INSTITUTION OF GAS ENGINEERS AND MANAGERS IGEM/TSP/21/261

IGEM/UP/9 Edition 3
Communication XXXX

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Application of Gas systems to gas turbines and supplementary and auxiliary fired burners

DRAFT FOR COMMENT

1 This draft Standard IGEM/UP/9 Edition 3 has been prepared by a Panel under the chairmanship of Nick Evans.

This draft Standard IGEM/UP/9 Edition 3 has been prepared by IGEM Secretariat.

2 This Draft for Comment is presented to Industry for comments which are required by Day Month 2021, 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/UP/9 Edition 3 – "Application of Gas systems to gas turbines and supplementary and auxiliary fired burners" and the associated comment form.

We wish to make it as easy as possible for those of you representing industry bodies to issue the draft to your Members. You can either forward this email with attachment complete or forward it without the attachment and invite them to visit our website via where the Draft and http://www.igem.org.uk/technical-standards/standards-development/drafts-for-comment.aspx Comment Form are posted.

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IGEM/UP/9 Edition 3
Communication xxxx

Application of Gas systems to gas turbines and supplementary and auxiliary fired burners

Draft for comment

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IGEM Institution of Gas Engineers & Managers

IGEM/UP/9 Edition 3
Communication xxxx

Application of Gas systems to gas turbines and supplementary and auxiliary fired burners

Draft for comment

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SECTION 1 : INTRODUCTION

1.1 This Standard supersedes IGEM/UP/9 Edition 2, Communication 1705, which is obsolete.

1.2 This Standard has been drafted by a Panel appointed by the Institution of Gas Engineers and Managers' (IGEM's) Gas Utilisation Committee, subsequently approved by that Committee, approved by the Technical Coordinating Committee and published by the authority of the Council of the Institution.

1.3 This Standard covers the application of fuel gas supply to gas turbines and the exhaust gas interaction with supplementary and auxiliary fired burners.

1.4 The development and application of gas turbines as efficient and reliable power sources is well proven throughout the world. The high temperature of the exhaust gases and its ability to support combustion of additional fuel with supplementary and auxiliary firing, has led to considerable use of turbines in conjunction with waste heat recovery equipment such as boilers, dryers, etc. The rapid start-up process enabling turbines to accept full load from a "cold start", and their very high power-to-weight ratio has popularised their use as power generation

1.5 In contrast to other types of gas burners, the start-up, operation and shut-down procedures employed on a turbine are determined by many more factors than merely the need to establish, maintain and control a stable flame. In particular the inter-dependence of turbine power and combustion air supply, the need to reach a self-sustaining speed rapidly to reduce the depletion of any starter motive power supplies, the avoidance of critical shaft or blade aerofoil resonance and the very rapid flame modulation needed to handle the sudden acceptance and shedding of loads, impose severe restrictions. These restrictions render many of the practices common on other large gas burners impracticable in this application. The high excess air quantities also provide considerable scope for safe deviation from practices used on other burners.

1.6 For gas firing, it is vital to consider the system as a whole, including the Gas Transporter (GT)'s network, the Meter Asset Manager's (MAM's) meter installation, installation pipework, fuel gas compressor, turbine, supplementary/auxiliary fired burners and other gas users on site. Although generally Natural Gas (NG) is dry, other gases may contain varying levels of moisture and contaminants which shall be considered at the design stage.

1.7 The ignition and subsequent operation of gas and dual fuel burner systems for supplementary firing are covered by IGEM/UP/12, and BS EN 746 Part 2 as appropriate.

1.8 This Edition of the Standard no longer covers the requirements for gas turbines being supplied by fuel oil.

1.9 This Standard makes use of the terms ''must'', ''shall'' and ''should'' when prescribing particular requirements. Notwithstanding Sub-Section 1.10:

(a) The term ''must'' identifies a requirement by law in Great Britain (GB) at the time of publication.

(b) The term ''shall'' prescribes a procedure which it is intended, will be complied with in full and without deviation.

(c) The term ''should'' prescribes a procedure which it is intended, will be complied with unless after prior consideration deviation is considered to be acceptable.

Such terms may have different meanings when used in Legislation, or Health and Safety Executive (HSE) Approved Codes of Practice (ACoPs) or Guidance, and reference needs to be made to such statutory Legislation or official Guidance for information on legal obligations.

1.10 Notwithstanding Sub-Section 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 to 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.

1.11 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. People who initiated actions that caused or contributed to accidents might have acted in a more appropriate manner to prevent them.

To assist in the control of risk and proper management of these human factors, due regard should be taken of HSG48 and HSG65.

1.12 The primary responsibility for compliance with legal duties relating to health and safety at work 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 not within 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.

1.13 Requests for interpretation of this Standard in relation to matters within their scope, but not precisely covered by the current text, should be either:

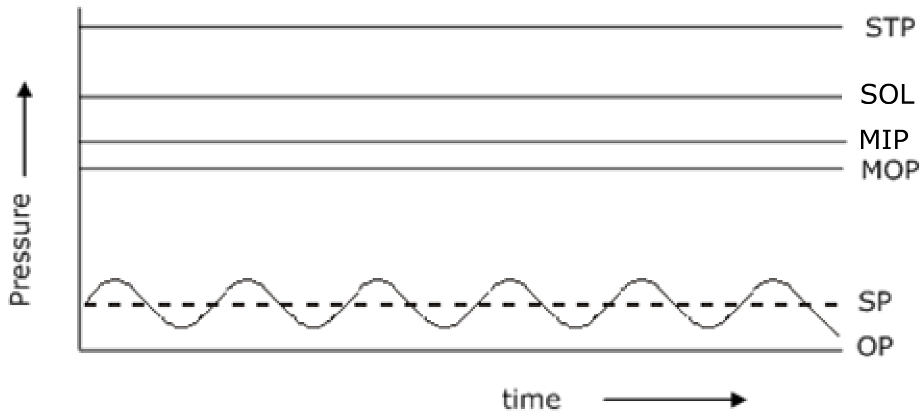
- addressed to Technical Services, IGEM, IGEM House, 26 & 28 High Street, Kegworth, Derbyshire, DE74 2DA; or
- emailed to technical@igem.org.uk.

These 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 liability for the consequences and does not relieve the responsible engineer of any of his or her obligations.

1.14 Terms such as "maximum operating pressure" (MOP), "maximum incidental pressure" (MIP), "operating pressure" (OP), "lowest operating pressure" (LOP) and "design minimum pressure" (DmP) were introduced in IGEM/UP/2 to reflect gas pressure terminology used in European standards.

Other terms were introduced to assist in recognition of design information to be transferred between interested parties.

Referring to Figure 1, attention is drawn to how OP oscillates about the set point (SP). Note also that MOP can be declared at a higher value than OP. The strength test pressure (STP) has to exceed MIP. This means that, at least with respect to integrity, the installation will withstand a fault pressure from the upstream system. Safe operating limit (SOL) is a requirement of the Pressure Systems Safety Regulations (PSSR) (where applicable).

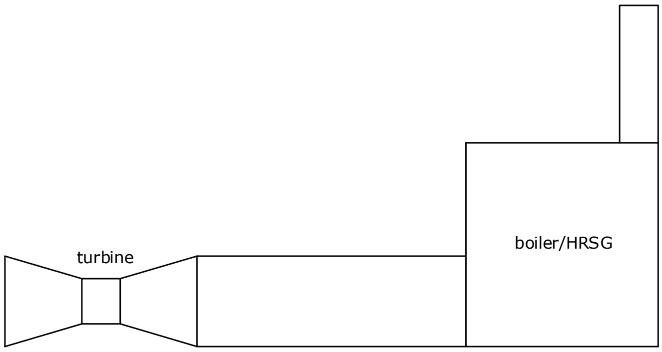


STP	=	Strength test pressure
SOL	=	Safe operating limit
MIP	=	Maximum incidental pressure
MOP	=	Maximum operating pressure
SP	=	Maximum set point of, typically, the active regulator
OP	=	Operating pressure.

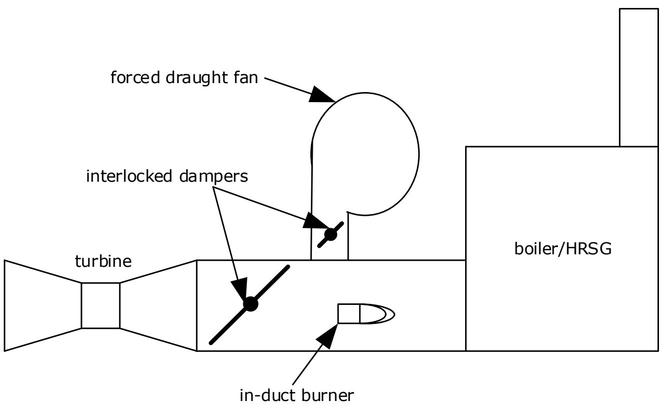
FIGURE 1 - OPERATIONAL PRESSURE LIMITS

SECTION 2 : SCOPE

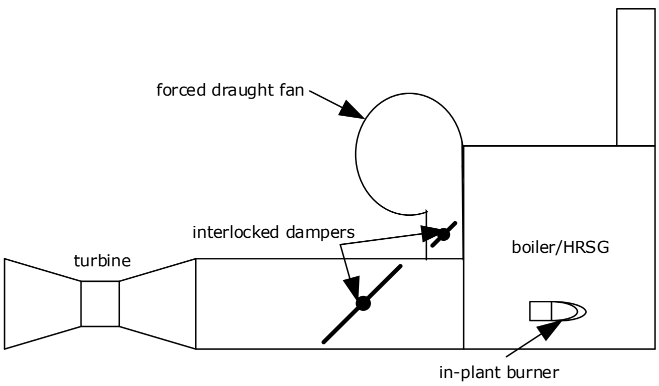
2.1 This Standard covers the essential safety aspects of the engineering, start-up, operation and shut-down of gas turbines and associated equipment (typical arrangements are shown in Figures 2 and 3). They are not intended to provide a complete specification for such equipment.



(a) Simple, unfired



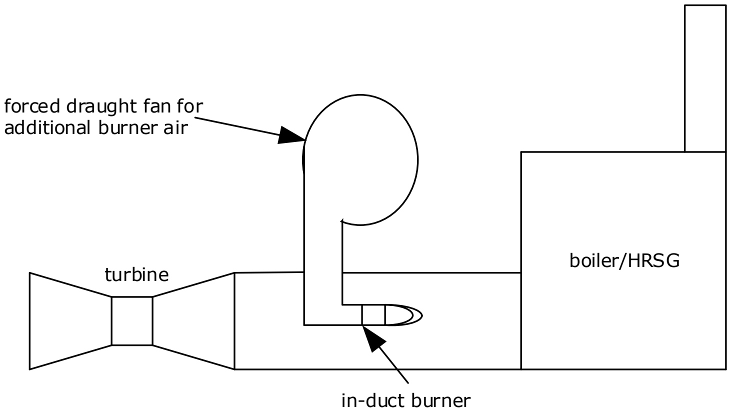
(b) In-duct, auxiliary fired



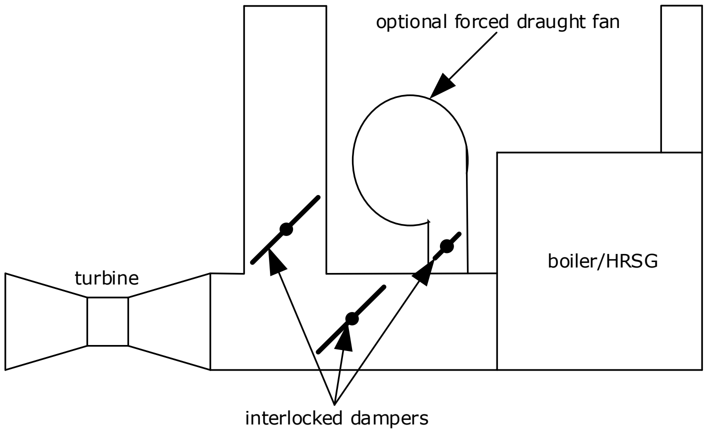
(c) Auxiliary fired in plant

Key:
HRSG – Heat recovery steam generators

FIGURE 2 - TYPICAL CHP INSTALLATIONS

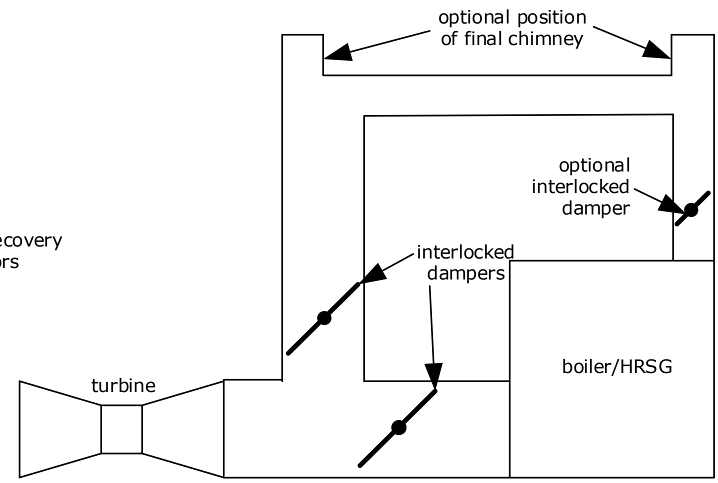


(d) Supplementary fired with optional fan



(e) With turbine by-pass and separate plant flue and optional forced draught fan

Key:
HRSG – Heat recovery
steam generators



(f) As (e) but with common exhaust from by-pass stack and plant flue

FIGURE 2 - TYPICAL CHP INSTALLATIONS (continued)

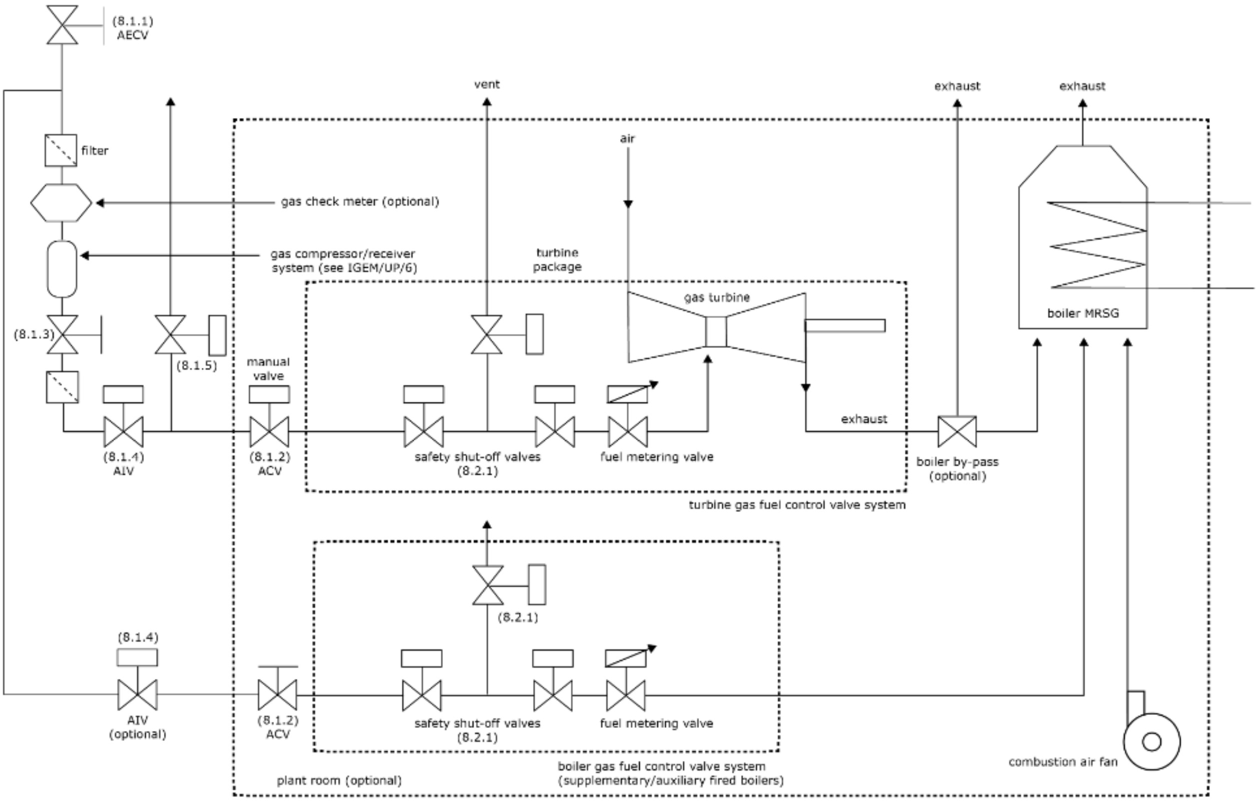


FIGURE 3: SIMPLIFIED GAS FUEL SCHEMATIC FOR A TYPICAL TURBINE INSTALLATION WITH A GAS FIRED BOILER

2.2 This Standard refers primarily to gas turbines using lighter and heavier than air flammable fuel gases such as Manufactured Gas, Natural Gas (NG), Liquefied Petroleum Gas (LPG), LPG/air mixtures, (1^{st}, 2^{nd} and 3^{rd} family gases are further defined in BS 1179). They may be appropriate for other non-conventional gases such as Landfill, Anaerobic Digester and Mines Recovery Gas and Hydrogen, but the particular characteristics of the gas needs to be recognised with respect to consequent effects on materials and operations.

2.3 This Standard applies to gas turbines for continuous and standby duties, for example in industrial and commercial sites for combined heat and power (CHP), power generation and gas compression systems.

Turbines used for vehicular propulsion or used offshore are not covered. However, the general principles outlined in this Standard may be used as guidance.

2.4 This Standard applies to:

- both single and multi-shaft turbine types

Note: In this context, "shaft" relates to the turbine and not to the alternator. The term "spool" is a commonly used alternative.

- both single and multiple burner types
- turbines exhausting to heat recovery equipment, with or without supplementary and/or auxiliary fired burners, which may or may not have air supplies other than the engine exhaust. Those having independent air supplies are also considered as auxiliary fired.

2.5 This Standard applies to gas turbines supplied directly from a gas supply and to those supplied via a gas compressor.

