurisation, flow surges, etc.

Note: For new plant, or in the absence of any operational or maintenance history, it may be desirable to use manufacturers’ recommendations as the initial basis of all maintenance activities. Normally, plant history will be gained, over time, from operational/maintenance data or may be gained from experience of similar equipment/installations.

14.1.3 A maintenance regime, which includes the requisite skills, experience and resources, shall be established or contracted to ensure maintenance is undertaken safely and effectively.

14.1.4 Arrangements shall be made to deal with emergencies both inside and outside normal working hours.

14.2 MANAGEMENT

14.2.1 Organisation

14.2.1.1 Any organisation carrying out maintenance of a PRI shall have the requisite knowledge, skills, experience and resources to ensure that maintenance is undertaken competently and safely.

This may be satisfied by allocating responsibilities and work activities to managers, responsible engineers and other personnel within the organisation and by the proper use of contracted personnel. All personnel shall be trained and
competent in the appropriate skills and procedures necessary to carry out their duties. Where appropriate, briefings, technical bulletins and safety alerts should be used to ensure personnel are updated with latest operational requirements.

14.2.1.2 Operating and maintenance instructions and emergency procedures shall be prepared for the guidance of all personnel connected with the operation and maintenance of a PRI.

14.2 Communications

14.2.2.1 Good communication shall be arranged between control centres and maintenance personnel at all levels in order to deal with routine, non-routine and emergency operations.

14.2.2.2 Maximum use should be made of suitable telecommunications techniques.

14.2.2.3 Consideration shall be given to equipping a PRI with an appropriate and permanent means of communication.

14.2.2.4 Communications equipment shall be suitable for use within the appropriate hazardous area classification zones of a PRI.

14.2.2.5 Training should be provided to ensure personnel are competent and disciplined in the use of communications equipment.

14.2.3 Systems of work

14.2.3.1 General

Any risk created by any undertaking and/or work practices shall be assessed to identify the measures that may be needed to eliminate them or to reduce them to as low as reasonably practicable as well as to comply with duties under health and safety law. The following steps should be incorporated in any risk assessment:

- identify the hazard
- decide who may be affected by work activities
- evaluate the risks and decide on whether existing measures are adequate or if additional measures are required to reduce the risks
- make a record of the assessment and findings
- review the assessment from time to time and revise as necessary.

Note: Further guidance may be found in IGE/SR/24.

14.2.3.2 Assessment of system risk

A well constituted operation and maintenance regime shall be in place to differentiate between high and low risk system categories. Depending upon the nature of the maintenance activity, it may be necessary to have a mix of generic and specific risk assessments.

Note 1: Elements typically contributing to high risk systems include:
- large capacity regulator feeding a small system
- single feed systems
- installation design not complying with modern standards
- unsteady flow conditions
- large difference in the inlet and outlet system pressures
- below-ground installations unless of special design for the purpose
- PRIs supplying large industrial, or otherwise sensitive, end users without an alternative fuel supply.
Note 2: Elements typically contributing to low risk systems include:
- small regulators feeding large systems
- multiple feed systems
- steady flow conditions
- installation design complying with modern standards
- small difference in the inlet and outlet system pressures
- small PRIs supplied from systems of MOP not exceeding 2 bar.

Note 3: IGE/SR/24 provides guidance on risk assessment.

14.2.3.3 Job instructions

Job instructions may be used to control all work activities with suitably referenced Permit to Work when required.

Job instructions should be used to control work of a routine nature, whether scheduled or unscheduled. Such work should be carried out by maintenance personnel or others who are competent to undertake the work without the necessity for on-site supervision or additional instructions. Examples of this kind of work include:
- changing filters
- changing set-points
- changing over working and standby regulator streams
- de-commissioning and maintaining equipment
- working at heights
- testing and recommissioning equipment after maintenance.

Job instructions should define clearly the task to be undertaken and make necessary reference to relevant maintenance procedures and instructions.

Job instructions should have provision for reporting the results or findings of work activities and for reporting the completion of a task.

A formal procedure should be established for the issue, control and return of job instructions, including all relevant work documentation and appropriate recording systems.

14.2.3.4 Permits to Work

A Permit to Work system should be used to supplement job instructions when the work is non-routine or for work which may be potentially hazardous and a risk to personnel and others or for work which could damage plant or equipment.

A Permit to Work system should:
- ensure the proper authorisation of work activities and receipt of permits
- make clear the identity, nature and extent of any work activity and the hazards involved, any precautions taken and limitations on the extent of the work activity, including times
- require that the control centre is aware of the work activity
- provide for suspension of any work activity
- provide for cross referencing of Permits to Work for work activities that may interact with, or affect, one another
- provide a formal handover procedure between teams
- provide a formal procedure to return plant and equipment to service.

An authorising engineer should determine which activities require a Permit to Work by taking into account the potential hazards by assessing the risks.
associated with the work activity, and should specify necessary precautions to reduce or eliminate risks.

Authorising engineers shall not issue a Permit to Work to themselves.

Consideration shall be given to issuing a Permit to Work for the following activities:
- cutting, grinding and welding, use of naked flames or other sources of ignition etc.
- welding onto live pipework
- modifying main pipework
- pressure testing on site
- work in asphyxiating atmospheres
- entry into a confined space, deep excavation or an area with restricted access
- work on machinery or electrical equipment
- demolition
- use of dangerous substances or exposure to ionising radiation
- any activity which is critical to the health and safety of those directly involved or others.

Additional guidance for when a Permit to Work may be required is given in IGE/GL/6.

Certain activities may require additional permits or specialised certificates and should be supplemented as such if appropriate, for example:
- hot work permit
- electrical isolation certificate
- machinery isolation certificate
- entry certificate.

Where a PRI is located within the premises of another undertaking, for example within an industrial site, a Permit to Work should be obtained, if required, from the site owner or occupier.

Any person who prepares, issues or receives a Permit to Work should be competent to do so. Training should be given as appropriate.

A Permit to Work should not be used without ensuring that its conditions are satisfied.

Note: A Permit to Work does not by itself make a task safe. It provides the opportunity to managers and responsible engineers to check what is needed and what is done and to inform those who are to carry out the task of how to proceed.

A Permit to Work should not be used to cover less hazardous work but there may be a benefit in using another safety document to control work in “non-hazardous” situations.

14.2.4 Emergency arrangements

14.2.4.1 Emergency procedures and instructions shall be prepared and kept updated for the guidance of all personnel connected with the operation and maintenance of a PRI or who may be called to a PRI in the event of an emergency.

14.2.4.2 Emergency procedures shall cover the reasonably foreseeable emergency situations arising from the supply of gas to or from the system, or resulting from
leakage. They shall detail the arrangements for alerting other persons who may be affected by an emergency situation.

14.2.4.3 Emergency procedures shall take into account the primary objectives which are to:
- ensure the safety of the public and personnel
- prevent damage to the installation and other property
- minimise the extent and effects of the emergency.

14.2.4.4 The organisation of routine work and the provision of communication shall be such that sufficient supervisory and maintenance personnel can be alerted and immediately dispatched to the installation(s) concerned.

14.2.4.5 Arrangements shall be in place to cover emergency situations arising outside normal working hours and should include procedures for calling out personnel.

14.2.4.6 Periodic tests or exercises shall be carried out to confirm the effectiveness of the emergency arrangements.

14.2.4.7 Procedures shall be reviewed, and amended as necessary, as a result of testing and of any practical experience gained during real emergencies.

14.2.5 Training and competence

14.2.5.1 Training should be designed so that relevant personnel have the appropriate knowledge and understanding of PRIs and associated equipment, with hazards associated with the supply of gas and with procedures and instructions (including Permit to Work systems). Consideration should be given to encouraging personnel to obtain recognised qualifications or education.

Training should be treated as a continuous process to ensure personnel have the requisite skills to undertake activities for which they are responsible.

14.2.5.2 Maintenance personnel should receive training and an assessment of competence on the plant and equipment used on PRIs, for example individual makes or types of regulators and their associated control equipment. This training should include diagnostic training and fault finding and should be supplemented when new equipment is brought into use and may involve courses arranged by the manufacturer of the equipment.

14.2.5.3 Periodic training and competence assessment should be given to appropriate personnel in the use of gas detection equipment, breathing apparatus, fire-fighting equipment and lifting gear.

14.2.5.4 First aid training should be given to personnel working on site.

14.2.5.5 Periodic training and competence assessment should also be given on emergency procedures and response to incidents and emergencies, including gas escapes.

14.2.5.6 Consideration should be given to requirements for the re-assessment of skills and knowledge to ensure that competence of personnel to carry out particular tasks is maintained.

14.2.5.7 Details of training and competence assessments should be retained to demonstrate that the necessary training has been given, competencies achieved and to aid planning for re-assessment and further training as appropriate.

14.2.5.8 Arrangements should be in place to provide assurance that contractors are suitably trained and competent to work.
14.2.6 **Records**

14.2.6.1 Maintenance should be supported by an adequate record system which is promptly and accurately updated.

14.2.6.2 Detailed technical and operational records should be maintained including flow diagrams and plans of all plant and equipment.

14.2.6.3 Any change or modification to a PRI should be recorded where appropriate and reference made to IGE/GL/5.

14.2.6.4 All maintenance work, diagnostic checks and function tests, together with details of replacement parts fitted to individual items of equipment, should be recorded.

14.2.6.5 Data arising from maintenance visits, breakdowns or other fault conditions should be recorded and processed to allow statistical assessment of the defect failure rate of the systems or items of equipment.

*Note: The results of such analysis may be valuable in determining the maintenance periods, levels of maintenance and in improving the specification and application of equipment.*

14.2.6.6 Data may be stored and retrieved using a variety of forms, such as paper systems or electronically. The responsible engineer should select the most appropriate system.

*Note: Computer aided records are recommended as they can be used readily to provide information analysis and facilities such as:
- work and material schedules
- automated job sheets
- tighter spares stock control
- identification of repetitive fault conditions and other trends.*

A suitable backup system should be provided for records of critical aspects of maintenance.

14.2.6.7 Operational settings of adjustable equipment should be recorded centrally and where reasonably practicable, should also be displayed at each installation. Such settings include:
- current set points for pressure or flow and the date when set
- for remotely controlled installations, the range of the pressure and flow parameters
- set points of relief valves and the date when last proved
- set points of SSVs and the date when last proved
- alarm settings where telemetry is installed.

14.2.6.8 Effective procedures for updating both technical and operational records should be in place, including central records supplied for reference to technical and operational personnel.

*Note: Statutory records may be required for the following:
- breathing apparatus
- fire fighting equipment
- lifting gear
- electrical equipment
- air cylinders*
14.2.7 Site information

Site information shall be readily available for reference by maintenance personnel. This information may not be all held on the site, and may also be available in electronic format as appropriate. For non complex installations, such as those supplying low capacity single users and local area networks, it may be appropriate to hold generic information in a central location, especially if there are large numbers of these.

The information should contain as a minimum:

- **emergency procedure**
  Personnel should be aware of what to do in the event of an incident on the site.

- **site plan**
  A plan showing the orientation of the plant, location of all main services power switches, water supply site drainage systems etc., together with entry and emergency exits, fire assembly points etc. as appropriate. For non complex sites, this may not be appropriate, and the gas supply diagram should be sufficient, if it contains details of plant identification and associated identification numbering.

- **hazardous areas**

- **diagram of the installation**
  A flow diagram showing clearly the main components, including their identification numbers. For non complex sites, this may not be necessary, and the gas supply diagram should be sufficient, if it contains details of plant identification numbers.

- **gas supply diagram**
  A schematic diagram, showing the arrangement of inlet supply pipework to the PRI and the downstream network including alternative supplies, where appropriate.

In Great Britain there is a statutory requirement under PSSR to follow a written scheme of examination for a pipeline and its protective devices where the pressure exceeds 0.5 barg. However, for gas pipelines where the normal pressure does not exceed 2 barg (up to a maximum of 2.7 barg under fault conditions) they are exempted from all parts of the regulations, including the written scheme of examination.

**Note:** A typical scheme would include details of:

- plant or equipment identifier
- parts to be examined which, normally, will include protection devices, pressure vessels and pipework, where a defect might result in unintentional release of contents when the pressure energy may cause danger
- an examination (including inspection and testing)
- the frequency of examination (including examination prior to use for the first time)
- specific measures to prepare the system for examination
- who certified and carried out an examination and when it was done
- the results of an examination, in writing.

14.3 MAINTENANCE PROCEDURES AND INSTRUCTIONS

14.3.1 Maintenance instructions and procedures should be prepared for all aspects of maintenance activity and may include:

- sectional drawings of equipment
- dismantling and assembly instructions
• equipment testing
• recommended spares
• manufacturer’s recommendations

14.3.2 Reference should be made to the following:
• checking the integrity of associated electrical equipment such as actuators, pilot motors, solenoid valves and control apparatus
• special checks such as wall thickness measurement, testing and non-destructive examination

14.3.3 Procedures should be included for calling upon the assistance of specialist maintenance personnel or others from outside organisations when required.

14.3.4 Procedures should recommend the most appropriate methods of carrying out an activity, for example maintaining equipment in-situ or removal from the line.

14.3.5 Procedures should take into account the effects of work activities on downstream plant, equipment, other gas transporters, pipeline operators and end users’ systems.

14.3.6 Instructions should, for example:
• specify the materials or methods used for cleaning components
• stress the importance of preserving surface finishes
• give guidance on acceptable wear and deterioration of critical components
• give guidance on component replacement or refurbishment
• include checks to ensure that vents and breathers are free and clear
• stress the importance of checking the security and alignment of equipment mountings
• advise on the recalibration of pressure gauges and other equipment

14.3.7 Procedures should be used to highlight certain safety aspects on maintenance, for example:
• the dangers to health of certain dusts and liquids in gas plant
• the dangers of powerful springs in certain regulators, slam shuts, relief valves and pilots
• the dangers of ingress of gas into hydraulic systems
• the need to use the correct tools for the job and to ensure that they are checked regularly for continued fitness for use
• the possibility of thermal and acoustic lagging still containing asbestos and what should be done if such material is discovered or suspected
• the dangers of noise, the importance of wearing proper ear protection and the need to ensure acoustic lagging and other sound proofing is in place
• the need to take additional precautions when working on a PRI containing unodorised gas.

14.4 MAINTENANCE PHILOSOPHIES

14.4.1 Introduction

A number of different maintenance strategies are available. A structured decision-making process shall be used to identify the optimum maintenance requirements for PRIs.
It should also be recognised that optimum maintenance requirements are dependent on a number of factors, including the operating conditions and duty.

Note 1: For example, an active regulator in the working stream in a twin stream installation located in an enclosure may have different maintenance requirements from those of a similar regulator serving as the monitor in a standby stream and which is located in the open.

Note 2: Strategies may be simple and straightforward or very complex involving the use of sophisticated mathematical models based on a study of failure modes and effects analysis, and reliability data. The strategy may consider the performance of individual key components in the installation. The models derived may be used to optimise the frequency of functional checks, determine a parts replacement programme, etc.

14.4.2 Selection of maintenance philosophy

The maintenance of PRIs shall follow an approach which utilizes any one or a combination of philosophies, such as:

- maintenance at regular intervals, (see clause 14.4.3)
- breakdown maintenance (see clause 14.4.4)
- condition based maintenance (condition monitoring) (see clause 14.4.5).

Note 1: An approach may be applied to:
- all PRIs or all PRIs of a certain type
- individual PRIs
- certain equipment types on PRIs etc.

Note 2: An overall philosophy may be adopted for PRI maintenance but within that there may be different approaches for different parts of the PRI or equipment types, for example:
- PRI as a whole – regular interval maintenance programme
- SSVs, regulators and relief valves – major scheduled maintenance, for example annually
- valves – scheduled lubrication but, otherwise, breakdown maintenance

Note: For additional guidance, see IGEM/TD/1.
- filters elements/baskets – condition monitoring, for example filter differential pressure with alarms

Some advantages and disadvantages of these approaches are shown in Table 12.

14.4.3 Maintenance at regular intervals

14.4.3.1 The PRI shall be visited at pre-set intervals. Pre-determined components shall be cleaned or replaced as required and worn/defective components shall be replaced.

14.4.3.2 The period between overhaul and inspection may be varied according to the requirements of the system, experience gained locally or manufacturer’s specific recommendations (particularly with reference to elastomeric components). Dust burden, gas humidity and abnormal chemical constituents, or the chemical additives used in the treatment of mains are factors that may affect adversely sealing materials and elastomeric components. All these factors shall be considered as they have a direct bearing on the frequency of scheduled maintenance.

14.4.3.3 Records of the PRI’s performance as indicated by chart recorders, data loggers, gauges etc. shall be examined to identify any malfunction or deterioration in performance.

14.4.3.4 On complete overhaul, all moving parts shall be stripped and worn or deteriorated parts replaced or refurbished. Prior to stripping, parts should be marked to ensure correct alignment during reassembly. Gaskets, seals and “O” rings shall not be reused after being disturbed.
14.4.3.5 Where scheduled replacement of regulator components is undertaken, the working and standby components shall be replaced at staggered intervals to minimise the likelihood of coincidental failure of components.

14.4.4 Breakdown maintenance

For some assets, a breakdown maintenance policy may be appropriate – “fix on failure”. However, there may be significant risks with this approach and it should only be adopted after a detailed assessment such as reliability centred maintenance (RCM) reviews, failure mode, effects and criticality analysis (FMECA) or failure simulation testing has been undertaken. It is essential that failure history, operator knowledge and consequences of failure are taken into consideration.

14.4.5 Condition - based maintenance (condition monitoring)

It is essential that inspections are carried at such intervals that will enable the necessary repair/replacement works to be undertaken before failure occurs.

*Note: Consideration will need to be given to the possible obsolescence of parts.*

14.5 SAFETY DURING MAINTENANCE

14.5.1 General

14.5.1.1 An assessment of the risks which may exist, or are foreseeable, during any maintenance activity, should be carried out to help decide what measures are necessary for safety. This should also include consideration of the suitability of those who are to carry out the tasks.

14.5.1.2 Risk control measures should be considered in the following order:
1. eliminate or avoid the risk altogether
2. reduce or minimise the risk at source
3. apply other measures, such as the use of PPE.

14.5.1.3 Necessary safety arrangements should be made and safety equipment should be provided when carrying out maintenance work. These include:
- the need for a Permit to Work
- an assessment of the appropriate number of personnel to be on site, taking into account activities such as opening of plant and pipework, lifting, working in confined spaces (especially pits), etc.
- adequate ventilation of housings, kiosks and pits including the use of air movers, testing and monitoring oxygen levels
- safe means of access and egress, including use of harnesses and safety lines when entering pits and chambers
- putting into place the necessary emergency arrangements before work in confined spaces is undertaken
- the provision of breathing and/or resuscitation apparatus
- ensuring no smoking, no naked lights and elimination of other possible sources of ignition and the posting of warning notices
- the provision of fire fighting equipment
- the provision of lifting equipment and other tools
- the provision of personal protective equipment
- requirements for the safe isolation of plant and equipment from sources of danger
- the removal of water and other liquids from pits using suitable pumps
• the safe handling and disposal of dust and liquids from the pipework system
• the provision of appropriate gas detection equipment.

14.5.2 **Lifting equipment**

14.5.2.1 Arrangements should be made to ensure that any lifting equipment and associated slings and shackles are examined in accordance with any statutory or formal certification inspection schemes.

14.5.2.2 Lifting equipment should be examined before use to check on its general condition and freedom from any damage that could cause it to be unfit for purpose.

14.5.2.3 Care should be taken to ensure that any load to be lifted is within the capacity of the equipment and that slinging is carried out in accordance with good practice.

14.5.3 **Personal protective equipment (PPE)**

14.5.3.1 Suitable PPE should be issued if this can help make a task safer as identified in the risk assessment.

14.5.3.2 The following should be applied when considering PPE:
• identify the hazards and assess the risks
• provide compatible equipment that gives adequate protection
• provide equipment that is compatible with other clothing and is adjustable to suit the user or wearer
• equipment to be properly maintained and fit for use
• training is to be provided to maintenance personnel and others in the proper use of PPE
• suitable storage for PPE is provided
• proper use of PPE is monitored, including checks that it is actually being used. Where appropriate, requirements for safety precautions and PPE shall be clearly identified on site entrance notice boards and in prominent places throughout a PRI stations, for example at the entrance to buildings.

14.6 **ISOLATIONS**

14.6.1 **Isolation schemes**

14.6.1.1 An isolation scheme for the PRI should be developed to ensure that the appropriate level of safe isolation from all sources of danger is achieved. The risk of any uncontrolled gas escape or release should be reduced to a minimum and attention paid to the disconnection and isolation of associated electrical supplies, instrumentation and control equipment, cathodic protection, etc.

*Note: Isolation schemes may have to be modified for particular installations or circumstances.*

14.6.1.2 In general, an isolation scheme should contain provision to:
• take into account the nature of the work to be undertaken, for example routine maintenance, dismantling, hot work, etc.
• take into account reasonably foreseeable risks
• ensure that the level of isolation is satisfactory and secure, for example, physical disconnection, double block and bleed, locking of valves (especially those which are remotely operable)
• ensure all relevant personnel have sufficient notice of the isolation scheme, for example control centres, site owners/operators and site personnel
• test and prove the adequacy of isolation
• specify monitoring arrangements
• have plant and equipment properly identified and labelled
• have suitable means of communication, for example between sites and control centres and between sites where isolations are being carried out at more than one location
• reference any Permit to Work system and isolation certificates
• ensure that maintenance personnel and others are properly trained and have the required competence to put isolations into effect and to return plant and equipment to normal operation once work is complete.

14.6.2 Isolation of gas plant and equipment

14.6.2.1 Agreement should be obtained from the person with responsibility for the gas supply system when the work to be carried out involves:
• isolation of a complete PRI that is a source of gas supply to a transmission or distribution system
• a reduction in the delivery capacity of a PRI
• any change in supply characteristics.

This person should ensure that no other work is carried out on the system during the period of maintenance if this, together with the isolation or change in supply characteristics associated with the maintenance, could affect the gas supplies.

14.6.2.2 The arrangements necessary for isolation and maintaining supply during routine maintenance should be set out in written job instructions.

14.6.2.3 On arrival at site, maintenance personnel should notify the control centre or other appropriate authority that the work is about to start.

14.6.2.4 Before isolating a regulator stream, maintenance personnel should verify that the downstream system is being supplied from alternative sources if continuity of supply is required. Where only one regulator stream is being worked on, the standby stream or alternative supply should be adjusted to take control before the working stream is isolated.

Note: HS(G)273 provides appropriate guidance.

14.6.2.5 Equipment should be fitted to monitor upstream and downstream pressures and any other relevant parameters.

14.6.2.6 Maintenance personnel should follow the correct decommissioning sequence and any other operation required to make equipment safe for dismantling. Particular attention should be paid to the safe venting or discharge of gas when decommissioning.

14.6.2.7 Any valve that has been closed should be locked shut or otherwise rendered inoperable if practicable. Where appropriate, the key holder should be referenced in the Permit to Work or procedure. If securing a valve in this way is impracticable, other precautions should be taken to prevent inadvertent operation, for example by attaching warning notices to the valve or using appropriate work practices. Where the consequences of opening such a valve could be severe, such steps should involve physically disabling the valve temporarily. Such other precautions should be referenced in Permit to Work documentation.

Power operated valves, particularly those which may be activated by a remotely generated signal, should be disabled in the required position, for example by
removal of electrical fuses or by isolation from the source of power fluid i.e. by disconnecting gas or hydraulic supply lines.

Note: It may be advantageous for such lines to have a short length of removable pipe which can be retained by the person in charge.

14.6.2.8 The body vents of upstream and downstream isolation valves should be fitted with temporary vent lines to carry any gas away from the immediate area of work and the body vents should be open. If excessive leakage is apparent from any vent, the position and sealing of the main valve should be checked. Where a valve is not fitted with a body vent, the isolated section of pipework should be checked for any rise in pressure before removal of plant or equipment.

14.6.3 Continuity bonds

Continuity bonds should be fitted across any pipework or equipment before its removal to prevent any unsafe condition due to the presence of cathodic protection or transient stray current effects.

14.6.4 Instrumentation and control systems

Isolation of plant and equipment from instrumentation and control systems may be required. However, care should be taken to account for the possible loss of control signals or isolation of instruments from energy sources.

14.6.5 Electrical equipment

When working on plant and equipment that may be connected to an electrical power supply, the main power circuit and any auxiliary circuit associated with that equipment should be isolated from sources of electrical energy. Measures should be taken to prevent inadvertent re-connection of the energy source to the equipment circuits, for example by removal of fuses as part of a procedure, by locking isolators in the “OFF” position and controlling keys, etc.

14.6.6 Earth continuity

14.6.6.1 If a procedure would result in a break of electrical earth continuity, a temporary bond should be fitted.

14.6.6.2 If an unsafe atmosphere exists in the location of any temporary continuity bond, the cable for the bond should consist of two pieces, each of which is connected to one side of the break. The final connection should be made in a safe area.

14.6.6.3 Any bond cable should have a cross-section of at least 25 mm² copper equivalent. The bond should be maintained until the pipework or component is replaced and reconnected. Checks should then be carried out to ensure continuity.