Note: Requirements for gas compressors are provided in IGEM/UP/6.

2.6 Metric standard conditions apply, unless otherwise specified.

2.7 All pressures are gauge pressures, unless otherwise stated.

2.8 All fuel inputs are given net unless otherwise stated.

2.9 The term "turbine(s)" refers to "gas turbine(s)" throughout, 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 "must", "shall" or "should".

SECTION 3 : LEGAL AND ALLIED CONSIDERATIONS

This Standard is set out against a background of Legislation in force in GB at the time of publication (see Appendix 2). The devolution of power to the Scottish, Welsh and Northern Ireland Assemblies means that there may be variations to the Legislation described below for each of them and consideration of their particular requirements must be made. Similar considerations are likely to apply in other countries and reference to appropriate national Legislation will be necessary.

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.

Care shall be taken to ensure that the latest editions of the relevant documents are used.

Appendix 2 lists Legislation, Guidance Notes, standards etc. which are identified within this Standard as well as further items of Legislation that may be applicable. Where Standards are quoted, equivalent national or international standards etc. equally may be appropriate. Unless otherwise stated, the latest version of the referenced document should be used.

3.1 PRIMARY LEGISLATION

3.1.1 Health and Safety at Work etc. Act (HSWA)

HSWA applies to all persons involved with work activities, including employers, the self-employed, employees, designers, manufacturers, suppliers etc. as well as the owners of premises. It places general duties on such people to ensure, so far as is reasonably practicable, the health, safety and welfare of employees and the health and safety of other persons such as members of the public who may be affected by the work activity.

3.1.2 The Gas Act

In particular, the Gas Act stipulates requirements for:

- notification to the gas supplier and the GT of the intention to install a compressor
- the fitting and maintenance of a supply protection device
- the avoidance of affecting the supply system.

3.1.2.1 The user of a gas compressor is required to provide written notification to the gas supplier and the GT of the intention to connect a compressor to the gas supply network.

The user is required to provide adequate protection for the gas supply pipework against high pressure being fed back into the supply so exceeding the maximum operating pressure (MOP) of that pipework or of any component contained within it. For this reason, the gas supplier and the GT are required to be provided with evidence that all appropriate safeguards have been taken.

3.1.2.2 Before a compressor that is to be fitted to an installation connected to the public gas supply network, is considered acceptable for operation, it is required (as permitted by the Gas Act) by the gas supplier and the GT that suitable protective devices be fitted and maintained by the compressor operator. The gas supplier and the GT has to be satisfied that no undue compressor induced perturbations are imposed on the metering system or into the gas supply. Usually, this will mean demonstrable compliance with relevant published Standards.

3.1.3 Factories Act 1961

An act to consolidate the Factories Acts 1937 to 1959 and certain other enactments relating to safety, health and welfare of employed persons.

3.2 SECONDARY LEGISLATION

3.2.1 Management of Health and Safety at Work Regulations (MHSWR)

In addition to specific duties under GS(I&U)R (see clause 3.2.8), MHSWR impose a duty on employers and the self-employed to make assessments of risks to the health and safety of employees, and non-employees affected by their work. They also require effective planning and review of protective measures.

3.2.2 Provision and Use of Work Equipment Regulations (PUWER)

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.

The Regulations place duties on employers in relation to selection, suitability, maintenance, inspection, installation, instruction and training, prevention of danger and control of equipment.
More information on the Regulations can be found in L22. Free leaflets include INDG 291 and INDG 229.

3.2.3 Pressure Equipment Directive (PED)

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 United Kingdom (UK) by the Pressure Equipment Regulations (PER) and the PSSR (see clauses 3.2.4 and 3.2.5 below).

3.2.4 Pressure Equipment Regulations (PER)

These Regulations are intended to cover the placing on the market and the putting into use of pressure equipment. The Regulations deal with the manufacture, design and supply of pressure equipment. They impose duties on the responsible person.

Note 1: A "responsible person" is defined as "the manufacturer or his authorised representative established within the Community; or where neither the manufacturer nor his authorised representative is established within the Community, the person who places the pressure equipment or assembly on the market or puts it into service as the case may be."

Note 2: "Pressure equipment" is defined as "vessels, piping, safety accessories and pressure accessories; where applicable, pressure equipment includes elements attached to pressurised parts, such as flanges, nozzles, couplings, supports lifting lugs and similar."

Note 3: The duties on the "responsible person" are to ensure that pressure equipment:

- *satisfies the relevant essential requirements*
- *has undergone the relevant conformity assessment procedure, if applicable*
- *has had the CE mark affixed by the manufacturer, if applicable*
- *has had the declaration of conformity drawn up by the manufacturer that the equipment is, in fact, safe.*

Note 4: Not all pressure equipment is covered by PER. There are 21 categories of exceptions, detailed in Schedule 1 of PER.

Note 5: The relevant conformity assessment procedure is determined by the classification of the pressure equipment according to criteria laid down in the Regulations. The classification system results in equipment being placed in one of five categories depending on the inherent level of hazard within the system.

The category then determines the range of conformity assessment modules relevant to that equipment. The modules are designed to allow the manufacturer to choose between a quality assurance route or type testing.

3.2.5 Pressure Systems Safety Regulations (PSSR)

3.2.5.1 These Regulations impose duties on designers, importers, suppliers, installers and user 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).

3.2.5.2 Relevant fluids for the purpose of this document would be NG at a pressure greater than 0.5 barg (above atmospheric pressure) or LPG (which is a liquid with a vapour pressure greater than 0.5 barg at ambient temperature). A pressure system would include bulk storage tanks, pipelines and protective devices but not an LPG cylinder (transportable pressure receptacle). 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 the Regulations. 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 L122). The regulations also apply to pipelines and its protective devices in which the pressure exceeds 2 barg (see Schedule 1 part 1 item 5 of L122).

3.2.5.3 More information is available in L122 and some information is presented in the HSE free leaflets INDG 261 and INDG 178.

3.2.5.4 Safe operating limits of plant, belonging both to the user and the GT, must be established. These limits must determine the "weakest link" and protect against failure.

Note: Formal communications, between the user and the GT, need to be established and a division of responsibility understood clearly by both parties. The MAM may need to be consulted with regard to the meter installation.

3.2.5.5 Information must be exchanged concerning safe operating limits and schemes of examination for protective devices, to ensure that both parties are aware of each other's limitations and, consequently, the safe operating limits.

3.2.5.6 There are many exceptions and partial exceptions to the regulations, which are detailed in Schedule 1 Parts 1 and 2.

Note: A schematic diagram showing division of responsibility is recommended.

3.2.6 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.

Note: A "Memorandum of Guidance on the Electricity at Work Regulations, 1989" is published by HMSO and gives useful information on the Regulations.

3.2.7 Noise at Work Regulations

Under these Regulations, the employer is required to identify any potential injurious noise sources and carry out an assessment when an employee is exposed to a level of noise in excess of the first action level of a daily personal exposure of 85 dB(A). Action is then required to reduce noise at source so far as is reasonably practicable. Only then can consideration be given to hearing protection. A duty is also placed on manufacturers and suppliers to provide information on the noise likely to be generated by their product.

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

3.2.8.1 GS(I&U)R are relevant statutory provisions of HSWA setting out general and detailed requirements dealing with the safe installation, maintenance and use of gas systems, including gas fittings, appliances and flues.

3.2.8.2 GS(I&U)R define the type of work that requires persons carrying out such work, or their employers, to be an "approved class of person", i.e. Gas Safe registered.

3.2.8.3 GS(I&U)R requires all those undertaking gas work to be competent. The Approved Code of Practice and guidance to the Gas Safety (Installation and Use) Regulations L56, provides guidance as those allowed to undertaking gas work and the training that needs to be provided. The requirements for training in gas work are set out in IGEM/IG/1.

3.2.8.4 The installer must check the safety of any appliance or pipework they install or work on and take appropriate action where they find faults. Where the premises are let or hired out, the landlord or hirer has special responsibilities to ensure that any installer they use for the gas fitting, service or maintenance is a member of an approved class of persons and / or competent to carry out such work. If any unsafe or potentially unsafe situations are found, the installer must inform both the landlord/hirer, as well as the user, so that such faults can be rectified before further use.

3.2.8.5 These Regulations with respect to fuel gas systems, also require:

- the fitting and maintenance of a supply protection device
- the need to avoid affecting adversely the upstream network.

3.2.8.6 The user must provide adequate protection for the upstream network as required by the GT. This includes protection against excess reverse pressures, low inlet pressures, large rates of change of flow and undue pressure/flow perturbations. The GT is permitted to demand suitable protection.

Note1: If a gas turbine, compressor, or any apparatus for using compressed air or extraneous gas is being proposed there is a legal duty to notify the GT of this intention not less than 14 days prior to its use. The GT may give direction as to the type and arrangement of any anti-fluctuation valves it may require. Failure to meet the requirements of the in this respect can lead to disconnection of supply. Compliance with the relevant requirements of these Regulations should be sufficient in most cases.

Note 2: It is essential that the fuel supplier is advised of the anticipated transient flow variations in order that they can be checked for compatibility with the gas metering/supply system.

Note 3: L56 and IGEM/IG/1 are also relevant.

Note 4: To meet the requirements of the HSWA, persons need to be experienced and competent to perform their work safely.

3.2.8.7 GS(I&U)R place responsibilities on LPG suppliers to deal with escapes of LPG. For NG, the Gas Safety (Management) Regulations GS(M)R apply.

Note: Advice on dealing with gas escapes is contained in IGEM/SR/29.

3.2.9 Confined Spaces Regulations

In general, an acoustic enclosure used for a turbine is an enclosed space for the purposes of these Regulations.

These Regulations apply to a whole range of confined spaces. The supplier or designer of an enclosure and equipment within it, is required to perform a risk assessment of the enclosure with respect to safe access and egress and to give clear instructions to operators on access/egress as well as to what actions to take in the event of a gas alarm occurring. Employers and the self-employed should avoid entry into confined spaces unless avoidance is not reasonably practicable and there is a system of work which renders the work safe. They are also required to have specific emergency arrangements in place.

Employers need to:

- establish safe systems of work for entry to, or carrying out work in, or leaving, a confined space that renders the activities safe and without risks to health
- establish suitable and sufficient arrangements for rescue of people in the confined space in the event of an emergency
- ensure compliance, so far as is reasonably practicable, with the provisions of the Regulations in respect of any work carried out by employees, or other people within the employer's control.

3.2.10 Construction (Design and Management) Regulations (CDM)-L153

These Regulations impose duties on designers, clients (and their agents), developers, planning supervisors and principal contractors. Not all the regulations apply to all construction projects. For a notifiable project (as defined in CDM) the planning supervisor must notify HSE before construction work commences. Construction includes the alterations, repair, redecoration, maintenance, decommissioning or demolition of a structure. It also covers installation, commissioning maintenance or removal of gas services.

3.2.11 Supply of Machinery (Safety) Regulations

These Regulations set out "essential requirements" written in general terms, which must be met by manufacturers/suppliers before a product may be supplied within the European Community. European standards provide the detail on the essential requirements. Machinery, as defined, once having been verified against the relevant standards, can then be affixed with the CE mark. The manufacturer or importer will have to be able to assemble a technical file detailing information on the health and safety considerations which went into the design of the product.

3.2.12 The Product Safety and Metrology etc. (Amendment etc.) (UK(NI) Indication) (EU Exit) Regulations 2020

Following the UK exit from the EU supplementary legislation has been added to the Supply of Machinery (Safety) Regulations in order to support the implementation of Part Three of the Withdrawal Agreement (Separation

Provisions), this instrument enables the Secretary of State to act as a market surveillance authority for the purposes of exchange of information on market surveillance relating to goods placed on the market before TP end with the European Commission and EFTA Surveillance bodies as required by the Withdrawal Agreements.

3.2.13 **The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations**

The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations place duties on the suppliers of equipment who must ensure that it complies with the essential health and safety requirements, generally by compliance with the relevant harmonised European standards, prior to CE marking.

3.2.14 **The Dangerous Substances and Explosive Atmospheres Regulations (DSEAR)**

These Regulations are concerned with protection against risks from fire, explosion and similar events arising from dangerous substances used or present in the workplace. The regulations 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 regulations also require the identification of pipelines and containers containing hazardous substances.

The following publications contain details of the regulations and their application:

- L138
- INDG 370.

3.2.15 **Reporting of injuries, diseases and dangerous occurrences regulations (RIDDOR)**

3.2.15.1 RIDDOR require employers, self-employed people or those in control of work premises to report certain work related accidents, diseases and dangerous occurrences.

3.2.15.2 Other people have duties to report certain gas incidents which may not appear to be work related:

- death, major injury, lost consciousness, or been taken to hospital for treatment to an injury arising out of the distribution, filling, import or supply of NG or LPG are to be reported by the conveyor for NG and the filler, importer or supplier for LPG
- dangerous gas fittings (as defined in RIDDOR) are required to be reported by a ''member of a class of persons''. Gas Safe registered engineers are to provide details of any gas appliances or fittings that they consider to be dangerous, to such an extent that people could die, lose consciousness or require hospital treatment. The danger could be due to the design, construction, installation, modification or servicing of that appliance or fitting, which could cause:
  - an accidental leakage of gas
  - inadequate combustion of gas or
  - inadequate removal of products of the combustion of gas.

3.2.15.3 Major injuries, death and dangerous occurrences are to be notified immediately, to the enforcing authority by the "responsible person" as defined by RIDDOR. Report can be made to the Incident Contact Centre:

- for fatal and major injuries only, telephone on 0845 300 9923 (opening hours Monday to Friday 8.30 am to 5 pm) and complete appropriate on-line form
- all other reports at HSE website www.hse.gov.uk
  Complete the appropriate online report form listed below.
  - report of an injury
  - report of a dangerous occurrence
  - report of an injury offshore
  - report of a dangerous occurrence offshore
  - report of a case of disease
  - report of flammable gas incident
  - report of a dangerous gas fitting.

3.2.15.4 The form will then be submitted directly to the RIDDOR database and a copy issued to the person making the report.

3.2.15.5 On-line written reports are to be submitted to the enforcing authority without delay but within the required timescale.

3.2.15.6 INDG 453 contains detailed guidance on RIDDOR, including a full list of injuries etc. that need reporting.

3.2.15.7 IGEM/GL/8 provides guidance on the reporting and investigation of gas-related incidents.

3.2.16 Control of Substances Hazardous to Health Regulations (COSHH)

3.2.16.1 These Regulations, 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.

3.2.16.2 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 the Regulations. 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.

3.2.17 Control of Asbestos at Work Regulations

3.2.17.1 These Regulations set out standards for the identification, monitoring and assessment of work that may expose workers to asbestos and the measures needed to control the risk.

3.2.17.2 Employers cannot carry out any work that exposes, or is likely to expose, employees to asbestos unless an assessment of that exposure has been made. Employers have to set out steps to be taken to prevent, or reduce to the lowest level reasonably practicable, that exposure. Employers have to carry out medical surveillance of employees if they work over a certain time limit.

3.2.17.3 The Regulations impose a duty on those with responsibilities for the repair and maintenance of non-domestic premises to find out if there are, or may be, asbestos containing materials within them; to record the location and condition of such materials and assess and manage any risk from them, including passing of any information about their location and condition to anyone likely to disturb them. There is an 18 month lead in period for this duty.

3.2.17.4 Further information is available in HSG227. Other ACoP associated with this Regulation is L143

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

3.2.18.1 GS(M)R place specific duties on GTs, or their emergency service providers (ESPs), for dealing with gas escapes from pipes on their networks. Their primary duty is to make the situation safe. They are responsible not only for dealing with escapes from their own pipes, but also for dealing with escapes from gas fittings supplied with gas from pipes on their network. In GS(M)R, the term "gas escapes" includes escapes or emissions of carbon monoxide (CO) from gas fittings.

3.2.18.2 The ESP has specific duties to:

- to provide a continuously staffed and free telephone service to enable persons to report gas escapes and
- to pass such reports on to the person who has the responsibility for dealing with the escape.

In addition, there are duties imposed on gas suppliers and GTs to notify the ESP should they, rather than the ESP, receive a report of an escape from the consumer.

3.2.18.3 GS(M)R require GTs to investigate fire and explosion incidents upstream of the emergency control valve (ECV) and to send a report of the investigation to HSE. GTs are also required to investigate fire and explosion incidents downstream of the ECV but this is limited to establishing whether the seat of the fire or explosion was in an appliance and, if so, which one, or in the installation pipework.

3.2.18.4 Responsibility for investigating RIDDOR reportable incidents as a result of an escape of CO from incomplete combustion of gas from a gas fitting, is placed on gas suppliers. HSE must be notified before such investigations commence.

Note: Advice on dealing with gas escapes is contained in IGEM/SR/29 and IGEM/G/11.

3.2.19 **The Construction Products Regulations (CPR)**

The CPR applies to construction products, which are placed on the market and produced for incorporating in a permanent manner in construction works (which includes both building and civil engineering works). The essential requirements are: mechanical; safety and stability; safety in case of fire; hygiene, health and environment; safety in use; protection against noise; energy economy and heat retention.

3.2.20 **Clean Air Act**

SECTION 4 : ARRANGEMENT OF PLANT

4.1 PLANNING

4.1.1 For new turbine installations and existing installations where there are changes to the gas load or pressure requirements, discussion shall take place with the GT, gas supplier and/or MAM to confirm the availability of gas, its supply and operating pressures, metering specification, any requirements for reverse flow protection and any additional safety equipment.

Note: The load and pressure profile within a turbine installation is important with respect to the design and specification of the meter installation (see IGEM/GM/8, IGEM/GM/6 or IGE/GM/4, as appropriate).

4.1.2 The designer must establish whether the turbine installation and ancillary equipment will fall within PSSR and take the appropriate action.

4.1.3 The designer shall establish MOP, MIP and STP for the system and if applicable the SOL. Any possibility of increasing OP at a later date should be taken into account at the design stage; for example by declaring a higher MOP.

4.1.4 Where the turbine installation and ancillary equipment necessitates substantial building work, all planning and relevant Building Regulations applications must be approved before construction starts.

4.1.5 Any plant room shall be constructed to comply with The Building Regulations for England and Wales, The Building Standards (Scotland) Regulations or The Building Regulations (Northern Ireland), as appropriate, and with particular respect to satisfying the minimum provisions of the relevant part of BS 476, in that, in the event of fire:

- the load bearing elements of construction shall have a 30 minute [60 minutes in Scotland] load bearing capacity
- the construction shall have at least a 30 minute [60 minutes in Scotland] integrity
- any constructional insulation shall have at least a 30 minute [60 minutes in Scotland] performance.

Note: For further information, see Approved Document B of The Building Regulations for England and Wales, and The Building Standards (Scotland) Regulations, and Technical Booklet Part E for The Building Regulations (Northern Ireland, as appropriate).

4.1.6 Plant design layout shall take account of means of egress in an emergency.

4.1.7 A risk assessment of the design and work activities must be carried out to minimise the risk of danger to the installer, the client/operators, third parties and property. Where applicable, this should be incorporated into the full project planning exercise and, if applicable, be undertaken as part of CDM (see Sub-Section 3.2.10). The risk assessment shall be carried out in accordance with HSG65.

Any risk of danger (due to the position and environment in which the gas turbine, associated pipework and controls are installed) must be considered and steps taken as necessary to minimise the risk of the equipment being affected in the future. Pipework must not be installed in any area posing unacceptable risk, for example in an inadequately ventilated void.

Where identified by risk assessment, a suitable permit to work (including hot work) procedure should be prepared and implemented.

Safe working practices must be employed to carry out all the activities undertaken. For example:

- design for gas free working during maintenance and repair
- fire safety procedures and fire hazards identification during work
- ensuring a safe environment during work.

Note 1: The following guidance is available for reference to assist safe working: HSG85; INDG 455, INDG 229; INDG 297; INDG 258 and HSG33.

Note 2: For methane based gases, information on risk assessments is given in IGEM/UP/16.

Note 3: Risk Assessment and Method Statements (RAMS) may also be required for certain work activities.

4.1.8 The location and ventilation of the turbine installation and ancillary equipment shall take account of risk assessments to ensure safety and adequate access for maintenance.

Note: A specific risk assessment will be necessary for pipework attached to the outlet of air/gas mixing machines.

4.1.9 A quality management system should be applied for the design and installation activities for installation of MOP greater than 500 mbar.

Note 1: A quality management system need not be formally recognised but management systems such as BS EN ISO 9000 and ISO 55000 are widely used.

Note 2: The principles of IGEM/GL/5 may be applied.

4.2 DESIGN

4.2.1 General

4.2.1.1 The designer of the gas installation shall provide information concerning its design, construction, examination, operation and maintenance. For systems of MOP exceeding 500 mbar, this shall be in the form of a technical file. The information/content of the technical file shall be appropriate for the size and complexity of the installation, to enable the owner/user to operate and maintain it safely.

4.2.1.2 The design shall result in a safe installation that is fit for purpose, sufficient to deliver the required capacity with the relevant pressure at the point of use.

4.2.1.3 The designer shall ensure the gas metering and pressure regulation equipment upstream of the gas turbine will be adequate to ensure pressure and flow stability due to the effects of abnormal loads (see Section 5).

Note 1: If sudden changes in flow rate occur, a pressure variation may arise due to the inertia of Rotary Displacement (RD) meter impellors, or the inability of a regulator to respond sufficiently quickly. Regulator control may be sufficiently disturbed to cause operational problems. This is particularly important for installations operating at elevated pressures and feeding gas turbines used for power stations and combined heat and power (CHP) plant.

Note 2: Adverse effects may be avoided by the consumer installing slow acting controls on major appliances served by the meter, and/or installing buffer vessels. Where this is not practical, installing a fast response regulator or a meter with low inertia may also assist.

In some cases, a separate meter and regulator stream may be required to supply the gas turbine/s.

4.2.2 **Gas constituents**

The designer shall ensure the available supply of fuel is suitable for the safe operation of the gas turbine. Consideration will be given to the hydrocarbon content and different constituents of the gas and its dew point (for example; inerts, condensates and acidic/sulphur content) and the possible consequent effect on materials and operations.

Note 1: This is not normally necessary for 100% NG systems but will be relevant to blended NG systems and non-conventional gases such as bio-gases, landfill and also LPG.

Note 2: Condensate formation and collection may also have to be considered.

4.2.2.1 Reference should be made to the equipment manufacturer's required minimum and maximum design supply pressure and any pressure loss of any particular supply components.

4.2.3 **Hazardous areas classification**

The hazardous area classification for an area containing gas pipework will restrict the location of electrical equipment and ignition sources in that area. It may be possible to increase the ventilation of the area which will reduce the hazardous area classification.

4.2.3.1 DSEAR requires that a hazardous area classification must be established for all pipework on non-domestic premises. The severity and thus the effects of the classification can be mitigated by good design. Guidance can be found in IGEM/SR/25, IGEM/UP/16 or Energy Institute's document EI IP-MCSP-P15.

Note 1: Outlet pipework from air/gas mixing machines will need a separate risk assessment that addresses the contained gas mixtures.

Note 2: The standards above are suitable for NG and LPG, should blended or non-conventional gases be used the classification will need to be undertaken with the gas characteristics and supply pressures in mind.

4.3 Typical plant arrangements are shown in Figures 2 and 3.

4.4 There shall be adequate space surrounding all plant and control equipment to allow proper access for maintenance and repair.

4.5 In an enclosed location, it shall be ensured that sufficient air is available for combustion and for ventilation, both while the plant is running and during shut-down.

4.6 Adequate ventilation must be available at all times to comply with requirements of DSEAR.

4.7 A turbine fitted within an acoustic enclosure or similar structures. shall be designed to ensure suitable ventilation for cooling and the dilution of any minor gas leak in accordance with DSEAR.

4.8 The incorporation of an Automatic Isolation Valve (AIV) outside of the enclosure (see 8.1.4) and suitable control protocols may mitigate the need for dilution ventilation within the enclosure when the turbine is not operating, as required by DSEAR.

4.9 Any turbine shall be fixed securely to its mountings. If used, vibration isolation mounts shall not permit movement in excess of normal vibration.

4.10 Vibration sensors shall fitted to a turbine to shut it down in the event of excess levels of vibration which might lead to failure of any part of the system and gas pipework.

4.11 During the design of plant layout, measures to mitigate or contain the effects of a catastrophic turbine failure on nearby plant, gas pipework and controls shall be detailed. All necessary measures identified to mitigate or contain the effects of catastrophic failure shall be provided by the installer and verified by the commissioner.

4.12 If more than one turbine exhausts into a common chamber, special consideration will be given to the design and to operational requirements.

4.13 The consequences of a major gas leak from any plant or associated pipework shall be subject to risk assessment. Further information on risk assessments techniques can be found in IGEM/G/7.

Note 1: A major gas leak could lead to a catastrophic failure of the plant enclosure and to major physical damage to any building containing the plant and to nearby buildings. Certain locations and plant constructions, for example basement plant rooms, fully enclosed reinforced concrete plant rooms, mid position plant rooms in high rise buildings, etc., require additional safety precautions for the affected supplies.

Note 2: Precautions may include:

- *use of high integrity pipework, all welded and subject to non-destructive testing (NDT)*
- *installing a gas/fire/smoke detection system leading to safe shut down*
- *ensuring secure ventilation with run and standby systems*
- *providing adequate explosion relief*
- *arranging daily visits by a person competent to carry out an inspection.*

4.14 Before installation an appropriate risk assessment/hazard and operability study (HAZOP), to assess the need for any precautions, shall be carried out by a suitably competent person.

4.15 A safe exit route shall be provided for any plant room. The distance from any point in the plant room to the nearest point of access shall not exceed 12 m.

Note: The design of plant rooms needs to take into account adequate lighting and ease of escape in an emergency, such as siting of doors and their opening in the direction of the escape route. It is essential that any emergency door in the escape route can be opened without the use of keys (reference may also be made to BS 9999).

SECTION 5 : GAS SUPPLY, PRESSURE REGULATION AND METERING

5.1 GAS SUPPLY

5.1.1 Where the supplied gas is not odorised, for example landfill and biogas, a risk assessment shall be performed at the design stage to determine the nature, if any, of additional safety precautions, for example gas detection systems, personal gas monitors, increased levels of inspection, etc. required during operation (see section 7).

5.1.2 For NG, the gas supplier or GT should be contacted to ascertain whether or not the gas is odourised.

5.2 PRESSURE REGULATION

5.2.1 Gas fired turbines

5.2.1.1 Normally turbines require gas to be supplied at higher pressures. This may be provided from a "high" pressure GT network with regulation either at a primary meter or at the inlet to the turbine. Alternatively, a compressor may be used where the GT network is at "low" pressure.

Note: Details on pressure regulating installations (PRIs) are given in IGEM/TD/13.

In assessing the effects on the overall fuel system, the rates of change of flow during start-up, operation, controlled shut-down and following emergency stop will need to be considered.

Note 1: In turn these operations affect the size of gas supply pipes and the supply pressure, meter type, regulator system (if fitted), volume of outlet pipework, type and design of fuel gas compressor and control, gas receivers, supplementary firing and turbine flows (especially during on-line fuel change-over and rapidly imposed electrical load changes).

Note 2: Advice on crash stop conditions when a compressor is installed is provided in IGEM/UP/6.

Note 3: It is essential that the Meter asset Manager (MAM) and the Gas Transporter (GT) are advised of the anticipated transient flow variations in order that they can be checked for compatibility with the gas metering system and supply network. A typical gas flow data sheet is shown in Appendix 3.

It is necessary to consider the effect of rapid load changes on the upstream network. This may require a detailed analysis of the network dynamic behaviour on "low" pressure systems and the effect of such behaviour on any connected "low" pressure system. If a meter by-pass is provided, it will be necessary to consider the situation with the meter by-passed.

5.2.1.2 The PRI installation must be designed to maintain a suitable pressure at the gas turbine to ensure the safe operation under all foreseeable conditions.

Note 1: Information concerning the performance of the gas turbine will need to be supplied to the gas supplier, identifying an acceptable range of supply pressures and the meter PRI installation will need to be designed to maintain its outlet pressure within the range.

Note 2: GS(M)R state "The gas shall be at a suitable pressure to ensure the safe operation of any appliance which a consumer could reasonably be expected to operate".

5.2.1.3 Where adequate "high" pressure gas is available without further compression, pressure control at the meter may not be necessary. Unregulated supplies may not be permitted under the GS(I&U)R. The Gas Transporter should be consulted where an unregulated supply is required. The supplier of the turbine should be made aware of the inlet supply parameters. The gas supply system shall be under the control of a stable pressure/flow system.

Note: Normally, compliance with these Procedures will provide adequate protection against the failure of the fuel pressure control system of the turbine.

Unregulated supplies shall only be installed when the installation fulfils the following criteria:

- when the installation is within the scope of the GS(I&U)R, an exemption has been granted by HSE.

Note 1: This has, usually, only been given for a dedicated supply to a gas turbine or CHP installation requiring gas compression.

Note 2: The scope of the GS(I&U)R does not include certain types of industrial and commercial premises, e.g. factories and power generating stations.

5.2.1.4 The pipework downstream of the primary regulator shall be designed to withstand at least the STP of the pipework. In addition account shall be taken of the speed of movement of the valves on the rate of change of gas flow and any peak pressure resulting therefrom.

Note: Normally for gas turbine installations STP will be the greater of 1.1 MIP and 1.5 MOP.

5.2.2 Dual fuel turbines

For a dual-fuel turbine, on-line change-over can occur at any load condition and in some cases within one second. Gas supply systems shall be capable of meeting changes in demand (which can be in either direction).

5.3 METERING

5.3.1 Details of any special features of gas plant which may affect the nature of the load, for example fast-fluctuating loads, snap-acting control valves creating rapid on/off load conditions attributed to gas turbines, and gas compressors, shall be provided to the gas supplier .

Note 1: Such special features require specialist analysis to determine the significance of possible interactions with the meter installation. The gas supplier will require specific information relating to load information required at meter installation and data for assessment of large gas compressor loads.

Note 2: The Gas Act allows a GT to insist on the fitting of an anti-fluctuator, to avoid excessive pulsations being present in the Network and, hence, at the meter installation. The fitting and maintenance of such a device is the responsibility of the consumer.

5.3.2 The provision of and ownership of the primary gas meter is normally the responsibility of the MAM and undertaken by an OFGEM Authorised Meter Installer (OAMI).

Note: Further information on the requirements for metering and PRI's can be found in IGEM/GM/4, IGEM/GM/6 and IGEM/GM/8.

5.3.3 Secondary fuel metering

5.3.3.1 Consideration shall be given to installing a flow measuring device (check meter) in fuel supplies to gas turbines for energy monitoring. When installing a fuel flow measuring device to an existing gas line, the additional operating pressure drop through the device / meter, at full flow rate, shall be considered and a suitable size and type of device be installed.

5.3.3.2 Any meter used to measure the flow to a gas turbine or compressor shall either be of a type which is not affected by flow oscillations, or shall be protected from flow oscillations by means of a suitable flow smoothing device.

Note: Some turbine meters may be unsuitable for gas turbine installations unless appropriate precautions are taken.

SECTION 6 : GAS CONDITIONING

6.1 GAS CONDITIONING

6.1.1 GS(M)R must be complied within respect of the quality of Natural Gas normally distributed in GB.

6.1.2 Details of the composition of gas and any known variations should be obtained from the GT or fuel supplier.

6.1.3 Where specific gas quality parameters stipulated by the manufacturer cannot be guaranteed the requirement for any gas conditioning equipment shall be included in the design of the plant and pipework.

Note1: Additional gas pre-treatment equipment may be needed. This may include liquid collection receivers (knockout pots), odorisation or heaters to be installed on the gas inlet. For example, knockout pots may be required if the supply is close to a point on the Network where glycol fogging is carried out by the GT on a low pressure distribution system.

Note 2: Wet gas may not be acceptable unless any water and liquid hydrocarbons are removed. The effects of pressure drop in the gas train are important. Gas heating and downstream trace heating may be required to achieve an acceptable margin to the gas dew point. In particular it is important to eliminate liquid hydrocarbon droplets/slugs flowing into the turbine gas fuel supply, as this would have the potential to cause major damage to the turbine.

6.1.4 Consideration should be given to potential periodic fluctuations in supply composition from the Network and advice should be sought from the gas supplier or GT.

6.1.5 Gas passing to a turbine system shall have a moisture content that will not cause hydrate/water formation in any downstream equipment, under the expected operating conditions.

Note: In order to achieve the required moisture content, it may be necessary to install a gas drying system which in turn may reduce any odorant level.

6.2 FILTRATION

6.2.1 Any plant control equipment shall have adequate protection against particulate contamination etc. fitted in the fuel supply. The level of protection shall be as specified by the manufacturer of the components requiring protection.

Note 1: Typically filtration of 10 μm is applied. See also clause 6.2.8.

Note 2: Meter filtration, due to its size is not usually adequate to protect any turbine, controls or safety shut off systems.

6.2.2 An inlet filter should be fitted upstream of any check meter used for energy monitoring or control. Reference should be made to the meter manufacturer's instructions.

Note: It is preferable that such filters be installed close to, but still upstream of the check meter.

6.2.3 A filter shall be fitted downstream of any inlet gas receiver or snubber or any gas pipework fabricated from carbon steel. This filter shall be upstream of the Automatic Isolation Valve (see Figure 3 and clause 8.1.4).

Note: Close-coupled components may be protected by a single filter. The quality and cleanliness of pipework construction may be such that a single filter (10 μm) is adequate for gas systems.

During commissioning of a new system an additional course filter (e.g. open hat filter), should be installed to protect the gas turbine and system components, this filter will be removed upon the completion of commissioning and final tests completed.

6.2.4 Where a meter with moving parts is fitted in installation pipework, a downstream protecting filter/strainer shall be fitted.

6.2.5 Where a gas turbine is to run continuously for long periods, twin-stream filtering with appropriate valves should be fitted, to enable routine cleaning or changing of filter elements to be performed without interfering with supply availability.

6.2.6 Means shall be provided to isolate and vent safely any gas filter system to atmosphere before opening.

6.2.7 The design of any downstream control system shall ensure that the specified differential pressure drop across any filter cannot be exceeded when the valve system opens, especially from a low outlet pressure condition.

6.2.8 Where a filter or other section of pipework has to be opened to atmosphere and left open for any significant period, blanking spades or double block and vent or double faced and vented valves shall be fitted.

6.2.9 A liquid separator shall be fitted if any liquid (such as water, lubricating oil or hydrocarbons) could enter the fuel gas system.

6.2.10 To enable simple monitoring of filter condition, permanent pressure gauges should be considered to enable differential pressure on any gas filter to be established(reference should be made to BS EN 837-1).

SECTION 7 : INSTALLATION PIPEWORK

7.1. DESIGN

7.1.1 General

7.1.1.1 Pipework must be designed to meet applicable national regulations and this shall be achieved using appropriate standards, for example BS EN 13480, BS EN 15001, and IGEM/UP/2.

Note 1: The standard selected will be dependent upon the intended MOP of the pipework.

Note 2: For gas pipework with an MOP not exceeding 60 bar it is recommended that IGEM/UP/2 be used.

Note 3: For a gas specific pipework standard for pressures above 0.5 bar see BS EN 15001 Parts 1 and 2.

7.1.1.2 Pipework shall be installed at sufficient clearance from any other service to be considered safe in operation. Any requirements for other services and their relevant Codes of Practice shall be taken into account.

Buried pipework should be installed at clearances sufficient to allow subsequent maintenance of any of the buried plant and at common depths below-ground level to assist detection of the service. In cases where it is not possible to apply adequate separation distances between gas pipes and other buried services, means shall be provided to protect the gas pipe by using suitable insulation materials.

7.1.1.3 Where individual pipe sections are to be hydrostatically tested, such sections shall not be joined by a weld unless that weld is subsequently hydrostatically tested.

7.1.1.4 At the test conditions of pressure and temperature, the pipework design shall be such that the Yield Strength shall not be less than 90% of the material's Specified Minimum Yield Strength (SMYS).

7.1.1.5 As far as is practicable, the volume of pipework of OP in excess of 75 mbar, within a building, should be minimised.