14.7 VENTING

The following should be considered when planning to vent gas from plant and pipework:

- possible ignition by stray currents, static electricity or other source of ignition
- prior warning to be given to control centres, including emergency control centres, about possible reports of gas escapes
- the display of suitable warning notices
- noise levels and public alarm
- the asphyxiating effects of vented gas.

Note: Further details, including the use of temporary vent systems, can be found in IGE/SR/23.
14.8 **PURGING**

14.8.1 Purging should be carried out as appropriate to the PRI and upon completion of work and prior to recommissioning.

14.8.2 On satisfactory completion of tightness testing for new or overhauled plant and equipment, the test media should be vented safely to near atmospheric pressure prior to testing for oxygen depletion.

14.8.3 Attention should be given to the asphyxiating effects of inert gas.

14.8.4 Where a PRI contains a significant volume of pipework, consideration should be given to mains or pipeline purging techniques described in IGE/SR/22.

14.9 **TIGHTNESS TESTING**

14.9.1 Tightness testing should be carried out in accordance with Section 12.

Tightness testing can involve high pressures with considerable amounts of stored energy due to the compressible nature of gases. Tightness testing should not be undertaken on plant or pipework designed to operate above 2 bar and which has not previously undergone a strength test.

14.9.2 If a leak is discovered which cannot be cured by careful tightening of bolts or nuts, the pressure should be reduced to ambient before further adjustment of or remaking the leaking joint.

14.9.3 A final tightness check at the operating pressure should be made after recommissioning plant and pipework.

14.10 **RE-COMMISSIONING**

14.10.1 A re-commissioning procedure should be prepared to return the installation to full and safe working order after maintenance work has been completed.

14.10.2 The re-commissioning procedure should:

- make provision for prior notification of re-commissioning to be given to those who were originally notified of the maintenance work
- describe measures to prevent uncontrolled gas entering the downstream system
- contain measures to ensure that isolations are reversed safely and that the required configuration, including valve positions, is defined
- have checks to ensure that power sources are re-established to valves, auxiliaries and other equipment isolated at the start of the maintenance work
- describe tightness testing and checks that are to be carried out
- allow set points of all safety devices to be checked and tested
- allow equipment to be checked for full movement and lock up
- allow set points on controllers and pilots to be adjusted as near as possible to the required values
- allow equipment to be properly put to work, set points adjusted to the required values and the operation of the system proven at its operating conditions where possible
- describe the restoration to normal working condition of ancillary equipment such as:
  - cathodic protection
  - clocks
  - recorders
  - lightning conductors
• pre-heaters
• trace heating
• require communications with control centres, including confirmation that the installation has been returned to normal operation
• specify any return visits to site to check on the condition and operation of the installation

14.11 MAINTENANCE REVIEW

The overall maintenance strategy shall be reviewed periodically to ensure that maintenance is being applied effectively. Plant history records will form a major part of the data required to justify making any changes to existing maintenance practices.

The review shall be carried out at an interval not exceeding 3 years or upon a major change of circumstances if sooner.

<table>
<thead>
<tr>
<th>Philosophy</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance at regular intervals</td>
<td>Ease of planning and management of resources, for example personnel and spares. Manufacturer’s recommendations are usually available to immediately set up a maintenance regime. Opportunity to build up an operational history of plant and equipment fairly quickly.</td>
<td>Difficult to establish optimum interval between maintenance/overhaul – needs considerable operational data and experience. Potentially wasteful – parts replaced without reference to their actual condition. May not take into account nature of duty, variations in loading of plant and equipment – may fail before next scheduled maintenance under arduous duty. Potentially greater risk of failure because plant and equipment are regularly “disturbed”.</td>
</tr>
<tr>
<td>Breakdown maintenance</td>
<td>Less unnecessary disturbance of plant and equipment. Potential savings in spares replacement costs.</td>
<td>Requires very careful assessment of consequences of breakdown. Potentially higher risk of loss to supply unless high reliability of standby plant and equipment. Difficult to manage resources due to unpredictability and location of failures.</td>
</tr>
<tr>
<td>Condition based maintenance</td>
<td>Components only replaced when needed – i.e. life is maximised. Number of failures can be minimised. Time is gained to organise personnel and materials to carry out maintenance. Repairs can be planned to ensure minimum disruption to the gas supply. Potential to monitor for wear and random failures.</td>
<td>Changes in parameters need to be present and detectable. The rate of deterioration needs to be sufficiently slow to allow maintenance activity. Failure characteristics of equipment are required. Extensive historical data on failures.</td>
</tr>
</tbody>
</table>

TABLE 19 - MAINTENANCE PHILOSOPHIES - SOME ADVANTAGES AND DISADVANTAGES

14.12 OPERATIONAL CHECKS

Regardless of which maintenance philosophy is used, operation of the PRI shall be checked periodically.

Checks shall include:

(a) Visual checks of the general condition and security of the PRI
Reference should be made to Appendix 5 or IGE/SR/25 as the inspection frequency may be dependent upon their requirements.

(b) Functional tests

The purpose of the functional test is to provide evidence that equipment is in working order. For example, SSVs, monitor regulators, relief valves and duplicate streams should respond at their set point pressure. One method of carrying this out is to use a portable test rig to raise the sensing pressure to the set point.

Functional tests shall be carried out on any PRI safety devices. They may be carried out on other equipment, dependant upon the maintenance strategy.

The frequency of the functional test shall be determined by the chosen maintenance strategy.

If functional tests are to be performed to ensure continuity of supply and/or to prevent system overpressurisation, Table 20 shall be applied.

<table>
<thead>
<tr>
<th>Type of regulator</th>
<th>Functional testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation</td>
<td>Continuity of supply</td>
</tr>
</tbody>
</table>

**TABLE 20 - FUNCTIONAL TESTS**

Wherever possible, tests should be carried out in such a way as to simulate (in a safe and controlled manner) a component malfunction. For example, the operation of a standby stream should be proved by lowering the set point of the working stream until the standby stream takes control.

(c) Diagnostic check

The diagnostic check is a particular type of functional test. It is a means of determining the health of specific equipment through the detection and clarification of degraded performance. This degradation is detected by simulating the working conditions of the equipment and comparing the
corresponding reaction with a set standard. Once the degradation has been detected, a diagnosis of the cause can be made.

The manner by which the diagnostic check is achieved may vary according to equipment and installation design. In addition to the items shown on the typical maintenance form the checks may include such items as the in situ pressure test of polymeric components, lock-up leakage test and set point repeatability.

Electronic analysis and recording is good practice as it can record the performance of the installation on commissioning which could be compared with subsequent diagnostic analysis. Laboratory based research may assist in the development of parameter profiles (performance characteristics, deterioration modes, component replacement action points etc).

Diagnostic checks can form a key part of condition based maintenance strategies.

14.13 CP SYSTEMS

The continued effectiveness of a CP system is dependent totally on a satisfactory level of monitoring and maintenance and shall form part of PRI management system (see Section 4).

Due regard shall be paid to the possible ageing effects on the pipework coating system and on locations where the integrity of the CP system could become increasingly vulnerable.

The frequency of monitoring the continuing suitability of the representative test locations shall be reviewed periodically and altered as required.

Note: Suitable procedures are given in BS 7361. The following routine might be considered appropriate. However, it is recognised that some PRIs, for example smaller installations, need not be subject to such a rigorous routine.

- for sacrificial anode systems, pipe and soil potentials, check 6 monthly at representative points and points of low level protection
- for impressed current systems, a monthly status check should be made to establish that the CP system power source(s) is/are functioning within limits previously shown to give the required degree of protection throughout the system. Checks should also be made on the integrity and accessibility of the means of isolation
- pipe and soil potentials should be measured and surface components examined to such a schedule that, in general, all points considered to be critical to the effectiveness of the system are checked annually
- after the commissioning period, and where practicable, a close interval polarised potential survey should be carried out over the total length of buried pipework within the PRI and thereafter at intervals not exceeding 10 years.

14.14 CORROSION MONITORING OF EXPOSED PIPEWORK

Exposed pipework shall be monitored on a planned and regular basis and faults rectified as necessary.

The monitoring and inspection shall pay particular attention to:

- points where undue corrosion might occur, for example where there are crevices open to the atmosphere or areas of metal where painting is difficult
- areas hidden by supports
- lagged components
- electrical insulations.
14.15 UPRATING AND DOWNRATING

14.15.1 Uprating

The need to uprate a PRI shall be considered if:
- the inlet pressure is being increased above the original design level, for example because the upstream system is itself being uprated
- the outlet pressure is being increased above the pressure rating of PRI equipment that senses or experiences the outlet pressure
- there is a new mode of operation for which the PRI was not designed, for example an increase in pressure cycling, new gas temperatures, etc.

14.15.2 Downrating

The need to downrate a PRI shall be considered if:
- the inlet or outlet pressures are being downrated to an extent that affects the correct functioning of any station equipment
- the gas flows have decreased considerably.

14.15.3 Design approach

The process of uprating or downrating, or merely of considering whether uprating or downrating is possible, is effectively a re-design of the PRI. For this reason, all components of the installation shall be assessed for suitability. Typically, these components will include:
- inlet and outlet pipework
- regulating stream pipework
- other installation pipework
- auxiliary pipework
- in-line valves
- regulators, safety devices
- pilot and other controllers
- instrumentation, telemetry and their sensors
- other installation equipment, used for operations such as preheating, metering, gas analysis and gas conditioning equipment.

In assessing the PRI components for suitability, the design process in IGEM/TD/13 Section 7 should be followed, and other appropriate requirements such as those found in IGE/TD/12 and IGE/SR/25.

14.15.4 Altering the maximum design factor, f

The PRI may be reclassified and/or the area in which it is located, for example:
- by protecting the PRI against external interference. This may allow the design factor to be increased
- by reassessing the area in which the PRI is located. An area that was expected to be developed may have subsequently had planning restrictions placed on it and, consequently, it may be possible to increase the design factor. Alternatively, an area may have developed more than expected and it may be necessary to review the operating parameters of the PRI.
14.15.5 **Modification process**

For installations with any components subject to system pressures above 2 bar, IGE/GL/5 should be used to define and control the modification process, the scope of IGE/GL/5 being:

- all gas transportation systems, of MOP exceeding 2 bar, or with slam-shut protective devices set at a pressure exceeding 2.7 bar, and including metering, pressure reduction and pressure control and associated equipment
- all gas storage systems of MOP exceeding 0.5 bar and
- all other pressure vessels of MOP exceeding 0.5 bar and in excess of 250 bar litres and
- all electrical, instrumentation and control systems (including any associated software) in connection with gas distribution, transportation or storage, irrespective of any PSSR classification.

14.15.6 **Validation**

Validation of the uprated or downrated PRI is achieved when pressure tests (where necessary) and commissioning tests have been completed and recorded.

14.15.7 **Uprating MOP of a PRI to a level above the previous design pressure**

14.15.7.1 **General**

The uprating of a PRI to a pressure level above the previous design pressure shall be controlled in accordance with formal procedures. The following control stages shall be adopted:

- viability – identification of any fundamental characteristic which may prevent uprating
- assessment – completion of design review and identification of all modifications necessary
- revalidation – confirmation that the PRI condition is acceptable for the proposed MOP
- modification – completion of all necessary modifications
- pressure raising – increasing the pressure and confirmation of gas tightness.

*Note: Figure 12 shows an overview of the uprating procedure.*
14.15.7.2 Viability

To determine whether a proposed PRI uprating is viable, exhaustive examinations of the records, physical characteristics and original design features shall be made.

The following shall be considered in assessing the viability of uprating a PRI:
- original design criteria
- construction standards and procurement details
- previous test results
• metallurgical details of all PRI materials and those of the attachments to it
• operational records, including:
• modifications since construction
• repairs
• condition monitoring results and actions
• pressure cycling/fatigue history
• service history
• CP history
• proximity and population density infringements and area classification.
• operating temperature history
• products carried previously in the pipeline
• susceptibility to stress corrosion cracking
• residual construction and operating stresses, including those due to ground movement particularly associated with deep mining, quarrying and landslips
• stress analysis on components included in, or attached to, the pipeline
• proximity of third party equipment
• special crossings and the requirements of rail, river or road authorities.

Note: IGE/GL/5 provides additional guidance.

14.15.7.3 Assessments

Once a proposed uprating has been determined viable, the following assessments should be applied:
• a complete survey of the PRI for any infringements of this Edition at the proposed revised MOP
• the information gathered under clauses 14.12.1 and above against Sections 9, for the proposed revised MOP
• a stress analysis, if necessary, of components included in, or attached to, the PRI for the proposed revised operating pressure. Any changes to operating temperature which are likely to result from the proposed uprating shall be taken into account.

Any infringement of Edition 2 of IGEM/TD/13 may be identified at this stage. A risk analysis of the infringements shall be carried out, for the proposed revised MOP, in accordance with Sub-Section ??. If required by legislation, the level of risk must be agreed between the PRI operator and the regulatory authority, taking into account the requirements of Section 9.