7.1.2 Pipework of MOP exceeding 16 bar

7.1.2.1 *Welding*

Any welding of pipework shall be to an appropriate standard, for example BS EN 287, BS EN 288, BS 2633, BS 4677 Class 1, BS EN 1011-3, ASME IX, etc. There should be at least 10% Non-destructive examination (NDE). Where hydrostatic testing has not been carried, 100% NDE shall be applied to welds.

Note: NDE is covered in BS EN ISO 17636 and BS EN ISO 3452 Part 1.

7.1.2.2 *Support*

(a) All pipework including any automatic safety shut-off system (SSOS) and block and vent valve system, or relief valve shall be supported securely.

(b) All pipework and its supports shall be designed (and installed) to accommodate normal pipe movement, including movement due to thermal expansion and the increased forces (including weight of the test medium) encountered during test procedures.

Note: Modal and response spectrum analysis may be useful anti-vibration design procedure.

(c) Any support shall be designed so as to protect against excessive wear or corrosion leading to pipe ''thinning''.

(d) Pipe shall be designed and installed to rest firmly on its supports and shall not be pulled down to the supports to correct for errors in elevation.

7.1.2.3 *Location of pipework and components*

(a) Pipework and any controls shall be located so that there is minimum risk of accidental damage, for example as caused by cranes etc. If there is a risk of accidental damage, the pipework and controls shall be protected suitably, for example by a guard rail.

(b) Any emergency block valve assembly shall be located where it is unlikely to be damaged by failure of a turbine disc.

(c) If a flexible pipe is included between rigid pipework and the turbine, the pipe shall be downstream of at least one of the safety shut off valves (SSOVs) protecting the turbine.

7.1.2.4 *Materials*

(a) Materials shall have physical properties appropriate to the proposed duty, consideration being given to the effect of gas composition, variation in operating temperature and pressure, imposed forces and corrosion and other aspects of the service environment and location.

(b) The pipework and fittings specifications, wall thickness, temperature and grade of material shall be selected for the design MOP, MIP and STP of the installation.

(c) If practicable, pipework downstream of the final turbine filter should comprise stainless steel pipe and fittings.

Note: Carbon steel components can give rise to internal debris which could in turn, cause damage to controls unless appropriate means of prevention have been included during the construction/installation.

(d) If the connection from rigid pipework to the turbine incorporates a flexible pipe, the flexible pipe shall be of stainless steel braided to BS EN ISO 10380 and shall be capable of withstanding for long periods the high frequency vibration that may occur, without incurring fatigue or be constructed of non-metallic materials provided they are fit-for-purpose, for example suitable for continued application in high temperature, high vibration frequency environments and incorporate fire-resistant surfaces.

All components including flexible hoses shall be able to operate at their design pressure under all operating temperatures. The use of a hexagon on the spigot end of any flexible should be used to control torsion during tightening of end fittings that might lead to subsequent flexible hose failure.

Flexible hoses shall be examined frequently as part of a scheduled maintenance procedure for the plant (see section 17).

Note: Flexible hoses used in this application will be to a high specification to minimise vibration related failure. Regular inspection will form part of the hazardous area classification and associated risk assessment.

(e) In order to avoid corrosion any leak detection fluid (LDF) used for checking stainless steel flexible pipe should be halogen-free.

(f) Suitable Stainless steel pipe will include, but not be limited to:
- BS EN 10216-5 for seamless pipe
- BS EN 10217-7 for pipe with a welded seam
- ASME 36.19

and have a wall thickness suitable for the duty and jointing method further details will be found in IGEM/UP/2.

(g) Stainless steel tubes will include, but not be limited to:
- ASTM A269 and A312 (Grade 304 or 304L, 316 or 316L)

and have a wall thickness suitable for the duty and jointing method.

(h) Carbon steel pipe with wall thickness selected to suit MOP, temperature and stress levels will include, but not limited to:
- BS EN 10216
- BS EN 10217-1
- API 5L grade B and (X42 to X80)
- BS EN 10220.

(i) Stainless steel fittings shall be to:
- BS 3799 or
- BS EN 1515 or
- BS EN 10253-2
- BS 1640 (WP 304 or WP 316) or
- ASTM A182 (F304 or F316) or
- BS 4882 (B8T or 8) or
- ASTM A193 (B8T or 8)

and be appropriate for the pipe material and jointing method.

(j) Flange gaskets shall be;
- spiral wound 316L windings, synthetic filler and stainless steel outer ring and appropriate for the pipe material and jointing method and in accordance with a suitable standard (such as BS 3381 or ASME B16.20) or
- ring type joints (RTJ) In accordance with a suitable standard such as ASME B16.20.

(k) Carbon steel fittings shall be to:
- BS 1640 or
- BS EN 10253 or
- BS EN 1092 – 1 & 2 or
- BS EN 1514

and be appropriate for the pipe material and jointing method.

7.1.2.5 *Selection of pipework components*

(a) The number of flanges and compression joints shall be minimised.

(b) All components shall be suitable for the test pressure.

Note: This includes flexible pipes.

(c) Any gas storage volume on the inlet of a turbine shall be either:

- a section of pipework or
- a gas receiver constructed to an appropriate standard such as BS 5500, BS EN 13445 and ASME VIII.

(d) The wall thickness of steel pipe shall be chosen according to the relevant design code.

(e) Any compression fitting for use on systems above 0.5 bar shall be of the twin ferrule type, carbon or stainless steel, and shall not exceed 50 mm diameter. It shall provide positive retention of the pipe in the fitting while maintaining integrity of the pipework. The appropriate manufacturer's assembly/torque procedures shall be complied with and recorded.

(f) Where such fittings are applied, the correct grade of gauged fully annealed stainless steel tubing shall be selected to ASTM A269 or A313.

(f) A twin ferrule compression fitting shall not be used unless it is with gauged outside diameter (OD) tubing.

(g) Tubing for compression fittings shall be free from scratches and suitable for bending as recommended by the manufacturer of the fitting.

Note: It is recommended that persons assembling such joints are trained by the manufacturer.

(h) Intermixing of different brands shall not be permitted within a single assembly or package unless suitable guarantees and independent testing can assure safety.

7.1.2.6 *Vibration isolation mounts*

When vibration isolation mounts are used, the fuel pipework should be designed to be connected at or near a node point and should be designed to provide sufficient flexibility using rigid pipe.

Note: Where this cannot be achieved, a flexible pipe complying with BS EN ISO 10380 may be needed (see clause 7.1.2.4 (c)).

7.1.3 **Area classification**

7.1.3.1 Area classification shall be undertaken in respect of all gas pipework and pressure vessels, subject to the moderation given in the Notes below. Risk assessment shall be carried out in all cases (see clause 3.2.12.2 and reference should be made to IGEM/G/7. All potential sources of leakage such as fittings, joints, valves, flexible pipes, vents etc. shall be considered. Where area classification is necessary reference should be made to IGEM/SR/25 for NG installations.

Note 1: Local ventilation around the joints and components within a fuel pipework system of MOP not exceeding 5 bar, installed and maintained to recognised standards, such as IGEM/UP/2 and these requirements, may reduce the requirement for hazardous areas. It may be possible to take this into account as part of a risk assessment associated with area classification. Typically, this would be the case for gas pipework to supplementary and auxiliary burners in well ventilated plant rooms/spaces.

Well ventilated would mean that any joints or components are located within open areas and not dead spaces. Typically well ventilated would be a minimum of 4 air changes per hour.

Note 2: "Dilution ventilation" (see Sub-Section 11.1.2) is intended to reduce the size of any accumulation of flammable fuel/air mixture from a detectable leak to a level that does not pose a significant hazard. It may be possible to take this into account as part of a risk assessment associated with area classification.

Note 3: Welded systems do not generate zoned areas unless encased in insulation leading from a zoned area. Non-welded joints located within insulation will generate hazardous areas throughout the length of the insulation until a break occurs.

Note 4: For operating reasons, it is preferable to avoid the routing of gas pipework at an OP exceeding 75 mbar where its hazardous zone contains other fuel systems.

Note: Regulations made to implement the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 (SI 1996/192 apply to gas fired systems where fuel leakage could lead to an explosion.

7.2 FACILITIES FOR COMMISSIONING AND DECOMMISSIONING

7.2.1 Gas pipework, including any manual gas valve, shall be designed to enable the whole system to be readily commissioned and decommissioned and to permit slow pressurisation when purging.

7.2.2 The sizing of the relevant parts of any gas system shall permit purge gas rates as specified in IGE/UP/1 and as necessary for the purging of any pressure vessel.

At the design stage, methodologies shall be prepared to purge both from gas to air and from air to gas and to both pressurise and depressurise the system.

Note: Preparation of such methodologies will indicate the nature of components needed and where to locate manual isolation, sampling and purge valves.

7.2.3 Pipework shall be kept free of debris during any pipework installation or modification.

7.3 FACILITIES FOR TESTING AND PURGING

7.3.1 For a gas system, a valved vent for commissioning shall be provided immediately upstream of each automatic safety shut-off system, to enable purging and commissioning of pipework up to that point. Such a vent should be plugged, sealed or locked-off after commissioning.

Note: It may be that an existing vent or pressure tapping provided for another purpose can be used for commissioning.

7.3.2 Suitable valves, pressure test points and purge points shall be fitted in gas pipework to enable tightness testing of all sections at a point as close as is practicable up to the turbine/burner head, pressure testing of SSOVs and purging both from air to gas and gas to air.

Purge points for gas systems shall be sized to achieve the required pipe purge velocity in accordance with IGEM/UP/1.

Any vent pipe on the gas system shall be independent of any gas relief valve vent system.

7.3.3 Any purge or test point of OP exceeding 5 bar shall be either double valved and sealed to prevent leakage, unless it is fitted to a fixed vent.

For all pressures, where the removal of a seal, for example a plug, may lead to a hazard, two valves shall be used and a safe method of depressurising the trapped volume shall be provided.

7.3.4 Any pressure vessel shall be fitted with a valve or connections near to the lower part and top, to permit purging both from gas to air and from air to gas and in order to take advantage of the difference in the relative density of the gases.

7.4 TESTING

7.4.1 Gas pipework of MOP not exceeding 16 bar

Pipework up to the manual plant isolation valve, shall be tested in accordance with applicable national Regulations using appropriate standards, such as IGE/UP/1.

7.4.2 Gas pipework of MOP exceeding 16 bar

7.4.2.1 *General*

(a) All components, for example valves and filters, shall be strength tested individually and certificated for use, at not less than the design pressure conditions.

Note 1: Where the component manufacturer provides certification at or above the design pressure, further strength testing of the component is not required.

Note 2: A pneumatic tightness test may be applied at 0.35 bar before proceeding on to higher pressure tests.

(b) Any individual section of new or replacement fuel pipe shall be hydrostatically strength tested before assembly. Where this is not possible, pipework shall be hydrostatically strength tested in-situ. Any component or sub-assembly that could be internally damaged by STP, or exposure to water (for hydrostatic testing), shall be removed prior to carrying out the strength test. Such a component or sub-assembly shall be, or be proved to have been, tested separately to an appropriate standard and certification shall be provided.

On completion of a hydrostatic test, the pipework shall be drained and dried adequately, for example with foam pigs and vacuum drying. Individual pipework sections shall be sealed to ensure dryness until installation.

(c) Following a successful strength test, a tightness test shall be performed on the complete assembly at the operating pressure for a duration determined within IGE/UP/1.

Note: Further information on testing is given in BS EN 13480 and HSE Guidance Note GS4.

7.4.2.3 The final test pressure conditions at the test temperature conditions shall not exceed 90% of the design Specified Minimum Yield Stress (SMYS).

7.4.2.4 *Hydrostatic strength testing*

(a) Remove components that may be damaged by the STP or the hydraulic fluid, and replace with suitable spool piece.

(b) Pipework including components should be pneumatically tested in accordance with IGE/UP/1 at a pressure not exceeding 350 mbarg, to ensure tightness prior to applying a hydrostatic strength test.

(c) The pipework system shall then be hydrostatically strength tested using the principles and guidance provided in IGE/UP/1.

7.4.2.5 *Tightness testing*

Following strength testing, a tightness test shall be carried out using the principles of IGE/UP/1 at OP.

7.4.3 **Gas tightness testing following maintenance of a turbine**

7.4.3.1 All replacement components, for example valves, filters, etc. shall be individually pressure tested and certificated for use at not less than the design pressure conditions. Individual sections of replacement pipes shall be strength tested before assembly (see clause 7.4.2.1(b)).

7.4.3.2 After assembly, all joints shall be checked, as far as is practicable, to confirm correct assembly. Affected parts of the system shall be tightness tested to at least OP, using a standard operating procedure provided by the system designer/manufacturer/competent person. Attention shall be given in these procedures to the validation of the section of pipework up to the gas turbine/ burner and the application of pressure in distinct stages.

Note : In general nitrogen or high-pressure air is used for testing but for smaller volumes, it may be acceptable to use fuel gas as the pressure medium, subject to a suitable risk assessment.

7.4.4 **Completion**

Upon completion of all strength and tightness testing the gas pipework system shall be purged in accordance with the principles of IGE/UP/1.

Note: Pressure vessels may require special purging procedures. Guidance may be obtained from IGE/SR/22 and IGE/SR/23 provide guidance.

7.5 **REPORTING**

A record of all testing carried out should be prepared for every installation and retained permanently including but not limited to:

- the authorised person responsible for the test
- date of the test
- manufacturer of the installation
- identification of the section to which the test relates
- 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 authorised person on site nominated to maintain details of test reports and certificates etc.

7.6 **INSPECTION AND MAINTENANCE PLANNING**

7.6.1 Upon completion of any gas pipework installation project, a scheme shall be drawn up for the inspection, maintenance and testing of all pipework to ensure continued integrity.

7.6.2 A risk assessment of each new gas pipework system should be carried out to ascertain a periodic inspection and testing plan.

Note 1: GS(I&U)R Reg.35, states that "it shall be the duty of every employer or self-employed person to ensure that any gas appliance, installation pipework or flue installed at any place of work under his control is maintained in a safe condition so as to prevent injury to any person".

Note 2: See PSSR Regulation 8 for details of written schemes of examination for systems with MOP greater than 500 mbar and pressure volume product greater than 250 bar litres.

Note 3: PUWER requires inspection of equipment under Regulation 6.

7.6.3 A risk assessment for the gas pipework system must be undertaken for compliance with DSEAR. Maintenance and leak testing that is required by this risk assessment must be performed.

7.6.4 A maintenance plan shall be drawn up for all ancillary equipment which would include valves, regulators and compressors. Reference should be made to the manufacturer's literature for the specific requirements and periods between maintenance. The plan should include the access arrangements for inspection, for example location of duct inspection hatches.

7.6.5 AECVs and other valves, as appropriate, should be checked periodically for effective operation (for valves see section 8).

7.6.6 Test instrumentation shall be selected for use with the appropriate type of gas. This is especially important for combustible gas analysers and hydrogen rich gases.

7.6.7 The maintenance of gas pipework may be carried out in varying degrees, the following being the industry accepted methods. Consideration shall be given to implementing some of the following procedures which can be referenced from IGEM/UP/2:

- visual inspection (typically annually) - a checklist is used to ascertain if the gas pipework is visually being maintained to an acceptable level. A competent person would report on particular parts and constituents of the gas pipework installation, making recommendations as required
- manual valves used during maintenance operations to be accessible for operation and verification of gas tightness before work continues, e.g. by the use of let-by test. Where a risk assessment requires the use of double block and vent valving this will require a check for valve seat tightness to be performed prior to commencement of work
- gas detector test in hazardous areas – using a gas detection instrument that can detect to less than 10% of the lower flammability limit (LFL) of the gas in the pipework, such areas are where small amounts of gas can accumulate and linger
- gas detector tests at building entries - using a gas detection instrument, as above, to detect gas tracking in from outside, by taking readings at and around the pipework entry
- leak detection fluid or gas detector checks - these may be used at each joint to check for leakage
- tightness test of pipework - a tightness test may be carried out as specified in IGE/UP/1 or IGE/UP/1A.

7.6.8 **Un-odourised fuel supply pipework**

Where the gas supply is un-odourised, such as bio-gases and landfill gases an enhanced maintenance regime for the pipeline shall be put in place. The extent of the regime shall be determined by a risk assessment that reflects the fuel gas characteristics, supply pressure and location of pipelines. The maintenance regime shall include adequate monitoring, maintenance and gas detection.

7.6.8.1 *Monitoring*

The route of a pipeline should be surveyed at pre-defined intervals to confirm the integrity of the system and to check easement accessibility, where applicable.

A gas leakage survey should be undertaken at pre-defined intervals, the frequency depending on OP, hazard location and assessed risk from system failure.

7.6.8.2 *Maintenance*

Joint and other repair methods or systems should be checked for compatibility with biogas.

7.6.8.3 *Gas detection*

As the gas is not odorised consideration shall be given to:

- alarms for personal protection
- fixed alarms for plant/personal protection
- alarms for emergency personnel attending escapes

Equipment shall be appropriate and calibrated for the intended use.

For methane based biogases, instruments calibrated for methane may be used to test for, monitor or detect biogas. Other instruments calibrated for LPG or pentane may respond in the presence of biogas, but readings may be inaccurate and, therefore, should not be relied on to derive meaningful information.

Note: FID survey instruments that measure hydrocarbons by volume are compatible for use with biogas. However, as biogas may not readily rise to the surface, surveys using FID equipment have to be interpreted with caution.

SECTION 8 : VALVES

Figure 3 shows a typical valve layout for a gas system supplying a gas turbine and supplementary fired boiler. Selection of valves for gas turbine installations will need to be in accordance with the requirements set out in IGEM/UP/2.

8.1 GENERAL

8.1.1 An additional emergency control valve (AECV) shall be fitted and suitably labelled. It shall be at or near the point of entry into individual buildings and consideration shall be given to positioning outside the plant room or building, in all cases it shall be located outside the acoustic enclosure (see Figure 3). The valve shall be readily accessible and manually operable.

8.1.2 A manual isolation valve of a quick acting type shall be fitted immediately upstream of all gas controls to each appliance. It may be located inside or outside any acoustic enclosure if required (see Figure 3, ACV). This valve may be the AECV if externally located.

Note: Where the valve stipulated in clause 8.1.1 is located in reasonably close proximity to the appliance, the addition of this further manual valve may not be required.

On a gas system of OP exceeding 5 bar to ensure working safety, the pressure between two upstream valves or two valve seats shall be reduced to near atmospheric.

Note: This can be achieved using two valves and a vent or a double-faced valve with a body vent.

8.1.3 A manual valve shall be fitted in the supply to the appliance, situated outside the enclosure. Where a gas compressor is used, the valve should be as near as practicable to the outlet of the gas compressor/receiver.

8.1.4 A fast acting Automatic Isolation Valve (AIV) should be fitted in the supply to the appliance, outside any enclosure. This valve shall close as detailed in clause 8.3.2. Where a gas compressor is used, the valve should be near as practicable to the outlet of the gas receiver (see Figure 3).

8.1.5 For MOP > 1 bar, a fast opening (preferably normally-closed) automatic vent valve should be fitted, to depressurise the downstream pipe system to a safe level (see Appendix 5. An automatic vent valve may not be required where pressure lies between 1 and 5 bar and volume is less than $0.1m^3$.

- attention shall be given to the volume of gas released from any dump valve and its vent pipework and the associated noise levels for higher pressure systems
- any purge or test point for MOP > 1 bar shall be either double-valved or sealed to prevent leakage, unless it is fitted to a fixed vent
- where the removal of a seal, for example a plug, may lead to a hazard, either two valves shall be used or a safe method of depressurising the trapped volume shall be provided
- any pressure vessel shall be fitted with a valve or connections near to the lower part and top, to permit purging both from fuel to air and from air to fuel and in order to take advantage of the difference in the relative density of the gases
- hazardous area classification shall be carried out on the location of all valves and vents (see IGEM/SR/25 and BS EN 60079-10).

Note: Where more than one turbine enclosure is used, it is permissible to fit such a valve before the entry to each enclosure.

The automatic vent valve may be installed downstream of the AIV to open under emergency conditions for gas or fire detection purposes, to reduce the contained pressure within the system to an acceptable level if the risk assessment determines that leakage of the contained volume is credible and may lead to a hazard.

The AIV and emergency vent valve need not operate each time the turbine shuts down under controlled conditions.

8.1.6 A manual by-pass shall not be fitted around any item of safety equipment. In the extremely rare case where it is not practicable to shut down plant during maintenance of safety critical items, duplicate safety equipment should be provided.

8.1.7 The rate of operation (opening/closing) of any fuel isolation valve shall not cause failure of other components in the fuel pipework system for example of filters, meters, regulators, flexibles etc.

Note 1: In some cases auto-pressurising loops may be necessary.

Note 2: In particular this is relevant to the operation of AIV's and vent valves on a gas system (8.1.4 on Figure 3).

8.1.8 Appropriate precautions shall be taken to discourage unauthorised tampering with any valve or its controls. Such precautions shall not jeopardize access to, or operation of, any manual emergency control valve.

8.1.9 Valve selection and duty shall take account of the maximum gas supply pressure and operating temperature.

8.2 SAFETY SHUT-OFF VALVES (SSOVs) AND GAS VENT VALVES

8.2.1 General

8.2.1.1 Any Safety Shut Off System (SSOS) for a gas appliance should comply with requirements as specified in BS EN 676 or BS EN 746 as appropriate.

8.2.12 Where multiple burners or turbine combustors can operate independently, they shall be treated as individual burners with respect to provision of SSOVs and gas valve/system proving.

Each turbine shall be protected by two independent SSOVs (and valve proving where required) at least one of which shall be located as close as practicable to the turbine combustor assembly.

8.2.1.3 For a turbine of OP exceeding 5 bar and where the two SSOVs are not located adjacent to each other, the contained volume between the SSOVs shall be capable of being vented to a low pressure immediately (within 5 seconds) upon the closure of the upstream SSOV, by the provision of a vent valve and vent. In addition the volume of gas released into the turbine in the event the downstream SSOV fails to close, shall not lead to a hazard.

Note: Following venting to low pressure of the contained gas, it is permissible to close the vent valve in order to perform a gas tightness test on the SSOVs.

8.2.1.4 Where a gas combustion system has parts of the burner operating independently each part shall be protected by two SSOVs, one of which may be common.

8.2.1.5 Any SSOS shall be mounted securely. It shall be sited as near as practicable to the turbine or burner. The SSOV's shall be located upstream of any flexible connection.

8.2.1.6 Where the fuel metering valve is fitted between the SSOVs, it shall not affect the operation of any gas valve proving system.

Note: Normally the gas fuel metering control valve will be sited downstream of the SSOS, but it may be sited at any point in the gas supply system agreeable to both the manufacturer and the customer, including positions between the two SSOVs.

8.2.1.7 Any SSOV assembly shall not have exposed spindles, etc., which could allow manual operation of the valves independently of the normal operating sequence.

8.2.1.8 On a gas system where a vent valve is fitted as part of the SSOS, using over-travel protection, the main SSOVs shall not be energised to open until the vent valve position switch indicates that the valve is closed.

8.2.1.9 Leak-tightness of all SSOVs and gas vent valves shall be checked at least annually as part of the normal maintenance programme, or as specified by the manufacturer.

Note: Following venting to low pressure of the contained gas, it is permissible to close the vent valve in order to perform a gas tightness test on the SSOVs.

8.2.1.10 Means shall be provided to permit manual venting and purging of all sections of pipework.

8.2.1.11 Pressure tappings shall be provided with additional valves where necessary to enable the gas-tightness and let-by to be checked on all individual valves, both manual and automatic and pipework.

8.2.1.12 Spool valves shall not be used for pneumatic actuator control duty.

Note: A poppet-type three-way valve is recommended.

8.2.2 Gas valve proving systems

8.2.2.1 Where the gas heat input exceeds 1.2 MW, a gas valve proving system shall be fitted between the two SSOVs. If the SSOVs incorporate over-travel switches to provide positive indication of the valve positions, this shall only be used as a secondary form of proving.

Where a sequential valve proving system is applied, the SSOVs shall be proved gas tight prior to the commencement, or before the completion of the turbine or boiler/downstream fired plant pre-purge. It is also recommended that a valve tightness check be completed upon shut down of a turbine or burner, failure of which would cause an alarm and prevent restart without manual intervention.

Gas valve proving shall also be fitted to the start gas valves where the gas heat input through the start gas valves exceeds 1.2 MW.

8.2.2.2 Gas sequential valve proving systems shall not cycle the main SSOVs during any part of the check. The sensitivity of the proving system shall be such as to detect a gas leakage of 0.05% of the design maximum flow rate through the valves.

Note: The value of 0.05% is based on the value of 0.1% required by European standard BS EN 1643 on valve proving for gas burners that normally use gas at low pressures. It has been increased in sensitivity to allow for the higher pressures in use with gas turbines. Thus this value may give higher than normal flow rates at the high pressures used in gas turbines and associated plant. It is recommended that valve system designers perform a risk assessment to verify the sensitivity does not give excessive flows of gas into the combustion system.

8.2.2.3 Where limit switches are applied to the SSOVs and the vent valve, the vent valve shall open immediately upon proof of closure of the upstream valve and shall not close unless both SSOVs are proven closed (see clause 8.2.1.8).

Note: The vent valve may be permitted to re-close only if there is a system to ensure there is a low pressure/near atmospheric between the SSOVs.

8.2.2.4 SSOVs with over-travel position proving only shall not be regarded as suitable for application on Gas Turbines with a heat input in excess of 1.2MW.

8.2.3 Specification for SSOVs

8.2.3.1 Two valves complying with an appropriate standard such as BS EN 161 shall be used wherever they are available.

Note: As such valves are not available in all sizes and pressure ratings or for all means of actuation, an acceptable alternative may be used.

8.2.3.2 Each SSOV shall have a separate fail-safe means for closure so as to close when de-energised or upon mechanical failure or upon failure of the actuating fluid. Pneumatically operated SSOVs shall each have their own separate fail-safe actuators.

8.2.3.3 Each SSOV shall, in the de-energised state, be designed to maintain tight shut-off at all forward and reverse flow pressure differentials up to design pressure. The design pressure shall be not less than MIP to which the valve could be subjected in the event of a fault occurring, for example failure of the upstream pressure regulators.

8.2.3.4 Each SSOV shall when energised open against all forward flow pressure differentials up to its rated design pressure.

8.2.3.5 Each SSOV shall close as soon as possible after being de-energised. The maximum closing time for each valve shall be one second. In all cases due attention shall be paid to the need to shut off the supply to prevent dangerous over speeding if the main throttle control valve fails to operate properly.

8.2.4 Specification for gas vent valves

For burners reference should also be made to BS EN 676 or BS EN 746 Part 2.

8.2.4.1 For a sequential proving system or where the SSOVs are not adjacent to one another, a vent valve shall be fitted between the two SSOVs on plant of gas heat input exceeding 1.2 MW and shall be of the "fail-safe" type so as to open when de-energised or upon mechanical failure or upon failure of the actuating fluid.

8.2.4.2 Any vent valve shall, when energised, maintain tight shut-off at all forward pressures up to design pressure. The rated design pressure shall be not less than MIP to which the valve could be subjected in the event of faults occurring, for example on failure of upstream pressure regulators.

8.2.4.3 Any vent valve shall, when energised, maintain tight shut-off against all reverse flow pressure differentials which may occur, for example due to manifolding of the vent pipes.

8.2.4.4 Any vent valve shall, when de-energised, open against all forward flow pressure differentials up to the design gas pressure.

8.2.4.5 Any vent valve shall have an opening time of typically one second for valves up to 100 mm diameter and in all cases not more than three seconds.

8.3 AUTOMATIC ISOLATION AND EMERGENCY VENT VALVES

8.3.1 Specification for automatic isolation valves

Any automatic isolation valve shall close as soon as possible after being de-energised,–typically within 1 second for valves up to and including 100 mm nominal bore and within 3 seconds for larger sizes.

8.3.2 Specification for emergency vent valves with automatic isolation valves

8.3.2.1 Any emergency vent valve shall open as soon as possible after being de-energised, typically within 1 second for valves up to and including 100 mm nominal bore and within 3 seconds for larger sizes.

8.3.2.2 Where an emergency vent valve is fitted it shall not be de-energised to open until the emergency block valve is proved closed.

8.3.2.3 Where an automatic isolation valve is fitted it shall not be energised to open until the emergency vent valve is proved closed.

Note: If the volume between the emergency block valve and a downstream SSOV is large and air ingress is to be prevented, it may be acceptable to close the emergency vent valve to maintain a pressure just above atmospheric in association with a suitable control system.

SECTION 9 : VENTING

9.1 DESIGN OF GAS VENTS

9.1.1 Additional information regarding the installation and application of vents is given within IGEM/UP/2.
Vent pipework shall be designed for the same pressure as the associated pipework section, be sized to pass the design flow.

9.1.2 Permanent vent pipework shall be of metallic construction. Materials, fittings and jointing methods shall comply with Sections 5 and 6 of IGEM/UP/2 respectively. The general principles outlined in Section 7 of IGEM/UP/2 should be applied.

9.1.3 Permanent vent pipes shall be strength and tightness tested to same standards as the main pipework system.

9.1.4 Any permanently installed vent pipe shall be constructed and installed as straight as practicable with the minimum number of bends.

9.1.5 Vents should be designed such that long lengths of pipe or numerous bends do not create a flow restriction through excessive pressure drop.

9.1.6 A vent pipe shall not be fitted in any position prejudicial to its safety, nor should it be laid through any electrical intake chamber, transformer or lift shaft.

9.1.7 In order to avoid the possibility of ignition of gas from static discharge, care should be taken to ensure that vents pipes are electrically continuous with the main pipework.

9.1.8 Vents shall be terminated in a safe place in open air and, when close to buildings/structures, they shall be terminated above roof level and shall not lead to any hazardous area impinging on other buildings/structures. The hazardous area zone radius for each vent shall be determined from IGEM/SR/25.

Note: Consideration needs to be given to the topography of the surrounding area, for example the effects of downdraught from large buildings and, for heavier than air gases, the prevention of accumulation of vented gas in depressions and low spots.

9.1.9 The vent pipe terminals shall be designed to prevent the ingress of water, snow and debris.

9.1.10 The vent termination from a natural gas control system shall not incorporate a flame arrestor.

Note: for other gases, such as LPG, biogas and hydrogen the requirement for a flame arrestor, which may be in the form of an inline device needs to be considered.

9.1.11 The design of vent pipework should anticipate any possible problems when venting from high pressures due to noise and thrust forces.

Note 1: The vent pipework needs to be sized based on the maximum anticipated flow rate.

Note 2: The high velocities produced can cause erosion, excessive noise and a reduction in temperature at the point of expansion (see also IGE/SR/23). Care is needed to ensure that the vent pipework and its supports can withstand any thrust loads imposed during venting.

Note 3: Due to environmental considerations, venting should be minimised.

9.1.12 Vent pipework from the fuel gas systems of a turbine shall not be manifolded together with vent pipework from fuel gas system operating at lower pressure tiers, for example supplementary gas burners etc.

Note: Normally turbine fuel systems generate much higher pressures than other plant.

9.1.13 Manual and pressure relief vents shall not be manifolded unless it can be shown that the operation of any vent will not affect another vent or lead to gas flowing to safety systems.

Note: Vents may be manifolded where it can be shown that excess pressures will not occur and that maintenance can be performed safely.

Note 2: Vents are not normally manifolded with other systems or other relief vents unless particular attention is given to increase the size of the vent pipe, such that the system operates safely under all conditions.

9.1.14 Any vent termination shall be classified as a hazardous area at the point of discharge. IGEM/SR/25 provides appropriate guidance.

9.2 LIGHTNING PROTECTION OF GAS VENTS

Where a vent terminal is to be located in an exposed, high, location, for example on the roof of a building, it shall be protected by suitably-positioned lightning conductors according to BS EN 62305.

SECTION 10 : PURGING OF A TURBINE AND ITS ASSOCIATED EQUIPMENT

10.1 Where the exhaust system includes large ducts, heat recovery equipment or other plant which could be damaged by internal explosion, a pre-purge with air or low temperature non-combustible gas shall be performed.

Normally 3 complete volume changes of the turbine, duct and waste heat system measured up to the base of any main chimney or a point where, under maximum load conditions the combustion system operates below 450°C for turbines fired solely by gas should be adequate. The pre-purge airflow rate shall be the highest practicable.

10.2 After the pre-purge of the turbine through the boiler by-pass or any downstream equipment, it is acceptable to purge the downstream equipment with turbine exhaust gases provided that they are proved to be at a temperature of less than 450°C. Where a plant by-pass is fitted, the sequential operation of dampers shall be proved to ensure that the purge has been performed correctly.

Note: In the special case where a turbine is operational and passing exhaust gases directly to a plant/boiler by-pass duct, it is acceptable to allow the exhaust gases to enter the boiler without further purging, provided that any supplementary burner SSOVs has been proved in the closed position.

It should be ensured, for example by the use of a sealing damper and an upstream vent to atmosphere, that air from heat recovery boiler fans does not flow back into the turbine. If long ducts exist between the turbine and the boiler these shall also be purged adequately.

10.3 Where a gas turbine shuts down under normal controlled conditions and a valve proving check takes place on shut down it would be acceptable, subject to a risk assessment to permit a re-start of the gas turbine after a limited period with a reduced purge of not less than one volume change. The gas fired supplementary or auxiliary burners shall also incorporate valve proving on shut down.

Note: A full pre-purge is required at all "cold starts", after all emergency shut down/lockout conditions where unburnt gases may enter the combustion system, for example flame out, valve proving failure, etc. and after any maintenance work has taken place that may affect safety.

10. 4 Pre-purging should be achieved by cranking of the turbine compressor itself or by use of separate suitably interlocked fans. Where separate forced-draught gas burners are fitted to heat recovery boilers etc., the fans may be used for pre-purging, the procedure to be adopted being identical to that which would apply for the gas fired boilers in the absence of the turbine see IGEM/UP/12 .

10.5 The required air purge volume shall be proved by the use of suitable pressure differential/flow rate sensors or current monitoring system suitably interlocked to timers in the start-up programme. Where the turbine air compressor itself is used to provide the purge flow, proof of adequate turbine compressor rotation speed is acceptable as proof of flow rate, provided that all the provisions of Section 14 are achieved.

A safe start check shall be performed upon flow sensors or current monitoring before each start-up attempt.

10.6 The pre-purge procedure shall be incorporated into the turbine start-up programme.

10.7 A separate pre-purge shall immediately precede each ignition attempt.

10.8 Throughout the initial pre-purge period, all SSOSs shall remain de-energised and where appropriate, proving systems shall be interrogated continuously. Failure under interrogation should lead to system lockout.

Note: Burners firing independently of the turbine need not be shut down if the turbine is purging to a by-pass. Attention is needed to ensure safe combustion under all operating conditions.

SECTION 11 : AIR FOR VENTILATION AND COMBUSTION

11.1 VENTILATION OF TURBINE ENCLOSURES

11.1.1 General

11.1.1.1 An adequate supply of air shall be provided for:

- dilution ventilation, supplied when the turbine is running and in some cases continuous when on stand-by (see 11.1.2).
- cooling, may continue following shut down for a predetermined period
- combustion

11.1.1.2 Where ventilation fan motors could lead to an ignition hazard, the motors shall be classified to the appropriate Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 (SI 1996/192 ATEX) rating.

11.1.1.3 The ventilation flow shall be verified at pre purge, should the design flow rate not be achieved within the start-up period the gas supply will not initiate and the turbine shall lock-out on ventilation failure.

11.1.1.4 Failure of the ventilation system during running shall initiate an automatic controlled shutdown unless the ventilation is automatically restored from an alternate or emergency power supply. This should also supply the air movement detection instruments and the associated turbine trip systems. If the ventilation is not restored the turbine shall remain locked out.

The ventilation air flow shall be monitored during turbine operation, for example by pressure differential or flow rate devices.

11.1.2 Dilution Ventilation

11.1.2.1 The normal basis of protection against the hazard of an explosion resulting from a gas fuel leak into an enclosure is dilution ventilation. Other options such as explosion relief or suppression may be adopted and specialist advice will need to be sought on the design of such equipment.