The results of all assessments shall be considered and all modifications necessary for the proposed revised MOP should be determined.

14.15.7.4 Revalidation-condition assessment for uprating

Revalidation of the PRI shall be carried out either by:
• an internal inspection using an appropriate standard of internal inspection, taking into account the proposed revised MOP of the PRI. Any features should be further analysed for growth potential using appropriate fitness-for-purpose techniques or
• hydrostatic test when any features previously identified should be reassessed for the proposed hydrostatic test pressure, using appropriate fitness for purpose techniques.
When the PRI is suitable for uprating with modifications, the modifications should be carried out before the hydrostatic test is undertaken.

*Note:* The modifications which may be necessary are described in clause 14.15.7.5.

The PRI should then be subjected to a hydrostatic test, consistent with the revised MOP, as described in Section 12.

### 14.15.7.5 Modifications

When all the requirements of clauses 14.15.7.2 to 14.15.7.4 have been taken into account and the PRI is suitable for uprating with modifications, such modifications shall be carried out before any pressure increase is allowed.

It may be necessary to carry out repairs, replace components, relay or divert sections or carry out protection measures.

*Note:* The modifications may be controlled and documented using the IGE/GL/5 modification procedure.

### 14.15.7.6 Raising the pressure to the revised MOP

If it is determined that the PRI is suitable for uprating, having carried out the appropriate requirements of this section, the raising of the pressure should be in accordance with the following:

If acceptable after consideration of clauses 14.4.4.3 or 14.4.4.4, the pressure shall be raised in accordance with the following:

- immediately prior to raising MOP, the PRI is surveyed to ensure that no operations are being carried out adjacent to the PRI
- the pressure is raised in incremental steps not exceeding 10% of the original design pressure
- the pressure is held after each incremental step to allow sufficient time for the PRI to be surveyed for any sign of leakage. This shall incorporate the whole of the PRI, with particular regard being given to those lengths which are subjected to routine leakage survey
- consideration is given to carrying out a leakage survey at the locations of all mechanical joints after 1 month of operating at the higher pressure.

If required, any changes to MOP shall be notified to the appropriate regulatory authority.
SECTION 15 : RECORDS

Acronyms and abbreviations

CP = cathodic protection
PRI = pressure regulating installation

15.1 DESIGN

Comprehensive records shall be compiled during the design phase and thereafter retained.

These records shall include:

- the design basis for the PRI
- results of any risk assessments carried out for the PRI
- design calculations such as stress analyses, pressure ratings, system capacities, equipment working parameters, etc.
- site layout
- hazardous area drawings and zoning
- equipment requirements, specifications and performance parameters, including those for the main gas system, electrical equipment, instrumentation, telemetry, CP, etc.
- detailed flow diagrams
- electrical and instrumentation diagrams
- planning approvals for the site.

15.2 CONSTRUCTION

A complete set of construction records shall be prepared and retained. This should include as appropriate:

- material and component certificates
- welding procedures
- qualifications
- pressure test results
- failures
- repairs
- re-tests
- charts
- radiographs
- other appropriate information.

Note: The manufacturer/supplier needs to be notified of any defects or damage.

15.3 TESTING

A record of all hydrostatic and pneumatic tests carried out shall be prepared for every installation and retained, including:

- the authorised person responsible for the test
- the date of the test
- the manufacturer of the installation
- identification of the section to which the test relates
- the design pressure
• the pressure reached during testing and the time for which this pressure was maintained
• the test medium
• the inspection method
• the test results
• a reference to the testing procedure.

The test documentation should be retained until the PRI is taken out of service or has been re-tested and new documentation has been filed.

15.4 **CORROSION CONTROL**

Records shall be maintained of all corrosion control methods, including:
• type of internal coating
• type of external factory or field applied coating
• disposition and type of CP components and bonds
• CP monitoring results
• state of interference bonds and shared schemes
• point system performance
• results of close interval potential inspection surveys
• remedial work.

*Note: An integrated computer/pipeline management system may require additional specific information.*

15.5 **COMMISSIONING**

Records of all commissioning processes and results shall be retained.

15.6 **OPERATION AND MAINTENANCE**

Detailed technical and operational records of plant and equipment should be maintained to build a complete history of the PRI and may include:
• detailed plans, flow diagrams, wiring diagrams, etc.
• changes, modifications, re-testing or revalidation work

*Note: IGE/GL/5 provides guidance.*

• operational settings of adjustable equipment – stored centrally and displayed on site
• records of monitored parameters such as pressure, flow, temperatures, alarms, etc.
• all maintenance work, diagnostic checks and function tests, together with details of replacement parts fitted to individual items of equipment
• data arising from maintenance visits, breakdowns or other fault conditions
• any statutory records for plant and other equipment.

*Note: Some of the above will be contained in the site manual (see clause 14.2.7).*
## APPENDIX 1: GLOSSARY, ACRONYMS, ABBREVIATIONS, SUBSCRIPTS, UNITS AND SYMBOLS

### A1.1 GLOSSARY

All definitions are given in the freely available IGEM/G/4.

### A1.2 ACRONYMS AND ABBREVIATIONS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ac</td>
<td>Alternating current.</td>
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<tr>
<td>AC</td>
<td>Accuracy Class.</td>
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<td>ACoP</td>
<td>Approved Code of Practice.</td>
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<td>AG</td>
<td>Accuracy Group.</td>
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<tr>
<td>CAD</td>
<td>Chemical Agents Directive.</td>
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<td>CCTV</td>
<td>Closed circuit television.</td>
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<tr>
<td>CDM</td>
<td>Construction (Design and Management) Regulations.</td>
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<tr>
<td>CNE</td>
<td>Combined neutral and earth.</td>
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<tr>
<td>CoP</td>
<td>Code of practice.</td>
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<td>COSHH</td>
<td>Control of Substances Hazardous to Health Regulations.</td>
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<tr>
<td>CP</td>
<td>Cathodic protection.</td>
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<tr>
<td>dc</td>
<td>Direct current.</td>
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<td>DP</td>
<td>Design pressure.</td>
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<tr>
<td>DSEAR</td>
<td>Dangerous Substances and Explosive Atmospheres Regulations.</td>
</tr>
<tr>
<td>EC</td>
<td>European Community.</td>
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<tr>
<td>ECV</td>
<td>Emergency control valve.</td>
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<tr>
<td>GB</td>
<td>Great Britain.</td>
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<tr>
<td>GRP</td>
<td>Glass reinforced plastic.</td>
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<tr>
<td>GS(I&amp;U)R</td>
<td>Gas Safety (Installation and Use) Regulations.</td>
</tr>
<tr>
<td>GS(M)R</td>
<td>Gas Safety (Management) Regulations.</td>
</tr>
<tr>
<td>GT</td>
<td>Gas transporter.</td>
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<tr>
<td>HSC</td>
<td>Health and Safety Commission.</td>
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<tr>
<td>HMSO</td>
<td>Her Majesty’s Stationery Office.</td>
</tr>
<tr>
<td>HSE</td>
<td>Health and Safety Executive.</td>
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<tr>
<td>HSWA</td>
<td>Health and Safety at Work etc. Act.</td>
</tr>
<tr>
<td>IGEM</td>
<td>Institution of Gas Engineers and Managers.</td>
</tr>
<tr>
<td>IP</td>
<td>Ingress protection.</td>
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<tr>
<td>LDF</td>
<td>Leak detection fluid.</td>
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<tr>
<td>LPG</td>
<td>Liquefied petroleum gas.</td>
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<tr>
<td>MAFF</td>
<td>Ministry of Agriculture, Fisheries and Food.</td>
</tr>
<tr>
<td>MHSWR</td>
<td>Management of Health and Safety at Work Regulations.</td>
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<tr>
<td>MIP</td>
<td>Maximum incidental pressure.</td>
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<tr>
<td>MOP</td>
<td>Maximum operating pressure.</td>
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<tr>
<td>NDE</td>
<td>Non-destructive examination.</td>
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<tr>
<td>NDT</td>
<td>Non-destructive testing.</td>
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<tr>
<td>NRV</td>
<td>Non-return valve.</td>
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<tr>
<td>OP</td>
<td>Operating pressure.</td>
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<tr>
<td>PE</td>
<td>Polyethylene.</td>
</tr>
<tr>
<td>PME</td>
<td>Protective multiple earthing.</td>
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<tr>
<td>PPE</td>
<td>Personal Protective Equipment.</td>
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<tr>
<td>PRI</td>
<td>Pressure regulating installation.</td>
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<tr>
<td>PRIIV</td>
<td>PRI inlet valve.</td>
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<tr>
<td>PRIOV</td>
<td>PRI outlet valve.</td>
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<tr>
<td>PSR</td>
<td>Pipelines Safety Regulations.</td>
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<tr>
<td>PSSR</td>
<td>Pressure Systems Safety Regulations.</td>
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<tr>
<td>PUWER</td>
<td>Provision and Use of Work Equipment Regulations.</td>
</tr>
<tr>
<td>RIDDOR</td>
<td>Reporting of Injuries, Diseases and Dangerous Occurrences Regulations.</td>
</tr>
<tr>
<td>SMYS</td>
<td>Specified minimum yield strength.</td>
</tr>
<tr>
<td>SP</td>
<td>Set point.</td>
</tr>
</tbody>
</table>
SSSI  Sites of Special Scientific Interest.
SSV  Slam-shut valve.
STD  Strength test duration.
STP  Strength test pressure.
SWL  Safe working load.
TOP  Temporary operating pressure.
UK  United Kingdom
UV  Ultraviolet.

A1.3  **SUBSCRIPTS**

max  Maximum.
u  Upstream.
d  Downstream.
pri  Pressure regulating installation.

A1.4  **UNITS**

A  amperes.
barg  bar gauge
dB  decibels.
ft³/h  cubic feet per hour.
Hz  hertz.
kg m⁻²  kilograms per square metre.
kN m⁻²  kilonewtons per square millimetre.
kHz  kilohertz.
m  metres.
m³  cubic metres.
min  minutes.
m³ h⁻¹  cubic metres per hour.
m³/h  cubic metres per hour.
mm  millimetres.
mbar  millibar.
mV  millivolts.
m s⁻¹  metres per second.
N mm⁻²  Newtons per square millimetre.
V  volts.
W  watts.
°C  degrees Celsius.
Ω  ohms.

A1.5  **SYMBOLS**

<  less than.
>  greater than.
≤  less than or equal to.
Cu  copper.
CuSO₄  copper sulphate.
d  inside diameter of pipe
D  outside diameter of pipe.
f  design factor.
p  pressure.
P  design pressure.
s  SMYS.
t  wall thickness.
Q  flow rate.
X  overpressure factor.
z  the pressure that produces a hoop stress of 90% SMYS in pipework.
Ø  diameter
APPENDIX 2 : REFERENCES

This Standard is set out against a background of legislation in force in GB at the time of publication. Similar considerations are likely to apply in other countries where reference to appropriate national legislation is necessary. The following list is not exhaustive.

All relevant legislation must be complied with and relevant Approved Codes of Practice (ACoPs), official Guidance Notes and referenced codes, standards, etc. shall be taken into account.

Where British Standards, etc. are quoted, equivalent national or international standards, etc. equally may be appropriate.

Care shall be taken to ensure that the latest editions of the relevant documents are used.

A2.1 LEGISLATION

- Acquisition of Land Act 1981
- Countryside Act and the Countryside (Scotland) Act
- Control of Pollution Act 1974, as amended
- Disease of Animals Act 1981
- Environment Act 1995
- Environmental Protection Act 1990
- Foot and Mouth Disease (Packing Materials) Order 1983
- Forestry Act 1967
- Health and Safety at Work etc. Act 1974
- New Roads and Street Works Act 1991
- Pipelines Act 1962
- Town and Country Planning Act 1990
- Traffic Management Act 2004
- Control of Substances Hazardous to Health Regulations 2002
- Construction (Design and Management) Regulations 2007
- Construction (Health, Safety and Welfare) Regulations 1996
- Dangerous Substances and Explosive Atmospheres Regulations 2002
- Electricity at Work Regulations 1989
- Gas Safety (Installation and Use) Regulations 1998
- Gas Safety (Management) Regulations 1996
- Lifting Operations and Lifting Equipment Regulations 1998
- Management of Health and Safety at Work Regulations 1999
- Noise at Work Regulations 1989
- Personal Protective Equipment at Work Regulations 1992
- Pipelines Safety Regulations 1996
- Pressure Equipment Regulations 1999
- Pressure Systems Safety Regulations 2000
- Provision and Use of Work Equipment Regulations 1998
• Pollution Prevention and Control Act 1999
• Utilities Act 2000
• Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995
• Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations
• Town and Country Planning (General Permitted Development) Order
• Workplace (Health, Safety and Welfare) Regulations 1992
• ATEX Directive EC Article 137.