Note 1 Most commonly, the current basis of safety in the event of a gas leak in a gas turbine enclosure is dilution ventilation. The current safety criterion given in HSE's Guidance note, PM84(1), is believed to be both conservative and attainable.

11.1.2.2. A hazardous area classification risk assessment must be carried out in accordance with DSEAR. The responsibility for the classification of the gas turbine package lies with the manufacturer and the wider gas installation lies with the duty holder.

Note 1: For further guidance on DSEAR risk assessments see IGEM/SR/25 or BS EN 67009:10

Note 2: Ventilation for GTs was originally provided for cooling but as the explosion risk became apparent ventilation was proposed as a means of diluting any escaping gas. However designs needed to be verified and computational fluid dynamics was used by the industry to model gas dispersion.

Note 3: The use of Computational Fluid Dynamics (CFD) as a design tool has been proven advantageous particularly for large enclosures. Best Practice Guidelines for CFD CM/03/12 provides further details.

11.1.2.3 Dilution ventilation shall be designed such that all areas of the enclosure are adequately ventilated.

Ventilation systems should be tested to confirm the absence of significant poorly ventilated areas or recognised CFD modelling may be undertaken.

11.1.2.4 Where a valve as specified in section 8.1.4 has not been installed, gas may be contained in the pipework within the enclosure when the turbine is shut down. In such cases adequate air flow throughout the enclosure shall be maintained when the turbine is not operating, to ensure Zone 2NE classification otherwise the installation is defined as Zone 2 and electrical equipment selected accordingly.

11.1.2.5 Any dilution air intake shall be taken from a designated safe location, that being a zone free atmosphere and preferably from outside.

Only in exceptional circumstances may ventilation air be taken from inside, for example large well ventilated areas, in which case a risk assessment shall be carried out to determine its suitability as a route for ventilation of gas turbines

11.1.2.6 A flammable-gas detection system shall be installed within the enclosure in an appropriate position, interlocked to trip the gas supply system in the event of gas detection, leaving the ventilation fan(s) operating.

Note: The use of sensitive gas detectors may be valuable as a means of giving early warning/alarm in the event of a gas leak. Additional detectors may be used at strategic positions within an enclosure to improve early detection. An alarm setting at a lower gas concentration may be used to minimise false trips.

Gas detectors should be located in the ventilation outlet of the enclosure and as dictated by the specific gravity of the supply gas. Two stage, alarm and shutdown detectors are preferred and the alarm should be set to the lowest reasonably practicable level, preferably below 5% of the lower flammability limit (LFL) but not exceeding 10%, to give an audible alarm to enable an operator controlled shut down. The high LFL trip should also be set as low as reasonably practicable, preferably not greater than 20% of the LFL, and should initiate automatic lockout of the system, and operation of the AIV and dump valves (if fitted) as described in clauses 8.1.4 and 8.1.5.

For an unmanned site, an indication external to the enclosure, to show that a gas leak lockout has occurred, should be considered.

It should only be possible to cancel alarms manually and preferably only after the plant has shut-down.

Note 1: HSE RR430 Appendix 3 reproduces HSE guidance note PM84 HSE, "Control of safety risks for gas turbines used for power generation", and provides advice on means of identifying and controlling hazards due to a gas leak. It also refers to ASME 98-GT-215 which proposed a criterion to be met by dilution ventilation design; the 50% LEL enclosed iso-surface volume of leaked gas under alarm conditions to occupy no more than 0.1% of the enclosure volume, resulting in an alarm level of 5% LFL being suggested.

Note 2 Multiple detectors with voting, on-line calibration facilities and trending indication may be used to reduce false alarms or trips.

Selection and installation of gas detectors shall be in accordance with BS EN 60079 -29.

11.1.2.7 Detection of gas leakage during pre-purge shall cause automatic shutdown of the turbine and isolation of the fuel gas supply and will lock out the start sequence.

11.1.3 Cooling Air

11.1.3.1 Air is required to provide general cooling of the gas turbine installation, in addition to combustion air when running. The rate of ventilation shall be sufficient to cater for any cooling requirements of the enclosed equipment. These required rates shall be specified by the turbine manufacturer or equipment packager.

Note 1: The ventilation provided as a means of diluting any escaping gas during operation will also be used for GTs cooling and in most cases will be considerably more.

11.1.3.2 Where the latent heat from the Gas Turbine will cause excessive temperature rise within the enclosure, following shut down, the cooling ventilation shall be configured to continue to run for either a predetermined time period or controlled by an ambient temperature sensors located inside the enclosure.

11.1.4 Ventilation of Plant Rooms

11.1.4.1 Normally a plant room is defined as containing more than one major item of equipment, for example a turbine and a heat recovery boiler. A plant room may also contain one or more enclosures.

11.1.4.2 Any acoustic enclosure containing fuel gas plant within a plant room shall be ventilated using sealed fire-resisting ductwork direct to the outside air to ensure gas leakage is contained and exhausted to outside the building.

11.1.4.3 Where an enclosure is located within a plant room, the safe operation of any combustion equipment in the room shall not be adversely affected by opening the enclosure doors.

Note: The very high extract rates within enclosures may lead to chimneys and combustion chambers on other plant being exposed to severe suction conditions.

11.1.4.4 Any plant room containing other plant, for example a heat recovery boiler or compressor shall be ventilated to permit the safe operation of any such appliance.

The ventilation system shall take account of the heat losses from the installed equipment if the resultant rise in temperature could lead to failure of gas or electrical components.

The temperature within a plant room, assuming ambient air conditions of 15 °C, shall not exceed 25 °C within 100 mm of the floor, 32 °C at mid height and 40 °C within 100 mm of the ceiling.

Note 1: Further guidance regarding plant room ventilation can be found in the current edition of IGEM/UP/10 section 7 and Appendix 7.

Note 2: Where plant is used in the summer or with high ambient temperatures, the ventilation rate/grille sizes may need to be increased to limit the plant room temperature to 40°C. In some cases, this may require mechanical ventilation.

11.1.4.5 Where gas turbines are installed within a plant room without acoustic enclosure, adequate ventilation is required which should be shown to be able to transport gas air mixtures arising from foreseeable gas leaks to safety without re-entrainment. CFD may be found to be able to make this demonstration but at present practical limitations reduce its reliability in comparison with its application for conventional acoustic enclosures. In large plant rooms, gas detectors should be in strategic positions to account for variations between hot and cold operation. CFD may be useful in assessing overall flow patterns and in positioning such gas detectors, but particular care should be taken over boundary conditions (sensitivity testing should be used) and results should be applied conservatively.

11.1.5 **Turbine Combustion Air Intakes**

11.1.5.1 Air intakes for combustion air supplies shall be taken from an external safe area.

11.1.5.2 Intakes and filters shall be designed so as to minimise risk of accidental blockage or restriction, for example by icing-up during winter or by ingress of extraneous matter.

SECTION 12 : ANCILLARY SUPPLIES

12.1 ELECTRICITY SUPPLIES

12.1.1 Unless otherwise specified for a particular site, the turbine and its associated equipment shall function satisfactorily when the voltage supplied ranges from 10% above to 15% below the nominal voltage, or an equivalent tolerance on the claimed voltage range of the equipment.

Unless otherwise specified, in island mode operation, ± 15% variations in frequency can be tolerated safely for short periods. Outside this range the equipment shall either continue to function safely or be shut down safely by the controls.

12.1.2 Interruption of electrical supply voltage shall not defeat any safety or lockout function and shall not result in a hazardous condition.

12.1.3 All electrical control equipment shall be of “fail-safe” design. In particular all equipment, including flame-failure trips responsible for effecting closure of the safety shut-off systems shall be of “fail-safe” design.

Typical “fail-safe” circuits should transfer to a safe state on loss of power whether this is provided by electrical, fluid or mechanical energy.

12.2 CONTROL CIRCUITS

12.2.1 As far as is appropriate, any safety control circuit component shall be “fail-safe”. This can be achieved by the application of certain criteria for example going to the de-energised position for shut-down, lockout and other safety conditions.

The fuel shut off system shall, when de-energised fail to safety under all conditions.

12.2.2 Fuel shut-off caused by a component failure shall not allow the system to be re-energised, until remedial action is taken.

12.2.3 Incorrect or out-of-sequence operation of push buttons, switches etc. shall not affect adversely the safety of the system.

12.2.4 Where components are of plug-in design and similar appearance, inadvertent substitution shall not affect adversely the safe operation of the system. Where this is not possible the components shall be marked clearly with easily-distinguishable labels.

12.2.5 All circuit diagrams shall be clearly presented with adequate legends to avoid ambiguity.

12.3 ELECTRICAL EQUIPMENT

12.3.1 All electrical equipment shall be installed in accordance with appropriate standards, for example BS 7671, BS EN 60204-1 and BS EN 50156 Part 1.

12.3.2 Automatic restart of main plant and ancillaries following restoration of a failed electricity supply shall be permitted only if the complete start-up sequence is followed, including the pre-purge.

12.3.3 Ventilation around gas joints or potential leakage sources on gas fired turbines shall be in accordance with the DSEAR risk assessment and any electrical equipment in the vicinity of those joints shall be of the appropriate Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 (SI 1996/192 ATEX) rating.

12.4 FUEL SUPPLY PIPEWORK

12.4.1 The supply pipework, including any flexible section, shall be equipotentially bonded, connection shall be made to hard pipe free of paint or other coverings and not applied directly to soft or flexible metal connections. Reference should be made to BS 7430 and BS 7671.

Note 1: Local earthing connections and/or bonding straps may need to be fitted across non-metallic joints to ensure electrical continuity.

Note 2: Vent pipes terminating at high level may need protection against lightning (see Sub-Section 9.2).

12.4.2 The supply pipe shall not be used as an earth path for any item of plant, i e. for safety earthing for control current paths at earth potential, subject to any additional requirements of cathodic protection systems.

12.5 PLANT

12.5.1 Turbine and other plant frames shall be electrically earthed independently Reference should be made to BS 7430.

12.5.2 For electrical connection to the national supply grid, the Electricity Association Engineering Recommendations G 99 shall be applied for all generating plant. The purpose of this Engineering Recommendation (EREC) is to provide requirements for the connection of Power Generating Facilities to the Distribution Networks of licensed Distribution Network Operators (DNOs).

12.6 INSTRUMENT AND CONTROL FLUID SUPPLIES

Undue loss of instrument or control fluid pressure, for example high pressure air, shall result in an alarm condition. A loss of pressure which could cause a hazard shall result in lockout of the affected turbine or burner.

Consideration shall be given to the provision of a locally-mounted accumulator or other pressure vessel to provide motive force for valves and dampers in the event of a main supply failure to guarantee operation of safety equipment.

SECTION 13 : SAFETY OF TURBINE FUEL GAS AND RELATED SYSTEMS

13.1 The overall start system shall:

- prove the turbine and supplementary burner safety shut-off system in a safe state

  Note: In some cases, it may not be necessary to prove the supplementary (or auxiliary) burner SSOV system closed before start up of the turbine, for example when the turbine is connected to a stand-alone dump stack. However, in this case interlocked dampers are to be proved to be in the correct position.

- prove full gas pressure availability
- prove turbine exhaust gas (TEG) plant by-pass where applicable is in the correct position
- prove the ventilation of any enclosure or plant room
- complete the purge either via the plant by-pass or through the plant if no by-pass is fitted.
- ignite the turbine and release to process control.

13.2 Exhaust duct dampers shall be interlocked in the correct position during the pre-purge and operation of the system.

Note: The purge needs to effect dilution of the combustion and downstream duct work to a safe level and ensure a temperature within the exhaust and ancillary equipment is no greater than 450°C. Normally, this may be achieved with 3 air changes depending on the design of the equipment (see Section 10).

SECTION 14 : SAFETY OF SUPPLEMENTARY AND AUXILIARY SYSTEMS

14.1 Burners for supplementary and auxiliary firing can be of an in-duct design or can be plant-mounted. It shall be ensured that the burner will fire correctly under all required turbine running conditions.

14.2 TEG flows should be uniform prior to entry into supplementary or auxiliary firing burners and, therefore, the aerodynamics of the duct shall be considered carefully.

Note: Detailed flow modelling may be required, including use of special techniques and expertise.

14.3 The ignition and subsequent operation of NG supplementary and auxiliary firing systems shall comply with BS 5885: Part 1 (partly replaced), IGEM/UP/12, BS EN 676 or BS EN 746 Part 2, as appropriate.

For auxillary fired burners fuel rates shall be adjusted in relation to the available unconsumed oxygen supply from the turbine, due account being taken of variations in mass flow and exhaust air/gas ratio and the rapidity with which these parameters may change.

In order to maintain the equivalent level of oxygen in the turbine exhaust, lower forced draught air supply rates may be acceptable. However, in such cases, the effect of reduced air flow rate on the burner characteristics should be considered.

14.4 Failure of the turbine shall immediately trip a supplementary firing system unless other proven means of combustion air supply is being provided.

Note: At low turbine load, the changes in air flow may also require the shutdown of the supplementary firing burner.

14.5 For turbine/plant installations with a combined thermal input greater than 1.2MW, without a by-pass stack, the SSOVs on each selected auxiliary burner or in-duct burner shall be proved prior to turbine start-up. In addition, where the burner(s) may not be required to fire for some time or where the turbine always starts to a by-pass stack, the SSOVs should be either monitored closed, proved on shutdown and proved again when required to fire.

14.6 All air supplies shall be fitted with a device(s) for proving adequate air flow. Such devices shall be proved to be in the “no-flow” state, or be part of the burner start-up sequence prior to burner light-up.

For a constant external air source which is constantly running, for example TEG the safe start check of the air proving device can be satisfied, for example, by the use of a three-way solenoid valve. De-energisation of the valve shall vent the high pressure (inlet) side of the switch to atmosphere.

Note: The use of a high temperature sensor in the burner outlet duct is not acceptable since it only monitors the burner after light-up and does not prove air flow during purge and ignition.

14.7 Failure of any combustion air supply shall cause safety shut down of the affected plant.

In some cases, the fan provides cooling air to flame detection cells, in which case fan failure shall also cause an alarm.

14.8 When auxiliary fired burners are to operate without the turbine, suitable diverters and dampers shall be fitted and the burner firing rates shall be controlled to correspond to the available air supply.

Burner combustion products shall not be permitted to flow back into the turbine.

14.9 The installation of gas boosters for supplementary and auxiliary firing is covered fully in IGEM/UP/2 to which reference should be made.

Precautions should be taken to prevent burner/process demands causing boosters to cycle.

Advice on suitable delay timers or control logic should be sought from the manufacturer.

14.10 High and low gas pressure protection for supplementary and auxiliary burners shall comply with BS 5885 Part 1, (partly replaced), IGEM/UP/12, BS EN 676 or BS EN 746 Part 2.

14.11 Preferably, a single turbine should feed its exhaust gases into a dedicated exhaust heat recovery system. Where more than one turbine supplies a heat recovery system, precautions should be taken to ensure that reverse exhaust gas flows cannot pass back into another turbine under any purge, start-up or other flow condition. In such cases, the use of a common dump stack, ductwork or flue will require special consideration with regard to the gas-tight sealing of dampers and additional measures to make sure that a damper cannot close when connected to an operating turbine. In addition, consideration shall be given to the means of purging of the heat recovery system under all conditions.

Note: Reverse flow of gases into a turbine may lead to catastrophic consequences.

SECTION 15 : CONTROLS AND OPERATION

15.1 Emergency stop switches should be fitted, both adjacent to the plant and at a remote safe place or control panel. These should be interlocked to produce instantaneous shut-down and lockout and closure of AIV (see clause 8.1.4). They should be labelled clearly and easily accessible but protected against accidental operation.

15.2 The following notices shall be displayed permanently and be adjacent to the plant:

- operating instructions, where these are simple enough for easy display
- emergency procedures
- information on automatic fire-fighting systems, if fitted
- P&ID which indicates the position of main isolating valve(s).

15.3 All reasonable steps shall be taken to prevent tampering with controls by unauthorised personnel. However, such steps shall not inhibit access to, or operation of, emergency shut down equipment.

Manual valves on pressure interlocks shall be locked or wired open.

Note: These valves can be of the three-port type, ventilating the pressure interlock to atmosphere.

15.4 The Owner / Responsible Person shall ensure that plant operators are familiar with the operating instructions and procedures as well as all emergency procedures.

15.5 In addition to the interlocks relating to the safety of the plant with respect to prevention of explosion, flame-out or other risk relating to the use of gaseous fuels, consideration shall be given to extra protection.

Note: Examples of devices may be fitted to protect the turbine from mechanical damage:

- *over-speed trips*
- *slow acceleration trips*
- *high exhaust gas temperature trips*
- *vibration trips*
- *lubricating oil temperature and pressure trips, etc.*

15.6 Usually, the machinery packager supplies turbine and burner control systems and many are based upon programmable electronic systems (PES). For turbines, guidance should be obtained from IGEM/SR/15 and BS EN 61508.

15.7 Any flame sensing device shall interlock into the start-up sequence such that a “no-flame” condition has to be indicated in order to permit start-up to commence.

Burners controlled by a PES should comply with IGEM/SR/15.

Note: It is essential that Change Control Procedures are in place relating to field modifications to turbo machinery safety critical control systems, to include software changes if microprocessor based controllers are used. A safety critical control system is any control system functionality that, if not executed when required, could lead to uncontrolled conditions where health and safety are jeopardised.) Levels of authority for such changes should be listed. Such field changes to safety critical control systems are rare and require proper investigation, documentation and authorisations.

The procedure should identify safety critical control systems and list safety critical functions, for example turbine over speed protection, protection against the unsafe combustion in the turbine or exhaust system and a current safety shut down list, for example over speed protection, flameout detection shut down.

The indication of absence of flame should remain as a permissive interlock throughout the pre-purge period continuously to a stage not earlier than 5 seconds before admission of start-gas for an ignition attempt.

Note1: This procedure, known as the "safe start check", effectively proves the ability of the flame detection system to function correctly.

Note 2: A variety of flame proving techniques are applicable to turbines. Some are able to cover only specific periods of duty, for example initial ignition proving or normal running on-load, and some utilise temperature or speed trip functions normally fitted for other turbine protection duties.