**HSE ACoPs AND GUIDANCE**

• HS(G)47 Avoiding danger from underground services.
• HS(G)48 Reducing error and influencing behaviour. Guidance.
• HS(G)85 Electricity at Work. Safe Working Practices. Guidance
• HS(G)224 Managing Health and Safety in Construction. Construction (Design and Management Regulations). ACoP and Guidance?
• HS(G)150 Health and Safety in Construction. Guidance
• HS(G)273 Health Surveillance Requirements of COSHH ??
• HS(L)5 Control of Substances Hazardous to Health. ACoP and Guidance
• HS(L)21 Management of Health and Safety at Work. ACoP and Guidance
• HS(L)22 Safe Use of Work Equipment. ACoP and Guidance
• HS(L)23 Manual handling. Guidance
• HS(L)24 Workplace health, safety and welfare. ACoP
• HS(L)25 Personal protective equipment at Work. Guidance
• HS(L)56 Safety in the Installation and Use of Gas Systems and Appliances. ACoP and Guidance
• HS(L)73 Reporting of Injuries, Diseases and Dangerous Occurrences Regulations. Guidance
• HS(L)80 Gas Safety (Management) Regulations. Guidance
• HS(L)82 Pipelines Safety Regulations. Guidance
• HS(L)108 Controlling noise at work. Guidance
• HS(L)113 Safe use of lifting equipment. ACoP and Guidance
• HS(L)122 Pipelines Safety Regulations. ACoP.
• HS(L)134 Design of plant, equipment and workplaces; Dangerous Substances and Explosive Atmospheres Regulations 2002. ACoP and Guidance
• HS(L)135 Storage of dangerous substances; Dangerous Substances and Explosive Atmospheres Regulations 2002. ACoP and Guidance
• HS(L)136 Control and mitigation methods; Dangerous Substances and Explosive Atmospheres Regulations 2002. ACoP and Guidance
• HS(L)137 Safe maintenance, repair and cleaning procedures; Dangerous Substances and Explosive Atmospheres Regulations 2002. ACoP and Guidance
• HS(L)138 Dangerous Substances and Explosive Atmospheres Regulations 2002. ACoP and Guidance
- HS(L)144 Construction (Design and Management) Regulations 2007. ACoP
- HSE CoP 20 Standards of training in safe gas installation
- HS(R)25 Memorandum of Guidance on the Electricity at Work Regulations. Guidance
- MISC 310 RIDDOR reporting: Information about the new reporting centre
- INDG 178 (rev 1) Written schemes of examination
- INDG 229 Using work equipment safely
- INDG 261 (rev 1) Pressure systems - safety and you
- INDG 291 Simple guide to the Provision and Use of Work Equipment Regulations
- No number Permit-to-Work systems in the Petroleum Industry ISBN 0 7176 1281 3

A2.3

**IGEM STANDARDS**

- IGEM/TD/1 Steel pipelines for high pressure gas transmission
- IGEM/TD/1 Handling, transport and storage of steel pipe, bends and fittings
- IGEM/TD/3 Steel and PE pipelines for gas distribution
- IGEM/TD/3 Handling, transport and storage of PE pipe and fittings
- IGEM/TD/4 PE and steel gas services and service pipework
- IGEM/TD/9 Offtakes and pressure-regulating installations for inlet pressures between 7 and 100 bar)
- IGEM/TD/10 Pressure regulating installations for inlet pressures between 75 mbar and 7 bar
- IGEM/TD/12 Pipework stress analysis for gas industry plant
- IGEM/TD/13 Pressure regulating, installations for transmission and distribution systems
- IGEM/GM/4 Flowmetering practices. Inlet pressure exceeding 38 bar and not exceeding 100 bar
- IGEM/GM/6 Standard meter installations
- IGEM/GM/7A Electrical connections for gas metering equipment
- IGEM/GM/7B Hazardous area classification for gas metering equipment
- IGEM/GM/8 Non-domestic meter installations. Flow rate exceeding 6 m3 h⁻¹ and inlet pressure not exceeding 38 bar.
- IGEM/SR/9 Safe working on pressure-regulating installations
IGE/SR/10 Procedures for dealing with escapes of gas into underground plant
• IGE/SR/15 Integrity of safety-related applications in the gas industry Edition 4
• IGE/SR/18 Safe working practices to ensure the integrity of gas pipelines and associated installations Edition 2
• IGE/SR/22 Purging operations for fuel gases in transmission, distribution and storage
• IGE/SR/23 Venting of Natural Gas
• IGE/SR/24 Risk assessment techniques
• IGE/SR/25 Hazardous area classification of Natural Gas installations.
• IGE/UP/1 Strength and tightness testing and direct purging of industrial and commercial gas installations Edition 2 RWA
• IGE/UP/1A Strength and tightness testing and direct purging of small low pressure industrial and commercial gas installations Edition 2 RWA
• IGE/UP/6 Application of positive displacement compressors to Natural Gas fuel systems.
• IGE/GL/5 Plant modification procedures. Edition 2
• IGEM/GL/6 Non-routine operations
• IGEM/G/1 Defining the end of the Network, a meter installation and installation pipework

A2.4 BRITISH STANDARDS (abbreviated titles)

• BS 21 Pipe threads for tubes and fittings
• BS 143 and 1256 Malleable cast iron and cast copper alloy threaded pipe fittings
• BS 459 Matchboarded wooden door leaves for external use
• BS 476 Fire tests on building materials and structures
• BS 493 Air bricks and gratings for wall ventilation
• BS 1042 Measurement of fluid flow in closed conduits
• BS 1377 Test of soils for civil engineering
• BS 1387 Screwed and socketed steel tubes
• BS 1560 Circular flanges for pipes, valves and fittings
• BS 1552 Open bottomed taper plug valves
• BS 1640 Steel butt welding pipe fittings
• BS 2633 Arc welding of ferritic steel pipework
• BS 2765 Temperature detecting elements and pockets
• BS 2971 Arc welding of carbon steel pipework
• BS 3293 Specification for carbon steel pipe flanges
• BS 3605 Austenitic stainless steel pipes and tubes
• BS 3693 Design of scales and indexes on analogue instruments
• BS 3799 Steel pipe fittings - screwed and socket welding
• BS 4368 Metallic tube connections
• BS 4515 Welding of steel pipelines
• BS 4800 Schedule of paint colours for building purposes
• BS 5482 CoP for domestic butane and propane gas-burning installations.
• BS 5353 Steel plug valves
• BS 5493 Protective coating of iron and steel structures against corrosion
• BS 5628 Use of masonry
• BS 5930 Protection against corrosion
• BS 6031 Earthworks
• BS 6400 Installation of domestic-sized gas meters
• BS 6510 Steel-framed windows and glazed doors
• BS 6651 Protection of structures against lightning
• BS 6739 Instrumentation in process control systems
• BS 6755 Testing of valves
• BS 7079 Preparation of steel substrates before application of paints, etc.
• BS 7361 Cathodic protection
• BS 7671 IEE Wiring Regulations
• BS 8004 Foundations
• BS 8500 Complementary British Standard to BS EN 206-1. Specification for constituent materials and concrete
• BS 8110 Concrete
• BS EN 331 Manually operated ball valves and closed bottom taper plug valves
• BS EN 334 Gas pressure regulators
• BS EN 593 Industrial valves
• BS EN 1127 Explosive atmospheres
• BS EN 1254 Copper and copper alloy fittings
• BS EN 1435 Non destructive examination
• BS EN 1555 Plastics piping systems
• BS EN 1776 Gas supply. Natural gas measuring stations
• BS EN 10208 Steel pipes for pipelines for combustible fluids
• BS EN 10216 Seamless steel tubes
• BS EN 10217 Welded steel tubes
• BS EN 10222 Steel forgings
• BS EN 10241 Steel threaded pipe fittings
• BS EN 12186 Gas pressure regulating stations for transmission and distribution
• BS EN 12279 Gas pressure regulating installations on service lines
• BS EN 13445 Unfired pressure vessels
• BS EN 13774 Valves for gas distribution systems with MOP less than or equal to 16 bar
• BS EN 13785 Regulators with a capacity of up to and including 100 kg/h. Maximum nominal outlet pressure of up to and including 4 bar
• BS EN 14291 Foam producing solutions for leak detection on gas installations
• BS EN 15761 Steel gate, globe and check valves
• BS EN 60079 Electrical apparatus for explosive gas atmospheres
• BS EN 60529 Specification for degrees of protection provided by enclosures (IP code)
• BS EN 61672 Electrical acoustics
• BS EN ISO 3183-2 Petroleum and natural gas industries. Steel pipe for pipelines. Technical delivery conditions. Pipes of requirement class C
• BS EN ISO 5167 Fluid Flow
• BS EN ISO 9000 Quality management and quality assurance standards
• BS EN ISO 10497 Testing of valves
• BS EN ISO 17292 Metal ball valves
• PD 5500 Unfired fusion welded pressure vessels.

A2.5 MISCELLANEOUS (abbreviated titles)

• API 5L Linepipe
• API 6D Specification for pipeline valves
• ASTM A 106 Seamless carbon steel pipe
• ASTM A 269 Seamless and welded austenitic stainless steel tubing
• ANSI/ASME B 16.5 Steel pipe flanges and flange fittings
• ANSI/ASME B 31.8 Gas transmission and distribution piping systems
• ANSI/ASME B 31.11 Slurry transportation piping systems
• AGA 3 Orifice meters
• MSS SP-75 High test wrought butt welding fittings.

A2.6 UKLPG

• UKLPG CoP 22
APPENDIX 3 : EXAMPLE CALCULATIONS

Important Note

It is not suggested that the following examples be used for existing PRIs not designed to IGEM/TD/13 Editions 1 or 2 as they include aspects that may not have been applied for installations designed to IGEM/TD/9 or IGEM/TD/10, for example Accuracy Groups and Accuracy Classes.

A3.1 INTRODUCTION

These examples illustrate the calculation of:

- the number of safety devices
- design pressure
- pipe wall thickness
- strength test pressure
- pressure limits and maximum set points.

It is important to understand the definitions of the relevant terms relating to pressure, repeated here with additional explanatory notices.

<table>
<thead>
<tr>
<th>TERMS</th>
<th>DEFINITION</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design pressure (DP)</td>
<td>The pressure on which design calculations are based.</td>
<td>This is the pressure that is used to determine minimum pipe wall thickness and STP, for the purpose of proving pressure containment, as well as to aid selection of components. DP upstream of a pressure boundary will be greater than or equal to MOP of the upstream system. DP downstream of a pressure boundary will be greater than or equal to MOP of the downstream system.</td>
</tr>
<tr>
<td>Operating pressure (OP)</td>
<td>The pressure at which the gas system operates under normal conditions.</td>
<td>OP will vary about the set point with variations in normal operating conditions. The set point will be equal to or less than MOP.</td>
</tr>
<tr>
<td>Maximum operating pressure (MOP)</td>
<td>The maximum pressure at which a system can be operated continuously under normal operating conditions.</td>
<td>This is the maximum allowable setting of the active regulator.</td>
</tr>
<tr>
<td>Peak level OP</td>
<td>The upper limit of variations in system pressure permitted under normal conditions.</td>
<td>The system pressure is not allowed to exceed peak level OP under normal operating conditions. The setting and accuracy class of the active regulator need to be considered. This level is permitted to exceed MOP.</td>
</tr>
<tr>
<td>Temporary operating pressure (TOP)</td>
<td>The maximum pressure at which a system can be operated temporarily under the control of regulating devices during fault conditions.</td>
<td>The system pressure is not allowed to exceed TOP when being controlled by, typically, the monitor regulator. The setting and accuracy class of the monitor regulator need to be considered. The system pressure is permitted to exceed MOP under fault conditions.</td>
</tr>
<tr>
<td>Maximum incidental pressure (MIP) MIP ≤ SOL</td>
<td>The maximum pressure which a gas system is permitted to experience under fault conditions, limited by safety devices.</td>
<td>The system pressure is not allowed to exceed MIP. The setting and accuracy group of, for example, the SSVs need to be considered. MIP is equal to or less than the PSSR, “safe operating limits” (SOL) defined as “the operating limits (incorporating a suitable margin of safety) beyond which system failure is liable to occur”. HS(L)122 further describes SOL as “These are the limits beyond which the system should not be taken. They are not the ultimate limits beyond which system failure will occur”. When determining the setting for safety devices, such as SSVs, the AG needs to be considered to ensure MIP and SOL are not exceeded.</td>
</tr>
<tr>
<td>Strength test pressure (STP)</td>
<td>The pressure applied to a system during a strength test.</td>
<td>For pressure containment, successful completion of the strength test validates the design pressure.</td>
</tr>
</tbody>
</table>
The examples in this appendix used the subscripts "u", "pri" and "d" to indicate where pressure terms relate to the upstream system, and/or the pri under consideration, and/or the downstream system, respectively. For example:

- MOP<sub>u</sub> indicates MOP for the upstream system
- DP<sub>upri</sub> indicates DP for the part of the pri upstream of any pressure boundary (so DP<sub>d</sub> for the part downstream of the pressure boundary).
- MIP<sub>d</sub> indicates MIP for the downstream system.