15.8 Normally, entry to acoustic enclosures for on-line maintenance is not necessary. All relevant instrumentation shall be remote and all operations be remotely controlled. Suppliers shall provide comprehensive instructions on access control, and in particular on access in the event of an emergency.

An access permit system must be in place and access be subject to documented risk assessment on each occasion. Access within the enclosure shall be limited in duration, for a specific purpose, there shall be no manually activated load change or fuel change during the access period (see also clause 11.1.4.3).

15.9 In the design of control systems and logic functions, IGEM/SR/15, BS EN 61508 and IEC 61511, where appropriate, should be used for those aspects that require the establishment of safety integrity levels, and the design should be in accordance with the principles contained in the standard. Consideration shall be given to establishing an independent validation to confirm the safety integrity of the design.

SECTION 16 : COMMISSIONING

16.1 During design and construction, the method of commissioning (and de-commissioning) the fuel gas system shall be considered. Before commissioning takes place for a new gas installation, the gas installation pipework shall be strength, tightness tested and purged upstream of the gas equipment isolation valve. This testing shall be fully documented in accordance with IGE/UP/1.

Prior to the commissioning of the gas equipment it shall be verified that there is adequate available pressure and volume for the application at full installation load.

Full written commissioning procedures shall be prepared and agreed by the parties concerned in the supply and installation of equipment. Possible interaction between gas equipment on the site shall be considered. Reference should be made to IGEM/UP/4.

Note: In particular, it is important that commissioning of any fuel gas system compressor or turbine and the meter installation be co-ordinated to avoid the possibility of excessive flow or pressure fluctuation in the fuel gas system.

16.2 The fuel gas system shall be commissioned only by engineers competent to do so. Before commencing commissioning a risk assessment of the commissioning procedures shall be performed and a method statement written. Relevant equipment manufacturers shall make available written commissioning instructions for use by commissioning engineers. Permits to work and confined space permits shall be in place prior to work taking place.

Note 1: Turbine manufacturers may undertake such commissioning themselves.

Note 2: The GT may wish to witness the commissioning of the gas turbine.

Note 3: Consideration to the hazard of releasing or removing end caps/plugs/flanges from parts of systems which may contain trapped high pressure gas, for example after isolation valves or in filters.

The commission operative shall ensure that the relevant design criteria for enclosure and plant room ventilation and exhaust ventilation are met by the final installation.

Where a waiver to the Clean Air Act is issued by the Environmental Health Officer, a suitable durable label or sign shall be displayed in the plant room, see IGEM/UP/10. For all gas turbines greater than 1 MW fuel supplied registration under MCPD shall have been applied for.

16.3 Any safety controls and interlocks shall be confirmed that they operate correctly. Following commissioning a completion certificate and a record of the setting of all safety controls, fuel flows, combustion conditions and exhaust dampers shall be included in the technical file.

16.4 The commissioned fuel gas system shall not be handed over until:

- adequate agreed written operational procedures are in place
- all relevant emergency notices are displayed
- gas system line diagrams showing all emergency isolation valves etc. are displayed
- area classification diagrams displayed, where appropriate
- operators have been trained in safe operation procedures.

16.4 The commissioning engineer shall retain records of all equipment as commissioned and a copy of the records should be left with the user.

SECTION 17 : OPERATING AND MAINTENANCE INSTRUCTIONS

17.1 The supplier/installer of a turbine, downstream plant, burners and controls, etc. shall make available, to the operator/user, an operating manual detailing at least:

- the safe operating procedures
- maintenance requirements
- commissioning and de-commissioning procedures.

17.2 Maintenance schedules shall be prepared and shall include, among other items, a check on the gas tightness and correct operation of the safety shut-off valve systems, valve proving system (see Appendix 6), any flame detection system, turbine safety circuits and any alarm trip system. At all times, the safety integrity shall be maintained. Advice on maintenance should be obtained from the manufacturer or supplier. Schedules should also include the verification of the fan flow rates of mechanical ventilation and fan diluted flue systems.

Note 1: Guidance on maintenance and validation of programmable equipment for safety related applications is given in IGEM/SR/15.

Note 2: It is recommended that exhaust termination positions also be checked to ensure they are not obstructed by trees, leaves etc.

17.3 Maintenance of turbines and ancillaries should be carried out as specified by the manufacturer. This may be daily or weekly for preventive maintenance and based on hours run for major service scheduling.

17.4 Written procedures shall be prepared for all maintenance and a log kept of work done and/or observations made.

17.5 Any equipment including boosters, compressors and gas safety controls shall be maintained by persons competent to carry out such work in accordance with schedules provided by the manufacturer or plant designer.

Pipework and valves within a plant room shall be checked for gas tightness and correct operation at least annually.

Note 1: In higher pressure systems, checks on gas tightness may be quarterly or less depending upon the conclusions of the risk assessment.

Note 2: Normally, gas tightness checks will be made with a suitable gas detection instrument. Full pressure testing of systems is not normally required if the pipework is maintained correctly and protected from corrosion.

17.6 Gas installation pipes and exhaust systems, including lagging, shall be inspected regularly as part of the scheduled maintenance of the plant for, in particular, corrosion and leakage.

17.7 Flexible pipes shall be examined frequently as part of the scheduled maintenance procedure for the plant. All flexible hoses and compression type joints including unions shall form part of a detailed visual inspection regime by a competent person to ensure they are not damaged.

Note: Flexible hoses used in the application are to be of a high specification to minimise vibration related failure. Regular inspection will form part of the maintenance of the hazardous area classification.

APPENDIX 1 :- ACRONYMS, DEFINITIONS, SYMBOLS AND UNITS

DEFINITIONS

Other definitions are given in IGEM/G/4 which is freely available by downloading a printable version from IGEM's website, www.igem.org.uk.

Recommended and legacy gas metering arrangements are given in IGEM/G/1 which is freely available by downloading a printable version from IGEM's website, www.igem.org.uk.

auxiliary fired burner	A burner that is provided with its combustion air (oxygen) from the turbine exhaust which may be supplemented from an air fan independent of the turbine. *Note: This burner is able to operate independently of the turbine and may be located on downstream process plant. It may also operate in the supplementary firing mode when the turbine is operating, with or without the support of the independent combustion air fan.*
cranking	The rotation of the turbine prior to ignition. Normally, cranking continues after ignition, assisted by power from the established flame until a certain critical speed is attained at which the engine becomes self-sustaining. Cranking may be performed by various methods, the most common being the use of electric starter motor or hydraulic drive.
dilution ventilation	Sufficient air to effectively dilute any reasonably foreseeable sustained leak to below lower flammability limit (LFL).
automatic isolation valve	A valve, which closes automatically in response to an external signal.
automatic vent valve	A valve, complete with open and closed limit switches, which opens automatically in response to an external signal.
fail-safe system	A system where loss of power or actuating fluid to any control element, for example an individual relay, valve, actuator, etc. or any failure of these to operate when energised, leads to a safe condition. *Note: In particular, all fault shut-down systems operate by de-energising and not energising components.*
heat recovery system (HRSG)	Boiler or other suitable equipment through which hot exhaust gases may pass en-route to a flue and in which energy, which would otherwise be wasted, may be extracted usefully.
lockout	The safety shut down condition of the control system such that re-start cannot be accomplished without manual intervention. *Note: Re-setting requires that all safety interlocks are in the "safe" condition.*
plant	A term covering all turbines, down-stream heating and energy recovery plant, burners, controls and pipework associated with the supply and combustion of fuel.
pre-purge	Purge which precedes an ignition attempt. *Note: A flow of air or low temperature non-combustible gases through the system so as to displace completely any explosive mixture which may have accumulated therein immediately preceding an attempt to fire up the plant.*

prove	The sensing of a system parameter, for example a gas pressure, a valve position or shaft speed, which either directly or indirectly, ascertains unambiguously that it is within a prescribed range.
safety shut-off system (SSOS)	System of safety shut off valves (SSOVs) with associated control circuits that enable the supply of fuel to be shut off.
safety shut-off valve	Valve that is actuated by the safety control so as to admit and stop gas flow automatically.
supplementary firing burner	A burner that is provided with all or most of its combustion air (oxygen) requirements from the turbine exhaust gases. *Note: A separate air fan may also supply some air for flame stabilisation or additional firing needs. It does not operate independently of the turbine.*
turbine	High speed rotating machine in which fuel is burned continuously in a combustion chamber at high pressure and the combustion products are expanded through the gas turbine to produce shaft horsepower .
vent valve	A valve having the same performance requirements as an SSOV and used as part of a SSOV proving system to prove the effective closure of the main SSOVs. *Note: It may be normally open or normally closed, depending on the design of the system.*
valve proving system	A system to check the effective closure of a system shut-off valves. *Note: It may take the form of a pressure or sequential valve proving system that detects small leakage rates through the valve seats.*

ACRONYMS AND ABBREVIATIONS

ACoP	Approved Code of Practice
ACV	Automatic control valve
AECV	Additional Emergency Control Valve
AIV	Automatic isolation valve
ATEX	Atmospheres Explosives
CDM	Construction (Design and Management) Regulations
CE	Marking affixed to a component to show compliance with a European Standard or Directive
CFD	Computational fluid dynamics
CHP	Combined heat and power
CO	Carbon Monoxide
COSHH	Control of Substances Hazardous to Health Regulations
DmP	Design minimum pressure
DNO	Distribution network operators
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations
ECV	Emergency Control Valve
EREC	European Renewable Energy Council
ESP	Emergency service provider
FID	Flame ionization detector
GB	Great Britain
GS(I&U)R	Gas Safety (Installation and Use) Regulations
GS(M)R	Gas Safety (Management) Regulations
GT	Gas Transporter
HAZOP	Hazard operability study
HMSO	Her Majesty's Stationery Office
HRSG	Heat recovery steam generator

HSE	Health and Safety Executive
HSWA	Health and Safety at Work etc Act
IGEM	Institution of Gas Engineers and Managers
ISBN	International Standard Book Number
ISSN	International Standard Serial Number
LDF	Leak detection fluid
LFL	Lower flammable limit
LOP	Lowest operating pressure
LPG	Liquefied petroleum gas
MAM	Meter asset manager
MCPD	Medium combustion plant derivative
MHSWR	Management of Health and Safety at Work Regulations
MIP	Maximum incidental pressure
MOP	Maximum operating pressure
NDE	Non-destructive examination
NG	Natural Gas
OAMI	OFGEM Authorised Meter Installer
OD	Outside diameter
OP	Operating pressure
PED	Pressure equipment directive
PER	Pressure Equipment Regulations
PES	Programmable electronic system
PRI	Pressure regulating installation
PSSR	Pressure Systems (Safety) Regulations
PUWER	Provision and Use of Work Equipment Regulations
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations
RTJ	Ring type joints
SMYS	Specified minimum yield stress
SOL	Safe operating limit
SP	Set point
SSOS	Safety shut-off system
SSOV	Safety shut-off valve
STP	Strength test pressure
TEG	Turbine exhaust gas
UK	United Kingdom.

SYMBOLS

µm	micrometre
%	percentage
>	greater than
≤	less than or equal to
◦C	degree celcius
±	plus or minus.

UNITS

Barg	Bar gauge
dB(A)	Decibels
mbar	millibar
bar abs	bar absolute
$m\ s^{-1}$	meters per second
mm	millimetre
mins	minutes
MW	megawatt
m	metre
kV	kilo Volt
m^3	cubic meters
m^3(st)	cubic metres at standard conditions 15°C, 1.01325 bar absolute

m^3/s	cubic meters per second
m^3h^{-1}	cubic meters per hour
secs	seconds
t	time
h_s	height of vent pipe above ground level (m)
d	nominal diameter of vent valve or limiting orifice
V	volume
P_1	absolute pressure before venting (bar abs)
t_v	time to vent volume to a pressure of 1 bar (secs)
Z	compressibility factor
Q_{ST}	flow rate through the vent when absolute pressure within the volume is P1 bar (m^3h^{-1} (st)
L_n	Napierian logarithm
STP	standard temperature and pressure
$V\rho t^{-1}$	mass flowrate (kg s-1)
X_r	dispersion distances radius to vent tip
X_k	radial dispersion distance
X_L	momentum driven downward dispersion
X_s	radius of the hazardous area from a vent pipe associated with seat leakage (m)
X_h	vertical height/length of the hazardous area extending from a vent pipe (m)
kg s^{-1}	kilograms per second
g	mass flow rate (Kg s^{-1})
ρ	gas density (Kg m^{-3} (st)).

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.

Where British Standards etc. are quoted, equivalent national or international Standards etc. equally may be appropriate.

A2.1 **PRIMARY LEGISLATION**

- Health and Safety at Work etc. Act 1974
- Gas Act 1986 (as amended)
- Factories Act 1961.

A2.2 **SECONDARY LEGISLATION**

- Building Regulations (England and Wales) 2010 (as amended)
- Building (Scotland) Regulations 2012
- Building Regulations (Northern Ireland) 2012
- Clean Air Act 1993
- Confined Spaces Regulations 1997
- Construction (Design and Management) Regulations 2015
- Construction Products Directive 1989
- Control of Asbestos at Work Regulations 2013
- Control of Noise at Work Regulations 2005
- Control of Substances Hazardous to Health Regulations 2004 as amended
- Dangerous Substances and Explosive Atmospheres Regulations 2002
- Electricity at Work Regulations 1989 and Memorandum of Guidance 1989
- Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996
- Gas Safety (Installation & Use) Regulations 1998 (as amended)
- Gas Safety (Management) Regulations 1996
- Management of Health and Safety at Work Regulations 2006 (as amended)
- Pressure Equipment (Amendment) Regulations 2002
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013
- Supply of Machinery (Safety) Regulations 2011 (as amended)
- Noise at Work Regulations 1989
- Pressure Equipment Directive 97/23/EC
- Pressure Systems (Safety) Regulations 2000
- Provision and Use of Work Equipment Regulations 1998
- The Product Safety and Metrology etc. (Amendment etc.) (UK(NI) Indication) (EU Exit) Regulations 2020

A2.3 APPROVED CODES OF PRACTICE AND GUIDANCE

A2.3.1 HSE PUBLICATIONS

- HSR25 Electricity at Work Regulations. Guidance
- HSG48 Human Factors in Industrial Safety. Guidance
- HSG65 Managing for Health and Safety
- HSG 85 Electricity at work: Safe working practices
- HSG227 A comprehensive guide to managing asbestos in premises
- HSGS4 Safety requirements for pressure testing. Guidance
- L22 Safe Use of Work Equipment. ACoP and Guidance
- L56 Safety in the Installation and Use of Gas Systems and Appliances. ACoP and Guidance
- L122 Safety of Pressure Systems. Pressure Systems Safety Regulations 2000. ACoP
- L138 Dangerous Substances and Explosive Atmospheres Regulations 2002. ACoP and Guidance
- L143 Managing and working with asbestos 2012. ACoP and Guidance
- HS(E)61 RIDDOR Explained
- HSE PM 84 Control of safety risks at gas turbines used for power generation (revised 2003)
- INDG 178 Written Schemes of Examination
- INDG 229 Using Work Equipment Safely
- INDG 261 Pressure systems –
- INDG 291 Providing and using work equipment safely
- INDG 297 Safety in Gas welding, cutting and similar processes
- INDG 370 Controlling fire and explosion risks in the workplace
- INDG 453 Reporting accident and incidents at work.
- INDG 455 Safe use of ladders and stepladders
- INDG 258 Confined Spaces
- HSG33 Health and safety in roof work
- HSE RR430 Offshore gas turbines (and major driven equipment) integrity and inspection guidance notes

A2.3.2 Electricity Association Engineering

- G99 Requirements for the connection of generation equipment in parallel with public distribution networks

A2.4 BRITISH, EUROPEAN AND INTERNATIONAL STANDARDS (abbreviated titles)

- BS 1179 Glossary of terms
- BS 1759 Flanges and their joints. Steel flanges
- BS 1600 Dimensions of steel pipe
- BS 1640 Steel butt-welding pipe fittings
- BS 1780 Bourdon tube pressure and vacuum gauges
- BS 2633 Class I arc welding of ferritic steel pipework
- BS 3381 Spiral wound gaskets for steel of flanges to BS 1560
- BS 3799 Steel pipe fittings, screwed and socket-welding

- BS 4677 Arc welding of austenitic stainless steel pipework
- BS 4882 Specification for bolting for flanges and pressure containing purposes
- BS 5410-3 Oil firing
- BS 5885-1 Automatic gas burners. Specification for burners with input rating 60 kW and above
- BS 6501 Metal hose assemblies
- BS 7430 Earthing of electrical installation
- BS 7671 IET Wiring regulations
- BS 9999 Fire safety in the design, management and use of buildings
- BS EN 161 Automatic shut-off valves for gas burners and gas appliances
- BS EN 264 Safety requirements and testing of safety shut off devices
- BS EN 287 Approval testing of welders - fusion welding
- BS EN 288 Approval of welding procedures for metallic materials
- BS EN 676 Forced draught burners for gaseous fuel
- BS EN 746 Industrial thermo-processing equipment. Safety requirements for combustion and fuel handling system
- BS EN 837-1 Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing
- BS EN 1011-3 Arc welding of stainless steels
- BS EN 1092-1 Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories. PN designated. Steel flanges.
- BS EN 1092-2 Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories. PN designated. Cast iron flanges
- BS EN 1514-2 Flanges and their joints. Gaskets for PN-designated flanges. Spiral wound gaskets for use with steel flanges
- BS EN 1515 Flanges and their joints. Bolting. Selection of bolting for equipment subject to the pressure equipment directive 97/23/EC
- BS EN 1643 Safety and control devices for gas burners and gas burning appliances. Valve proving systems for automatic shut off valves
- BS EN 62305 Protection against lightning
- BS EN 10216 Seamless steel tubes for pressure purposes
- BS EN 10217 Welded steel tubes for pressure purposes
- BS EN 10217 -1 Welded steel tubes for pressure puposes. Technical Delivery Conditions. Electric welded and submerged arc welded non-alloy steel tubes with specified room temperature properties
- BS EN 10216 Part 5 Seamless steel tubes for pressure purposes. Technical delivery conditions. Part 5 stainless steel tubes
- BS EN 10217-7 Welded steel tubes for pressure purposes. Technical delivery conditions. Part 7. Stainless steel tubes
- BS EN 10220 Seamless and welded steel tubes. Dimensions and masses per unit length
- BS EN 10253-2 Butt-welding pipe fittings. Part 2. Non alloy and ferritic alloy steels with specific inspection requirements
- BS EN 13445 Unfired pressure vessels
- BS EN 13480 Metallic industrial piping