### A3.2 THE PRI AND RELATED PRESSURE SYSTEMS

Figure 13 illustrates a PRI's relationship to its upstream and downstream pressure system, as considered in these examples.

![Figure 13 - Schematic Illustration of a PRI and Related Pressure Systems](image)

### A3.3 EXAMPLE 1

Suppose a new/replacement PRI is required as shown in Figure 8, located in a built up area, in a PRI housing, and:

- MOP<sub>u</sub> = 2 bar
- MIP<sub>u</sub> = 2.7 bar
- MOP<sub>d</sub> = 75 mbar
- DP<sub>d</sub> = 75 mbar
- MOP<sub>u</sub> > TOP<sub>d</sub>
- for above ground pipework:
  - nominal pipe size = 80 mm (actual diameter = 88.9 mm)
  - SMYS = 241 N mm<sup>-2</sup> (API 5L Grade B pipe)
- the accuracy class (AC) of the regulator is ± 5%
- the accuracy group (AG) of the SSV is ± 5%.

#### A3.3.1 Number of safety devices

MOP<sub>u</sub> falls in the range between 100 mbar and 2 bar. By following the decision algorithm in Figure 10, or by examining Table 9 (both are reproduced below) it will be seen that at least one safety device is required.
A3.3.2 **DP for PRI**

$D_{upri}$ can be chosen to be any value equal to or greater than $MOP_u$. In this example, $D_{upri}$ equals $MOP_u = 2$ bar.

$D_{upri}$ can be chosen to be any value equal to or greater than $MOP_d$. Calculations involving the downstream part of the PRI will not be detailed in this example as they replicate those for the upstream part of the PRI.

A3.3.3 **Minimum pipe wall thickness**

The procedure for determining minimum wall thickness is given in clause 7.10.1.7.

Applying the equation in clause 7.10.1.7:

$$ t = \frac{PDX}{(20fs)} $$

- $t$ = minimum wall thickness of pipe (mm)
- $P$ = pressure, which equals design pressure (bar)
- $D$ = outside diameter of pipe (mm)
- $f$ = design factor
- $s$ = specified minimum yield strength (N mm$^{-2}$)
- $X$ = $(MIP_u)(MOP_u)^{-1}$ and is an overpressure factor.

Substituting for $P$ and $X$, for that part of the PRI which is upstream of any pressure boundary, the above equation becomes:

$$ t_{upri} = \frac{D_{upri} DMIP_u}{(20fs MOP_u)} $$
From Table 7 (reproduced below) it can be seen that \( f_{\text{max}} = 0.3 \) for an unmanned PRI in a housing in a built-up area.

<table>
<thead>
<tr>
<th>Site description</th>
<th>Area</th>
<th>Maximum f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location manned</td>
<td>All</td>
<td>0.67</td>
</tr>
<tr>
<td>Location protected against external interference and</td>
<td>R</td>
<td>0.67</td>
</tr>
<tr>
<td>unmanned</td>
<td>S</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>T</td>
<td>0.3</td>
</tr>
</tbody>
</table>

\[ t_{\text{upri}} = (2 \times 88.9 \times 2.7) + (20 \times 0.3 \times 241 \times 2) = 0.17 \text{ mm} \]

However, Table 8 (reproduced below) gives the least nominal wall thickness for 80 mm pipe as 4.78 mm. This is the value to use as it is greater than the calculated value.

<table>
<thead>
<tr>
<th>NOMINAL DIAMETER OF PIPE (mm)</th>
<th>MINIMUM WALL THICKNESS (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>3.9</td>
</tr>
<tr>
<td>80</td>
<td>4.78</td>
</tr>
<tr>
<td>100</td>
<td>4.78</td>
</tr>
<tr>
<td>150</td>
<td>4.78</td>
</tr>
<tr>
<td>200</td>
<td>6.35</td>
</tr>
<tr>
<td>250</td>
<td>6.35</td>
</tr>
<tr>
<td>300</td>
<td>6.35</td>
</tr>
<tr>
<td>400</td>
<td>6.35</td>
</tr>
<tr>
<td>450</td>
<td>6.35</td>
</tr>
<tr>
<td>500</td>
<td>7.92</td>
</tr>
<tr>
<td>600</td>
<td>7.92</td>
</tr>
<tr>
<td>750</td>
<td>9.52</td>
</tr>
<tr>
<td>900</td>
<td>9.52</td>
</tr>
<tr>
<td>1050</td>
<td>11.91</td>
</tr>
<tr>
<td>1220</td>
<td>12.7</td>
</tr>
</tbody>
</table>

This procedure will need to be repeated for that part of the PRI which is downstream of any pressure boundary if the design pressure or pipe size differs from equivalent values for the upstream part of the PRI.

**A3.3.4 Strength test pressure (STP)**

STP is related to DP as shown in Table 18 (reproduced below).

<table>
<thead>
<tr>
<th>MOP</th>
<th>TEST METHOD</th>
<th>STP</th>
<th>STABILIZATION PERIOD (mins)</th>
<th>STD (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \leq 75 \text{ mbar} )</td>
<td>Pneumatic</td>
<td>350 mbar</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>( &gt; 75 \text{ mbar} \leq 2 \text{ bar} )</td>
<td>Pneumatic</td>
<td>3 bar</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>( &gt; 2 \text{ bar} \leq 7 \text{ bar} )</td>
<td>Hydrostatic</td>
<td>10.5 bar</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>( &gt; 7 \text{ bar} )</td>
<td>Hydrostatic</td>
<td>The lower of Z and DP</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

Given that \( DP_{\text{upri}} \) falls in the range 1 bar to 2 bar, it can be seen that:

\[ \text{STP}_{\text{upri}} = 3 \text{ bar}. \]

This procedure will need to be repeated for that part of the PRI which is downstream of any pressure boundary if the design pressure differs from the equivalent value for the upstream part of the PRI.
Pressure limits and maximum set points

The maximum allowable downstream pressures are given by the relationships in Table 14 (reproduced below).

<table>
<thead>
<tr>
<th>Pressure (bar)</th>
<th>Peak level OP</th>
<th>TOP</th>
<th>MIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOP ≤ 0.1</td>
<td>1.125 MOP</td>
<td>1.35 MOP</td>
<td>The lower of 2.5 DPd and 0.2 bar</td>
</tr>
<tr>
<td>0.1 &lt; MOP ≤ 1.0</td>
<td>1.125 MOP</td>
<td>1.35 MOP</td>
<td>1.75 MOP</td>
</tr>
<tr>
<td>1.0 &lt; MOP ≤ 2.0</td>
<td>1.1 MOP</td>
<td>1.2 MOP</td>
<td>1.35 MOP</td>
</tr>
<tr>
<td>2.0 &lt; MOP ≤ 7.0</td>
<td>1.05 MOP</td>
<td>1.1 MOP</td>
<td>1.2 MOP</td>
</tr>
<tr>
<td>7.0 &lt; MOP ≤ 100</td>
<td>1.025 MOP</td>
<td>1.05 MOP</td>
<td>1.1 MOP</td>
</tr>
</tbody>
</table>

Given that MOPd is 75 mbar, falling in the range 0.021 bar to 0.1 bar, the following may be determined:

(a) Peak level OPd = 1.125 MOPd
    = 1.125 x 75 mbar
    = 84 mbar.

This means that the nominal setting of the active regulator should not allow a pressure of more than 84 mbar in the downstream system under normal conditions.

However, the maximum setting of the active regulator is to be the lower of:

- MOPd and
- the peak level OPd multiplied by a factor that accounts for the regulator's accuracy class (AC).

In this example, the AC of the regulator is ± 5%. Thus:

\[
\text{Peak level } \text{OP}_d \times \text{AC factor} = \left(\frac{100\%}{105\%}\right) \times \text{peak level } \text{OP}_d
\]

\[
= \left(\frac{100\%}{105\%}\right) \times 84 \text{ mbar}
\]

\[
= 80 \text{ mbar}.
\]

Here, MOPd is lower than peak level OPd multiplied by the AC factor. Thus, the maximum set point equals MOPd, i.e. 75 mbar.

(b) TOPd is not relevant in this case, as there is, for example, no monitor regulator.

(c) MIPd = the lower of 2.5DPd and 0.2 bar.

2.5DPd = 2.5 x 75 = 188 mbar. Thus, MIPd = 188 mbar.

This means the setting of the SSV should not allow a pressure of more than 188 mbar in the downstream system.

In this example, the accuracy group (AG) of the slam-shut valve is set point ±5%. Thus, the SSV's maximum set point may be determined as follows:

Maximum set point = \left(\frac{100\%}{105\%}\right) \times \text{MIP}
A3.3.6 Summary

For the PRI in this example:
- at least one safety device is required
- design pressure ($D_{upri}$) = 2 bar
- $MOP_u = 2$ bar
- $D_{pupri}$ may equal $D_{upri}$ or may be lower to suit the downstream system
- $D_{p} = 75$ mbar
- $MOP_d = 75$ mbar
- minimum pipe wall thickness = 4.78 mm (for upstream part of the PRI)
- strength test pressure ($STP_{pri}$) = 3 bar
- the set point must not exceed:
  - 75 mbar for the active regulator (= $MOP_d$)
  - 179 mbar for the SSV.

The relationships between the maximum equipment settings and $D_{p}$, peak level $OP_d$, $TOP_d$ and $MIP_d$ are shown in Figure 14.

![FIGURE 14 - RECOMMENDED MAXIMUM EQUIPMENT SETTINGS (EXAMPLE 1)](image)

A3.4 EXAMPLE 2

Now consider the case where a new/replacement PRI is required as shown in Figure 10, located in a rural area, in a PRI housing, and:
- $MOP_u = 40$ bar
- $MIP_u = 44$ bar
- $MOP_d = 7$ bar
• MOP_u > TOP_d
• for above ground pipework
  • nominal pipe size = 100 mm (actual size = 114.3 mm)
  • SMYS = 241 N mm^{-2} (API 5L Grade B pipe)
• the accuracy class of the regulator is ± 5%
• the accuracy group of the SSV is ± 2.5% of its nominal set point.

For installations where MOP_u is (about) 40 bar, it is common practice to specify a Class 300 PRI. For the purposes of this example, it will be assumed that a Class 300 PRI has been specified.

A3.4.1 Number of safety devices

Table 15 and Figure 10 indicate that at least two safety devices are required.

A3.4.2 DP for the PRI

DP_{upri} can be chosen to be any value equal to or greater than MOP_u. In this example, it is assumed that the installation will meet the requirements of a Class 300 installation, i.e. DP_{pri} = 50 bar (note that DP_{upri} > MOP_u)

DP_{dpi} can be chosen to be any value equal to or greater than MOP_d. Calculations involving the downstream part of the PRI will not be detailed in this example as they replicate those for the upstream part of the PRI.

A3.4.3 Minimum pipe wall thickness

From Table 7, f has a value of 0.67. Using this value in the equation in clause 7.10.1.7, a pipe wall thickness of 1.56 mm is calculated for that part of the PRI which is upstream of the pressure boundary. Table 8 indicates a minimum pipe wall thickness of 4.78 mm which is the value to use, being the greater of the two.

A3.4.4 Strength test pressure (STP)

From Table 16, take the lower value of 1.5 DP or Z;

\[
\begin{align*}
\text{STP}_{upri} &= 1.5 \times \text{DP}_{upri} \\
&= 1.5 \times 50 \text{ bar} \\
&= 75 \text{ bar} \\
\text{OR} \\
\text{STP}_{upri} &= (20 \times 4.78 \times 0.9 \times 241) + 114.3 \\
&= 181.4 \text{ bar}.
\end{align*}
\]

So, STP_{upri} = 75 bar.

This procedure will need to be repeated for that part of the PRI which is downstream of any pressure boundary if the design pressure differs from the equivalent value for the upstream part of the PRI.

A3.4.5 Pressure limits and maximum set points

From Table 8, the following may be calculated:

(a) Peak level OP_d = 1.05 \times MOP_d \\
= 1.05 \times 7 \text{ bar} \\
= 7.35 \text{ bar}.