- BS EN 15001-1 Gas Infrastructure. Gas installation pipework with an operating pressure greater than 0.5 bar for industrial installations and greater than 5 bar for industrial and non-industrial installations. Detailed functional requirements for design, materials, construction, inspection and testing
- BS EN 15001-2 Gas infrastructure. Gas installation pipework with an operating pressure greater than 0.5 bar for industrial installations and greater than 5 bar for industrial and non-industrial installations. Detailed functional requirements for commissioning, operating and maintenance

  BS EN 50156 Part 1 Electrical equipment for furnaces. Application, design and installation
- BS EN 67009 :10 Explosive atmospheres. Classification of areas. Explosive gas atmospheres
- BS EN 60079 Part 29-1 Performance requirements of detectors for flammable gases
- BS EN 60079 Part 29-2 Selection, installation, use and maintenance for flammable gases and oxygen
- BS EN 60204 Part 1 Safety of machines - electrical equipment of machines
- BS EN 61508 Functional safety of electrical/ electronic/programmable electronic safety related systems
- BS EN ISO 3452 Part 1 Non-destructive testing. Penetrant testing
- BS EN ISO 9000 Quality management systems. Fundamentals and volcabulary
- BS EN ISO 10380 Pipework. Corrugated metal hoses and hose assemblies
- BS EN ISO 17636 Non-destructive testing of welds. Radiographic testing
- BS EN ISO 23553 Part 1 Safety and control devices for oil burners and oil-burning appliances. Shut-off devices for oil burners
- BS EN ISO 23553 Part 1 Safety and control devices for oil burners and oil-burning appliances
- BS ISO 55000 Asset management. Overview, principles and terminology
- PAS 55 Asset Management Standards

A2.5 INSTITUTION OF GAS ENGINEERS AND MANAGERS

- IGE/UP/1 Strength testing, tightness testing and direct purging of industrial and commercial gas installations
- IGEM/UP/2 Installation pipework on industrial and commercial premises
- IGEM/UP/4 Commissioning of gas fired plant on industrial and commercial premises
- IGEM/UP/6 Application of positive displacement compressors to Natural Gas fuel systems
- IGEM/UP/10 Installation of flued gas appliances in industrial and commercial premises
- IGEM/UP/16 Design for Natural Gas installations on industrial and commercial premises with respect to DSEAR
- IGEM/UP/12 Application of burners and controls to gas fired process plant
- IGEM/G/1 Defining the end of the Network, a meter installation and Installation pipework

- IGEM/G/7 Risk assessment techniques
- IGEM/GL/5 Procedures for managing new works, modifications and repairs
- IGEM/GM/4 Flow metering practices. Inlet pressure exceeding 38 bar and not exceeding 100 bar
- IGEM/GM/6 Non-domestic meter installations. Standard designs
- IGEM/GM/8 Non-domestic installations
- IGEM/SR/15 Integrity of safety-related systems in the gas industry
- IGE/SR/22 Purging operations for fuel gases in transmission, distribution and storage
- IGE/SR/23 Venting of Natural Gas
- IGEM/SR/25 Hazardous area classification of Natural Gas installations
- IGEM/SR/29 Dealing with gas escapes.

A2.6 **ENERGY INSTITUTE PUBLICATIONS**

EI IP-MCSP-P15 Area classification for installations handling flammable fluids.

A2.7 Building Regulations: Fire safety Approved Document B

APPENDIX 3 : TURBINE AND BURNER DATA GAS FLOW ENQUIRY FORM

The following information may be required by the MAM or GT to enable them to assess the demands on the meter installation or PRI and the network. This list is not comprehensive since other information may be relevant to any particular site.

Information		Data	Units
Required gas pressure			mbar/bar
Turbine gas consumption	maximum no-load synchronized minimum		Standard m^3/h
Number of gas turbines			
Time to minimum no-load synchronised at start up			secs
Time to minimum full load after start up			secs
Time from full load to minimum no-load synchronised			secs
Gas firing burners on associated plant, input each			Standard m^3/h
Number of burners			
Burner gas pressure required			mbar/bar
Gas compressor if fitted max/min inlet pressure			mbar/bar
Gas compressor if fitted max outlet pressure			mbar/bar
Number of compressors on line at max flow. State serial or parallel			
Compressor rated capacity			Standard m^3/h
Type of compressor			
Compressor start arrangements (IGEM/UP/6)			
By-pass capacity			Standard m^3/h
Number of compression stages per compressor			
Estimated rate of change of flow at each step			Actual m^3/s
Inlet compressor receiver volume			Actual m^3
Outlet compressor receiver volume			Actual m^3
HP pipework volume			m^3

APPENDIX 4 : SIZING OF EMERGENCY VENT VALVES

A4.1 For gas supplies of MOP > 5 bar, it is recommended that pipework downstream of the ECV be vented in an emergency to below 0.5 bar gauge in less than 60 seconds, where practicable. The approximate size of vent may be calculated from:

Q_{ST} = $0.415\, P_1 d^2\, Z^{-0.5}$ ($m^3\, h^{-1}$ (st))

d = nominal diameter (port diameter) of vent valve, or limiting orifice (mm)
V = volume to be depressurized (m^3)
P_1 = absolute pressure before venting (bar abs)
t_v = time to vent volume to a pressure of 1 bar (secs)
Z = compressibility factor - an average value taken over the whole of the venting period (see Table 1)
Q_{ST} = flow rate through the vent when absolute pressure within the volume is P_1 bar (m^3h^{-1} (st))

d = $93\, [V\, L_n\, (2.0137^{-1}\ P_1)\, (Z^{0.5}\ t_v)^{-1}]^{0.5}$ (mm)

Note 1: The equation for d is derived from the equations of state and mass flow rate. The value 93 takes account of the inconsistency in units between d, V, P_1 and t_v.

Note 2: The equation for Q_{ST} is derived from equations of state and mass flow rate equations. The value 0.415 takes account of the inconsistency in units between Q_{ST}, P_1 and d.

Note 3: If a meter is included within the pipework to be vented, consideration needs to be given to the possibility of over-speeding the meter. A discharge coefficient of 0.6 is assumed.

For pressures up to 6 bar abs, Z can be taken as 1. Therefore, to simplify the formulae for a 60 sec vent time:

d = $12\, [V\, L_n\, (2.0137^{-1}\ P_1)]^{0.5}$ (mm) and

Q_{ST} = $0.415\, P_1 d^2$ ($m^3\, h^{-1}$ (st))

L_n = Naperion (natural) logarithms (Log_e).

A4.2 **EXAMPLE OF CALCULATION**

For a given 60 second vent:

V = 1 m^3
P_1 = 6 bar abs

Then:

d = $12\, [1\, L_n(2.0137^{-1}\ 6)]^{0.5}$
$12\, [1.0917]^{0.5}$
= 12.5 mm
Q_{ST} = $0.415\, (6)(12.5)^2$
= 389 $m^3\, h^{-1}$ (st)

and, when pressure has fallen to 1.5 bar abs (0.5 barg)

Q_{ST} = 97 $m^3\, h^{-1}$ (st).

PRESSURE (BAR ABSOLUTE)	TEMPERATURE °C		
	15	**50**	**75**
2	0.9957	0.9972	0.9979
10	0.9783	0.9859	0.9896
20	0.9568	0.9721	0.9796
30	0.9355	0.9588	0.9700
40	0.9145	0.9458	0.9608
50	0.8940	0.9335	0.9521
60	0.8742	0.9217	0.9440
70	0.8554	0.9107	0.9364
80	0.8377	0.9005	0.9295
90	0.8214	0.8911	0.9233
100	0.8068	0.8828	0.9178

Note: For the purposes of these Procedures, at 1 bar absolute, the compressibility of Natural Gas in the temperature ranges shown are taken as unity.

TABLE 1 – COMPRESSIBILITY FACTORS FOR TYPICAL NATURAL GAS (CALCULATIONS ARE BASED ON AGA 8 USING TYPICAL NATURAL GAS) (COURTESY OF NATIONAL GRID, FORMERLY BG TRANSCO)

A4.3 It is inadvisable to fit a meter where it may be exposed to the flow through an emergency vent. If a meter is fitted in such a position, refer to IGE/GM/8 Part 1.

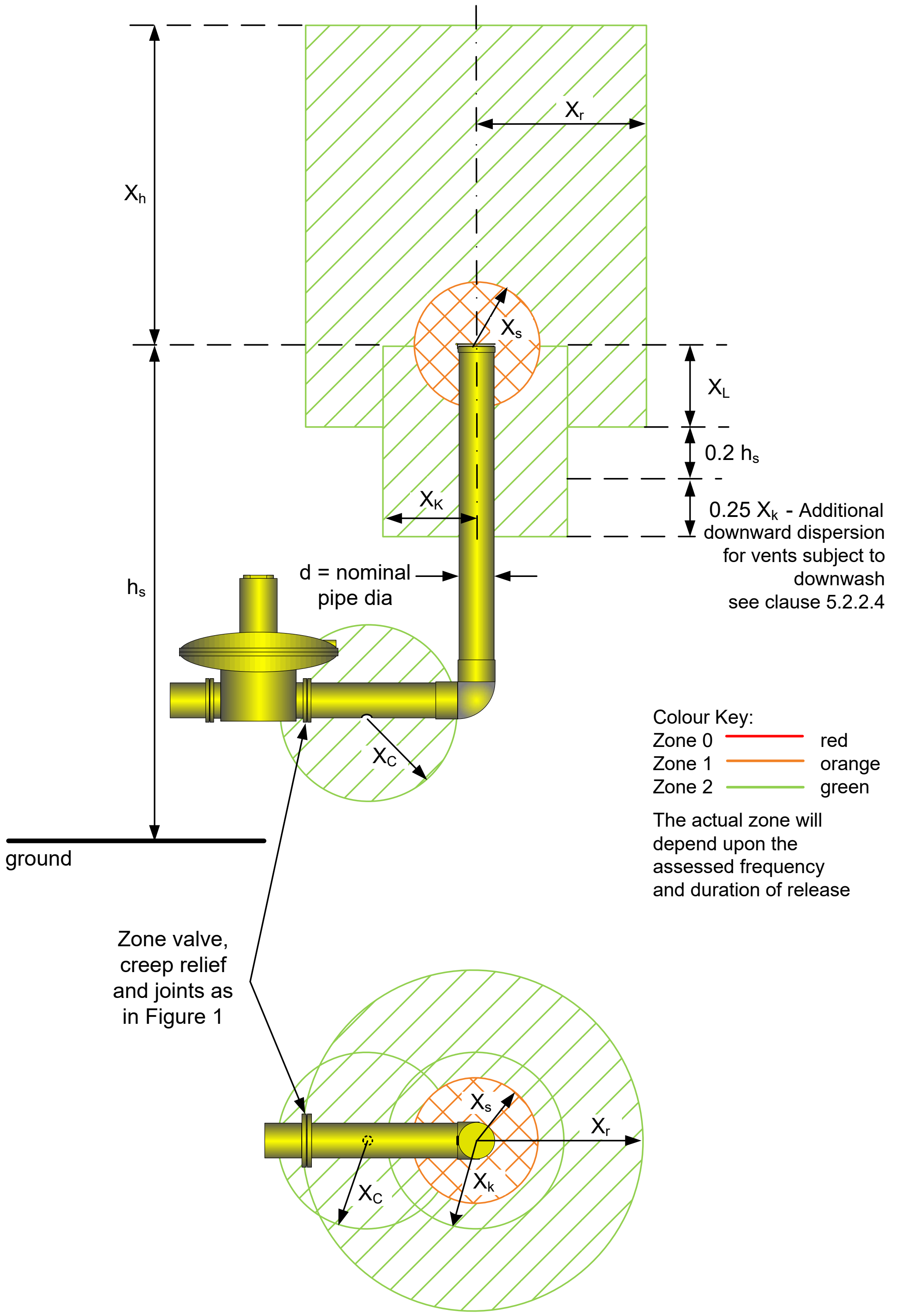
A4.4 Where the length of the vent exceeds 20 m, the diameter of the vent may need to be greater than d.

A4.5 Further guidance on the sizing of vents is provided in IGE/SR/23.

APPENDIX 5 : DESIGN OF VENTS

IGEM/SR/25 gives guidance on the dispersion of continuous releases through vents. The dispersion distances that are quoted in this document take account of a range of wind speeds and atmospheric conditions.

The zoning distance for an ideal vent pipe termination should be as indicated in Figure 13 of IGEM/SR/25 and is based upon.



Note: X = zone distance (see Tables 13 to 16)

FIGURE 4 - EXTENT OF HAZARDOUS AREAS FOR VENT PIPE TERMINATIONS. IDEAL VENTING

The guidance includes provision for what is referred to as downwards dispersion, to take account of any vertical meandering of the plume that may occur over a long period of time due to varying atmospheric conditions. For certain short duration, decaying releases, the plume will not be present for a sufficient length of time to warrant the inclusion of such a zone. In particular, for discrete events involving releases of or up to 1 minute duration that are initially taking place under sonic conditions, the provision of this zone is not necessary.

Dispersion distances radius to vent pipe (X_r) and vertical height from vent tip (X_h) should be selected from Tables 14 and 15 for the appropriate flow rate and vent pipe termination diameter.

Ideal and other upward pointing vent pipe terminations are subject to some downward dispersion. Momentum driven downward dispersion distance X_L should be determined in accordance with the formula:

X_L = 0.5 m or 2 d (m) whichever is the lesser, where d = nominal diameter of the vent (m).

Wind driven dispersion distance should be determined in accordance with the radial dispersion distance is represented by X_k and is given in Table 16.

Ideal and other upward pointing vent pipe terminations which are located close to a structure or on a roof close to the edge of the building may be subject to additional downward dispersion due to downwash

The total downward dispersion distance is:

$(X_L + 0.2h_s + 0.25X_k)$ or X_k in Table 16, whichever is the smaller

A Zone 1 area, X_s should be provided to cater for leakage past the seat of a closed valve or closed relief valve in accordance with IGEM/SR/25.

The guidance includes provision for what is referred to as downwards dispersion, to take account of any vertical meandering of the plume that may occur over a long period of time due to varying atmospheric conditions. For certain short duration, decaying releases, the plume will not be present for a sufficient length of time to warrant the inclusion of such a zone. In particular, for discrete events involving releases of or up to 1 minute duration that are initially taking place under sonic conditions, the provision of this zone is not necessary. In these cases, the horizontal extent of the zones (X_r) may be determined from an average flow rate over the duration of the release, i.e. $g = V\rho t^{-1}$

g = mass flowrate (kg s^{-1})

V = fixed standard volume of gas to be vented (m^3(st))

ρ = gas density (kg m^{-3}(st))

t = duration of release (s).

The value of X_r is found from Table 14 of IGEM/SR/25.

If the vent is located close to a structure, downward dispersion due to downwash may occur. The horizontal extent of this downwash zone is given by X_k in Table 16 of IGEM/SR/25.

The vertical extent of this downwash is given by $X_L + 3d + 0.25X_k$ which should not exceed X_k.

X_L = 1m or $0.4h_s$ m whichever is the greater

d = diameter of vent tip (m)

h_s = height of vent tip above ground level (m).

APPENDIX 6 : CHECKING SAFETY SHUT-OFF SYSTEMS FOR LEAKS

Checking the leak tightness of a safety shut-off valve system is to be part of a planned regular maintenance schedule. A simple test procedure is suitable for checking the leak tightness and if the system is found to be leaking, test methods can be devised which will identify which of the valves in the system are at fault without having to remove the valves from the installation. This section gives details of the basic requirements for simple tests.

A7.1 TEST METHOD

The test method can conveniently be split into parts:

- a let-by test of the turbine isolation valve at 50% OP, any pressure rise will identify a faulty isolation valve (which is to be repaired or replaced before commencing with the tests below) then
- a tightness test of the gas pipework between the isolation valve and the first SSOV is to be undertaken in accordance with IGEM/UP/1 or
- a check for external leakage using, for example, electronic leak detector, any leaks being dealt with before proceeding, then checks that the upstream valve of the system is not leaking, provided that the downstream valve is also tight
- a check that atmospheric pressure is maintained between the SSOVs when they are closed and the isolation valve is turned on and the pipework pressurised, any rise in pressure will indicate the first SSOV is passing
- a check that at least OP can be maintained between the valves checks that the downstream valve is not leaking provided the upstream valve is tight.

Should any test reveal unacceptable leakage the system requires servicing.

A7.1.1 Atmospheric pressure check

Vent any pressure trapped between the valves prior to the test. This can be done using the pressure test point. If the volume of gas between the valves is large it will be necessary to vent the gas to a safe place.
Monitor the pressure between the valves for a fixed time. This can be done by attaching a pressure gauge to the test point any observed pressure rise will indicate that the first SSOV is passing gas.

A7.1.2 Pressure check

A pressure at least equal to the normal operating pressure of the gas supply is introduced between the SSOVs and monitored for a pre-determined time. The pressure may be introduced via the pressure test point from a hand or foot pump, or by temporarily connecting the test point to a similar pressure test point upstream of the first SSOV any loss in pressure will indicate the second SSOV is passing gas.

A7.1.3 Check of pressure proving systems

It is desirable to carry out frequent checks to ensure that any valve-proving system is functioning correctly.
When positive pressure systems are used, this test may be carried out by manually isolating the make-up pressure line. Loss of pressure during the sequence will simulate a leaking downstream valve and may cause system lockout. After re-setting the system following this check, it is essential that a further check is carried out by manually isolating the exhaust line from the system, thus preventing the release of the pressurising medium. This will simulate a leaking upstream valve and may cause system lockout. System lockout in each case will prevent turbine start up. Alternatively, in a well ventilated area, a small leak may be introduced between the SSOVs during

proving, which should result in a system lockout. When vacuum systems are used, a leak may be introduced, for example, opening a pressure test point. System lockout will prevent start up.