(b) TOP_d = 1.1 \times MOP_d
In this example, the accuracy class (AC) of both regulators is ± 5%, and the accuracy group (AG) of the SSV is ± 2.5%. The maximum equipment settings will be as follows:

- **Active regulator:** 7.00 bar (MOP\(_d\) is the maximum setting)
- **Monitor regulator:** 7.33 bar \(\left(\frac{100\%}{105\%}\right) \times 7.7\)
- **SSV:** 8.20 bar \(\left(\frac{100\%}{102.5\%}\right) \times 8.4\)

### Summary

For the PRI in this example:
- at least two safety devices are required
- design pressure (DP\(_{upri}\)) = 50 bar
- MOP\(_u\) = 40 bar
- MIP\(_u\) = 44 bar
- DP\(_{d pri}\) may equal DP\(_{upri}\) or may be lower to suit the downstream system
- MOP\(_d\) = 7 bar
- nominal pipe wall thickness = 4.78 mm (for upstream part of PRI)
- strength test pressure (STP\(_{upri}\)) = 75 bar
- the set point must not exceed:
  - 7.00 bar for the active regulator
  - 7.33 bar for the monitor regulator
  - 8.20 bar for the SSV.

The relationships between the maximum equipment settings and MOP\(_d\), peak level OP\(_d\), TOP and MIP\(_u\) are shown in Table 6.
A3.5 EXAMPLE 3

If in Example 2 (see A3.4) the accuracy class of the regulator was ± 10%, and the accuracy group of the SSV was ± 5%, their range of operation would overlap as shown in Figure 16 (also note the reduction in the SSV’s maximum set point).
FIGURE 16 - OVERLAPPING RANGES OF OPERATION (EXAMPLE 3)
(not recommended as there is no relief zone and regulators clash with SSV).

To eliminate the possibility of the SSV operating when the PRI’s outlet pressure is still within the control of the active regulator or monitor regulator, the maximum set points would have to be reduced. The reduced values are as follows and are illustrated in Figure 17.

Active regulator: 6.5 bar
Monitor regulator: 6.7 bar
SSV: 8.0 bar.

The maximum set point of the monitor regulator is determined such that its range of operation does not overlap with that of the SSV.

A "safety margin" is included between the upper limit of the monitor regulator's range of operation and the lower limit of the SSV's range of operation. The size of this safety margin is arbitrary.

The maximum set point of the active regulator is below MOP_d, and is at an arbitrary level below the monitor regulator's set point.
FIGURE 17 – RECOMMENDED MAXIMUM EQUIPMENT SETTINGS (EXAMPLE 3)

In circumstances such as these, an alternative to reducing the maximum set points is to select equipment with better accuracy than that used in this example.

Note: BS EN 334 requires accuracy classes for regulators to be specified as, 1%, 2.5%, 5%, 10%, 20%, or 30%.

A3.6 POINTS TO REMEMBER

A3.6.1 The foregoing procedure indicates the MAXIMUM values for all of the PRI's operating pressures. Having determined the MAXIMUM values, the system may be operated at a lower pressure, for example to reduce leakage.

In some circumstances, legislative or other constraints may necessitate equipment settings being lower than those calculated by this procedure.

A3.6.2 Where the active regulator is set below MOP_{d}, safety equipment settings may still be based on TOP_{d} and MIP_{d} where safe to do so, or reduced in line with the active regulator setting.

A3.6.3 Where the downstream system experiences a pressure constraint that has safety implications, such as a temporary repair, a temporary MIP_{d} needs to be calculated based on the temporary MOP_{d}.

A3.6.4 As DP increases, the formula in clause 7.10.1.7 tends to take precedence over the wall thickness quoted in Table 9.

A3.6.5 An increase in grade of pipe material can reduce the wall thickness required.
APPENDIX 4 : PRESSURE AND/OR FLOW CONTROL METHODS

This Appendix illustrates typical systems that may be used to achieve pressure and/or flow requirements (see Section 9).

FIGURE 18 - TYPICAL MONITOR AND ACTIVE REGULATORS

FIGURE 19 - TYPICAL SSV AND ACTIVE REGULATOR

FIGURE 20 - TYPICAL SSV AND ACTIVE REGULATOR WITH STREAM DISCRIMINATION
FIGURE 21 - TYPICAL SSV, MONITOR AND ACTIVE REGULATORS WITH STEAM DISCRIMINATION

FIGURE 22 - TYPICAL SSV, MONITOR AND ACTIVE REGULATORS (NO STREAM DISCRIMINATION)

FIGURE 23 - TYPICAL SSV AND 2 STAGE REGULATORS WITH MONITOR OVERRIDE ON 1ST STAGE
FIGURE 24 - TYPICAL SSV, 2 STAGE REGULATOR WITH MONITOR OVERRIDE ON 1ST STAGE AND STREAM DISCRIMINATION

FIGURE 25 - TYPICAL TWO SSVs AND ACTIVE REGULATOR

FIGURE 26 - TYPICAL 2 STAGE PRESSURE REDUCTION AND MONITOR OVERRIDE. NO PERMANENT BY-PASS
FIGURE 27 - TYPICAL VOLUMETRIC REGULATING INSTALLATION WITH 2 STAGE PRESSURE REDUCTION AND MONITOR OVERRIDE, ON 1ST STAGE VOLUMETRIC CONTROL ON 2ND STAGE REGULATOR WITH HIGH AND LOW OUTLET PRESSURE OVERRIDES.

Note: Relief valves, silencer and regulated by-pass are shown, but may not be required.
APPENDIX 5 : NOISE ASSESSMENT AND CONTROL

A5.1  PROTECTION OF HEARING

A5.1.1 The aim of The Noise at Work Regulations is to reduce the risks of occupational hearing damage to as low as reasonably practicable.

There are, among others, legal duties to:

- protect the hearing of those at work and of others
- carry out a noise assessment if employees are exposed to noise levels exceeding 80 dB(A)
- take measures to reduce noise levels to the lowest level reasonably practicable
- use warning signs to indicate where hearing protection must be worn
- inform workers about risks to hearing.

The regulations specify the following exposure limit values and action values:

- lower exposure action values are a daily or weekly exposure of 80 dB(A); and a peak sound pressure of 135 dB(C).
- upper exposure action values are a daily or weekly exposure of 85 dB(A); and a peak sound pressure of 137 dB(C).
- the exposure limit values are a daily or weekly exposure of 87 dB(A); and a peak sound pressure of 140 dB(C).

While attempts have to be made to reduce noise level, exposure above the lower exposure action value requires the employer to make hearing protection available on request and exposure above the upper exposure action value requires the employer to provide hearing protection.

Areas above the upper exposure action value, are designated Hearing Protection Zones. Access has to be controlled to these areas.

No worker should be exposed to a noise level above the exposure limit value (taking hearing protection into account)

An employer should provide health surveillance for those regularly exposed above the upper action value or for those occasionally exposed above the upper action value but who are particularly sensitive.

A5.1.2 The HSE publication "Reducing Noise at Work – Guidance on the Noise at Work Regulations" is designed to give those with responsibilities for reducing noise exposure guidance and advice on legal duties on the introduction of control measures, the selection of ear protection and how to carry out a noise assessment by a competent person.

A5.2  DESIGN PROCEDURE FOR ENVIRONMENTAL NOISE CONTROL

The following represents a general design procedure for environmental noise control.

A5.2.1 Background noise survey

A5.2.1.1 Survey the location of a proposed site or PRI initially to confirm its suitability and to confirm existing background noise levels. Since this survey serves as a basis for the design of noise control measures and the validation of any future noise
complaints, competent and trained personnel are required to undertake the survey.

A5.2.1.2 Specify a noise survey procedure, to incorporate the following, using a recently-calibrated precision sound level meter conforming to an appropriate standard such as BS EN 61672:

- minimum background levels that, normally, occur between midnight and 0400 hours
- both octave band and "A" weighted sound level data
- the procedure adopted and the data obtained (reported in detail and retained for future reference).

A5.2.2 Identification of noise sources

A5.2.2.1 Before effective noise control can be applied, identify probable significant noise sources within the site in terms of generation and radiation. Recognise that noise can be radiated and reflected from points other than its source of generation. The significance of pure tones and infrasound cannot be overstated.

A5.2.2.2 Regulators are the main cause of noise generation at PRIs. They generate significant noise at frequencies in the range of 500 Hz to 8 kHz. The acoustical energy transmitted by the gas itself, and the pipe wall, will radiate from above-ground downstream and upstream piping, even where the piping is brought above the ground after a buried run.

A5.2.3.3 Jet boosters use the energy content of higher pressure gas to entrain gas from lower pressure storage and to compress it to some pressure in between the two values is required for distribution. Jet boosters and their associated pipework produce high levels of noise at frequencies in the range of 1 kHz to 8 kHz.

A5.2.3.4 In general, relief valves do not require acoustic treatment. However the need for such treatment may need to be assessed in relation to Common Law, Control of Pollution Act, HSWA Sections 3 (1) and 5 (1) and The Noise at Work Regulations.

A5.2.3.5 Water bath heaters may cause nuisance due to low frequency combustion noise and exhaust stack resonance, together with high frequency air intake noise. In addition, there is often a characteristic low frequency impulse noise when the burner gas ignites.

A5.2.4 Noise radiation

A5.2.4.1 Predict the effective radiated sound power (on a decibel scale with a reference level of $10^{-12}$ W) for each exposed area of piping. Gas-borne regulator noise radiated by exposed pipework is, generally, more significant than the noise radiated by the regulator itself. Significant levels of noise generated by a monitor regulator can be radiated from upstream pipework.

A5.2.4.2 The correct aerodynamic design of piping and components may be expected to reduce locally-generated noise, but will seldom influence the radiation of gas-borne regulator noise which is, normally, dominant.

A5.2.4.3 Water bath heater noise radiates directionally at high frequencies from the air intake(s), and omni-directionally at low frequencies from the stack exit.

A5.2.5 Sound pressure level prediction

A5.2.5.1 Identify the nearest noise sensitive location (control point) to the PRI using the noise survey report (see A5.2.1). The total sound pressure level spectrum produced at that point by contributions from all sources identified in A5.2.2 can
then be predicted using suitable guidance, for example, OCMA Specification NWG-1. The following information will be necessary:
- the effective radiated sound power spectrum in octave bands for each acoustically significant source
- directional data for each source or group of sources
- the exact location of each of the sources relative to each other and to the noise-sensitive location
- the situation of sources with respect to the ground and any large reflecting or absorbing surfaces
- any environmental or topographical features which could influence the propagation of sound, for example, embankments, hard and soft ground and groups of trees
- acoustical data for any items such as buildings, fixed enclosures, movable covers, line silencers and insulation incorporated in the design.

A5.2.5.2 Some sources may be found to be insignificant when compared with the total level, but care is needed to ensure that they will not assume prominence when more powerful sources have been treated.

A5.2.6 Prediction of noise reduction

Compare the predicted sound pressure level spectrum with the required levels for that particular site. Distribute the total attenuation among the sources, beginning with the most significant. Exercise judgement at this stage to establish an acceptable compromise between cost, and extent of treatment. The effect of such treatment on maintenance costs is relevant.

A5.2.7 Application of noise control methods

A5.2.7.1 It is unlikely that any one method will provide a complete solution to the noise problem at an individual installation, but it should be possible to obtain a satisfactory result at optimum costs by adopting an appropriate selection of the measures set down in A5.2.7.3.

A5.2.7.2 Noise reduction methods include:

- burying as much of the interconnecting pipework as practicable, with headers buried where possible, and the length of exposed pipework kept to a minimum, particularly that downstream of regulators
- selection of regulators to combine satisfactory overall performance with least noise generation among their characteristics. Primarily, the sound power of a regulator is a function of flow-rate and differential pressure.

  When the flow is unchoked, differences in valve internal geometry influence the sound power spectrum.

  Unchoked valves are quieter than choked valves.

  Considerable noise control benefit may be obtained by the use of more than one stage of pressure reduction if the stages are thereby made subsonic

- correct use of enclosures, i.e.
  - locating the complete installation in an underground pit or pits with heavy, lagged, ventilated removable covers which can achieve a reduction in noise level up to 40 dB(A)
  - complete enclosure of the pressure-regulating equipment in a suitable building or kiosk of solid construction. Reverberant noise within enclosures
may be reduced by lining them with sound absorbent material. The noise-reducing performance is limited by the need for ventilation, doors and explosion relief features, and is unlikely to exceed 40 dB(A). This value may fall to 20 dB(A) when constructional compromises are adopted

- enclosure of the installation by use of bund walls, with or without removable covers. Uncovered pits cannot be expected to provide noise reduction in excess of 10 dB(A). They do not have good energy absorbing properties but concentrate the energy elsewhere

- light-weight glass fibre canopies can provide 10-15 dB(A) noise reduction if lined with absorptive material on the inside

- barriers have limited application in the control of valve noise. To be effective, they need to be located very close to the noise source, and to be very large in relation to it. Unless specially designed and located, it is difficult to reduce valve noise, at a distant location, by more than 10-15 dB(A)

- cladding provides a convenient method of reducing radiation from exposed piping. It is difficult to achieve noise reductions in excess of 25 dB(A) using this method with reasonable economy. OCMA Specification NWG-5 provides guidance on acoustic cladding.

A5.2.7.3 Where space allows, or provision has been made in the overall layout of the system, line silencers can be effective, particularly if assisted by the cladding of exposed pipework and components. Overall reductions in sound pressure levels of the order of 20 dB(A) may be obtained from a well designed unit. In all cases, the overall performance will be limited by flanking paths, regeneration and impingement noise from the inlet diffuser. The performance of line absorptive silencers falls as the pipeline pressure increases above 7 bar. Guidance on line silencers may be obtained by reference to a suitable standard such as OCMA Specification NWG-4.

A5.2.7.4 Acoustic treatment of water bath heaters needs to be in accordance with an appropriate standard.

A5.3 PERFORMANCE EVALUATION

When the installation is commissioned, check the acoustic performance. Carry out a noise survey, over a similar period of time on the same basis the pre-design survey referred to in A5.2.2 at appropriate rates of flow and pressure differential, to confirm that an adequate degree of noise reduction has been achieved and that any contract specifications for noise control have been met.

Should any changes to the operating parameters or physical specifications be carried out, conduct a similar procedure to that outlined above, and include confirmation or otherwise of the background noise conditions.
APPENDIX 6: CONTINUITY OF SUPPLY

Methods to ensure continuity of supply are varied and any one, or a combination, of the following options may be considered. These are not exhaustive and other options may be available.

A6.1 INTEGRATED PRI SYSTEMS

An integrated PRI system ensures that, in the event of failure of one PRI system, control is provided by another PRI system in the supply network. Protection is included in the design against inadvertent closure of other slam-shut valves as outlined in A6.2.

A6.2 MULTIPLE REGULATOR STREAMS

Each of the duplicate streams contains a regulator(s) so that, if any one stream fails, the remainder maintains continuity of supply.

A6.3 STREAM DISCRIMINATION

Where SSVs operate in a slam-shut selection system in a duplicate stream system, protection is included in the design against one failure causing inadvertent closure of other SSVs. This protection can be achieved, for example, by fitting NRVs or other stream discrimination devices.

A6.4 MONITOR REGULATOR

A monitor regulator, or other override system, may be employed. The regulator takes over control of the downstream pressure in the event of failure of the active regulator to the open position.

A6.5 CREEP RELIEF VALVES

Creep relief valves can be installed to protect SSVs and SSOVs from inadvertent operation due to failure of active regulators to “lock up” during periods of low demand for gas.

Note: Typically, the capacity of a creep valve is less than 1% of stream design capacity.
APPENDIX 7 : REDUCING THE FREQUENCY OF VIBRATION-RELATED FAILURES

A7.1 GENERAL

A7.1.1 Typically, vibration-related fatigue failures occur at threaded connections, welded connections (for example at the toe of fillet welds and through the throat of fillet welded socket type connections) and compression fittings on impulse pipework.

A7.1.2 Threaded connections are one of the potential sites for initiating a fatigue crack, due to the local stress concentration factor at the root of the thread, with the stress distribution being highest at the first engaged thread as it enters the valve body or flange. Therefore, fatigue cracks can initiate at this location if the fatigue loading is high enough.

A7.1.3 The toe of a fillet weld is another likely site for fatigue failures, due to the local stress concentration factor of the weld toe and the presence of slag intrusions (microscopic imperfections), which exist there, and form which fatigue cracks may propagate. Therefore, in both these instances, fatigue cracks can readily initiate and the fatigue life is dominated by fatigue crack growth if stresses due to vibration are sufficiently high.

A7.1.4 Fatigue failures can also occur on impulse pipework at compression fittings, with the failure originating from where the ferrule of the compression fitting is located on the pipe.

A7.1.5 The main causes of vibration-related problems are:
- severe sources of vibration energy associated with the process conditions or the geometry of gas path. At a PRI, the dominant source is likely to be the pressure drop occurring at each regulator – although the severity of this is highly sensitive to the regulator type. Other sources include turbulence, which can be severe if the gas velocities are high, and the flow path is tortuous.
- the effective transmission of vibration energy to more vulnerable parts of pipework, including transmission through the pipe and through the gas.
- resonance, which can occur when individual pipe attachments, the main pipe, or the gas itself, are excited at their natural frequencies because the source vibration contains similar frequencies. Some thermowells may also be susceptible to resonant excitation caused by vortex shedding.
- vulnerable geometry, for example a long, cantilevered small-bore branch with large end mass.
- vulnerable pipework connections, for example, poor welds, socket fittings.

A7.2 MEASURES TO REDUCE THE LIKELIHOOD OF VIBRATION RELATED PROBLEMS

The following guidance represents good engineering practice and gives some of the measures that can be taken to reduce the likelihood of vibration-related fatigue failures at PRIs. The main area that is susceptible to failures occurring is pipework around the regulators.

A7.2.1 Regulators

Use regulators with low noise performance and minimise (within the constraints of the design) gas velocities through streams. Low noise can be achieved by making the gas take multiple paths through the regulator, and making each path contain multiple restrictions. The benefits of using such a regulator can be dramatic.
A7.2.2  Pipework

A7.2.2.1 Ensure the wall thickness of the main pipework is as large as practically possible, as this will reduce the vibration of the pipework and the stresses at connections. It is recognised that this requirement may conflict with other design requirements, such as ensuring sufficient flexibility, so the designer needs to balance such conflicting requirements.

A7.2.2.2 As far as practicable, maximise the diameter of the pipe in order to minimise the gas velocity through the pipe.

A7.2.2.3 Where practicable, minimise the number and severity of any bends and tees.

A7.2.2.4 Ensure that adequate support is provided for the pipe, particularly near bends and close to larger masses such as valves.

A7.2.2.5 Ensure that pipe supports do not introduce stress concentrations themselves by, for example, welding them to the pipe. However, take care to avoid wear due to rubbing of the pipe against the support.

A7.2.2.6 If pipe supports overly constrain thermal expansion, consider the use of a pipe support that can slide once a predefined thermal load is exceeded.

A7.2.2.7 Provided it does not unduly compromise access for inspection and maintenance, bury pipe to dampen vibration where practicable.

A7.2.3  Small bore attachments

A7.2.3.1 Make small branch connections (up to a diameter of 80 mm) with short weldoflange type (one piece) fittings. Take care to ensure that the weldoflange is not disproportionately large, relative to the pipe that it is attached to.

A7.2.3.2 Avoid large unsupported masses, such as long unsupported branch connections, and unsupported pressure gauges mounted on long impulse tubes, pipework or branch connections.

A7.2.3.3 Where practicable, ensure that dead-leg branches are shorter than 8 times the internal diameter of the small-bore attachment.

A7.2.4  Impulse pipework

A7.2.4.1 Independently support any valve, control pilot or transducer, connected to impulse pipework or branch connections. If they are supported on a rigid base, ensure the connecting pipework is sufficiently flexible to accommodate the relative movement.

A7.2.4.2 Support impulse pipework at regular intervals with anti-vibration supports, such that there are no long unsupported sections. Use the anti-vibration type and not the hard plastic type. Following BS 6739, for impulse pipework up to 12 mm diameter, limit the maximum distance between supports to 1 m. However, ensure the impulse tube arrangement that, for single bend arrangements, the length of the first leg be longer than 300 mm, and the length of the second leg, to the anchored mass or first pipe support, also exceed 300 mm. Straight impulse pipework runs connecting directly to a fixed point are not recommended. Figure 28 presents the recommended impulse pipework configurations.

Take care to ensure that impulse pipes are not touching.

Correctly install compression fittings on impulse pipework, following the manufacturer’s installation procedures, taking care not to over tighten. Do not
mix components from the compression fittings of different manufacturers. Avoid the use of pipe-to-pipe compression fittings between the instrument stabbing and the first pipe support (the fitting will otherwise add mass and may make the vibration levels higher. In addition, the pipe may be weakened at the fitting).

Do not use impulse pipework as a structural support for attached masses such as a pilot or a filter.

A7.2.5 Temperature monitoring

Use only surface mounted temperature measurement devices unless temperature response time is critical or the temperature device is associated with custody transfer measurement. For those cases, which still require a thermowell, use weldoflange-type instrument stabbings.

FIGURE 28 - RECOMMENDED IMPULSE PIPEWORK CONFIGURATION TO MINIMISE RISK OF VIBRATION RELATED FAILURES

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APPENDIX 8 : INSTALLATION AND USE OF TEMPORARY OPEN-ENDED SKIRT TYPE STRAINERS

A8.1 APPLICATION

Strainers are installed into the pipework to protect equipment such as meters or regulators from damage caused by any deleterious material such as welding slag, pipe scale, rust, valve grease, or any other debris existing or occurring in the length of the pipework between the main filter unit and the equipment to be protected.

Strainers are generally fitted as a temporary measure and should be removed after being in service for one winter period. A sign shall also be placed on the relevant section(s) of pipework to indicate their presence and their removal date shall be set up on MIMS.

A8.2 STRAINER DESIGN

Both open-ended (Skirt Type) and closed-end (Top Hat Type) strainers exist but the open-ended strainer is considered adequate to protect downstream equipment. The purpose of the strainer is to trap large particles of debris or grease being carried along the outer edge of the pipe and is not intended to stop the finer gas borne dust particles considered to be negligible on new installations. Open-ended strainers shall therefore be used in all instances.

The open-ended type strainer has the advantage of a relatively low-pressure differential, which can be critical at lower pressures i.e. less than 7 bar.

Strainers are of mild steel and stainless steel construction. They consist of a support cone of mild steel perforated plate, with a 200-micron stainless steel filtration mesh fitted on the outside. The length of the support cone is approximately ½ “D” where “D” is the bore of the pipe. Details of the strainer material and dimensions are given at G4 Data Sheet below.

A8.3 INSTALLATION

The strainer is installed by being clamped down between two adjacent flanges and it is very important at the design stage to allow for the removal of the adjacent pipe section to enable the strainers withdrawal for cleaning, inspection and removal, whilst maintaining the operation of the PRI.

A8.3.1 Metering Installations

All turbine and rotary displacement meters shall be fitted with an open-ended (Skirt Type) strainer for operating pressures up to 75 and of the closed end type for operating pressures above 75 mbar. The strainer is to be inserted in the horizontal pipework upstream of the meter.

A8.3.2 Turbine Meters

For turbine meters the strainer shall be fitted at a minimum of 3D upstream of the meter inlet. In the majority of cases it will be necessary to fit extra flanges to meet the required distance and enable withdrawal of the strainer.

A8.3.3 Regulator Installations

On new and updated Pressure Regulating Installations where a large amount of pipework has been provided on site, and there is a likelihood of foreign matter
being left in the pipework, temporary open-ended strainers shall be fitted upstream of the first regulators on each steam prior to commissioning. This avoids the inevitable damage to the regulator internal parts. Where small “under pressure” drilling operations have taken place upstream of the regulators, guidance should be taken from the responsible engineer for the installation on whether it is appropriate to fit a strainer.

A8.4

DATA SHEET

Dimensions of open-ended (skirt type) strainers for pressure regulating installations with operation pressures greater than 75 mbar

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NOTES:
1. All strainers shall be the “open-ended” type of stainless steel/mild steel construction as follows:
   a) Support Cone – 16 s.w.g. perforated plate, 3.5 mm diameter hole.
   b) Filtration Mesh – 80 mesh 200 micron filtration (to be fitted on outside of support cone).
2. Open-ended strainers shall not be used on low-pressure regulator/meter installations because of high-pressure drops (i.e. Installations with inlet pressures).
3. Details of pipe bore and flange rating to be stamped on the rear of the handle, i.e. Side upstream of gas flow.
APPENDIX 9 : PERFORMANCE REQUIREMENTS FOR STREAM DISCRIMINATION NRVS

A9.1 REVERSE PRESSURE

The manufacturer will state the maximum reverse pressure that the NRV will withstand without impairing its performance, with two preferred pressures:
• 350 mbar minimum reverse pressure
• 1 bar minimum reverse pressure.

A9.2 TEST

The NRV has to withstand the specified reverse pressure for a period of 60 minutes without any permanent distortion to either the flap or the bearings and thereafter perform as specified when subject to normal flow through the NRV.

A9.3 REVERSE FLOW (ALL SIZES)

The manufacturer will supply details of the reverse flow rates for each size of NRV.

For NRVs of diameter greater than 200 mm, the maximum reverse flow will not exceed 30 s.m³h⁻¹ when subjected to reverse pressures up to and including their maximum rating.

A9.4 PRESSURE RELATED CHARACTERISTICS

The manufacturer will supply details of pressure drops across the NRV for each size of NRV.