

***IGEM/UP/6 Edition 2
Communication 1741***

Application of compressors to Natural Gas fuel systems



*Founded 1863
Royal Charter 1929
Patron: Her Majesty the Queen*

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SECTION 1 : INTRODUCTION

- 1.1 This Standard supersedes IGE/UP/6 Communication 1646, which is obsolete.
- 1.2 This Standard has been drafted by an Institution of Gas Engineers and Managers (IGEM) Panel, appointed by IGEM's Utilization Committee, and has been approved by IGEM's Technical Coordinating Committee on behalf of the Council of IGEM.
- 1.3 This Standard covers the application of positive displacement reciprocating compressors; screw compressors; slide vane compressors and centrifugal compressors to Natural Gas installation pipework systems. It does not cover gas compressors used for gas transportation systems.
- 1.4 Positive displacement compressors installed on industrial and commercial premises, within the stated scope for pressure, volume and power input, are covered, as are the positive displacement compressors utilized in Natural Gas vehicle filling stations, where the shaft power input, normally, is in the range 10 to 100 kW.
- 1.5 This Standard makes use of the terms "should", "shall" and "must", when prescribing particular requirements. Notwithstanding Sub-Section 1.8:
- the term "must" identifies a requirement by law in Great Britain (GB) at the time of publication
 - the term "shall" prescribes a requirement, which, it is intended, will be complied with in full and without deviation
 - the term "should" prescribes a requirement which, it is intended, will be complied with unless, after prior consideration, deviation is considered to be acceptable.

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.

- 1.6 The primary responsibility for compliance with legal duties rests with the employer. The fact that certain employees, for example "responsible engineers", are allowed to exercise their professional judgement does not allow employers to abrogate their primary responsibilities. Employers must:
- have done everything to ensure, so far as it 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.
- 1.7 It is now widely accepted that the majority of accidents in industry generally are in some measure attributable to human as well as technical factors in the sense that actions by people initiated or contributed to the accidents, or people might have acted better to avert them.

It is therefore necessary to give proper consideration to the management of these human factors and the control of risk. To assist in this it is recommended that due cognisance should be taken of publication HSG48.

- 1.8 Notwithstanding Sub-Section 1.5, 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 IGE and other publications as appropriate.
- 1.9 Requests for interpretation of this Standard in relation to matters within its scope, but not precisely covered by the current text, should be addressed in writing to Technical Services, IGE, IGE House, 26-28 High Street, Kegworth, Derbyshire, DE74 2DA and will be submitted to the relevant Committee for consideration and advice, but in the context that the final responsibility is that of the engineer concerned. If any advice is given by or on behalf of IGE, this does not relieve the responsible engineer of any of his or her obligations.
- 1.10 This Standard was published in December 2009.

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SECTION 2 : SCOPE

- 2.1 This Standard covers the installation and operation of positive displacement reciprocating compressors; screw compressors; slide vane compressors and centrifugal compressors, with outlet pressures in the range exceeding 0.5 bar but not exceeding 400 bar and a shaft power input exceeding 10 kW.

Note 1: Requirement for the installation of boosters and compressors with outlet pressures not exceeding 0.5 bar are given in IGEN/UP/2.

Note 2: For the purposes of this Standard and IGEN/UP/2, a booster is a centrifugal compressor with an outlet pressure not exceeding 0.5 bar.

- 2.2 This Standard applies to compressors using Natural Gas (a 2nd family gas as defined in BS EN 437). This Standard may not be appropriate for other gases such as 1st family, other 2nd family and 3rd family gases, including "landfill gas", "mines gas", "digester gas" etc. (see Sub-Section 4.3).

This Standard applies only to gas compressors that are installed downstream of a primary meter installation.

This Standard does not specify the design and manufacturing requirements of compressors such as those contained in BS EN 1012.

- 2.3 Unless otherwise specified, metric standard conditions are assumed by this Standard.

- 2.4 This Standard applies to new compressor installations only.

- 2.5 This Standard applies to compressor installations within the preferred installation arrangements given in IGEN/G/1.

- 2.6 All pressures are gauge pressures unless otherwise stated.

- 2.7 Italicised text is informative and does not represent formal requirements.

- 2.8 Appendices are informative and do not represent formal requirements unless specifically referenced in the main sections via the prescriptive terms "should", "shall" or "must".

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. Similar considerations are likely to apply in other countries and reference to the appropriate national legislation will be necessary. The following legal and allied considerations outlined are particularly relevant to turbines.

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 THE GAS ACT

3.1.1 In particular, the Gas Act stipulates requirements for:

- notification to the gas supplier and the gas transporter (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 The user of a gas compressor must provide written notification to the gas supplier and the GT of the intention to connect a compressor to the public gas supply network.

The user must 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 must be provided with evidence that all appropriate safeguards have been taken.

3.1.3 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 must also be satisfied that no undue compressor induced perturbations are imposed on the metering system nor into the gas supply. Usually, this will mean demonstrable compliance with relevant published Standards.

3.2 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.

All persons engaged in the design, construction, commissioning, operation, maintenance and alteration of pipework must be competent to carry out such work. Competency is achieved by an appropriate combination of education, training and practical experience.

3.3 MANAGEMENT OF HEALTH AND SAFETY AT WORK REGULATIONS (MHSWR)

Linked closely with specific duties under GS(I&U)R (see Sub-Section 3.4) 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.

3.4 **GAS SAFETY (INSTALLATION AND USE) REGULATIONS (GS(I&U)R)**

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.

Note: GS(I&U)R do not apply to certain premises (see HSL56 Guidance Notes 28 and 29). However, where they do not apply, the principles of GS(I&U)R need to be applied.

GS(I&U)R place responsibilities on those installing, servicing, maintaining or repairing gas appliances, pipework etc. as well as suppliers and users of gas.

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", for example Gas Safe registered.

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 or safety is a member of an approved class of persons and is competent to carry out such work. If any serious fault is found, the installer must inform both the landlord/hirer, as well as the user, so that such faults can be rectified before further use.

3.5 **PROVISION AND USE OF WORK EQUIPMENT REGULATIONS (PUWER)**

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

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

3.5.3 More information on PUWER can be found in HSL22. Free leaflets include INDG291 and INDG229.

3.6 **PRESSURE EQUIPMENT DIRECTIVE (PED)**

3.6.1 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 Pressure Systems Safety Regulations (PSSR). Compliance with PED can be demonstrated by the use of a harmonised standard. BS EN 15001-1 and -2 have been specially prepared for the gas industry and include a wide range of materials. Systems falling within the scope of PED must display a CE mark and this must be affixed by an approved person or body.

3.6.2 Other pipework systems "designed and specified" by the consumer and which are thereafter installed and tested by a contractor will not normally fall within the scope of PED.

Sections of pipework designed and manufactured "off-site" will, generally, always fall within the scope of PED if designed and specified by the contractor, as is the normal procedure within the UK.

Systems in which the pressure (bar) times the volume (litres) is less than 250 are partially exempt from PED on the basis that they have a low contained energy. Pipework of diameter not greater than 25 mm nominal size is also partially exempt.

- 3.6.3 There is also a duty on the user of an installed system within the scope of PED not to allow the system to be used until they have a written scheme of examination covering protection devices, pressure vessels and parts, which if they fail, give rise to danger.

The scheme of examination must be drawn up by a "competent person" and the system must be examined in accordance with the written scheme of examination by a "competent person". The more complex a system is, the more qualifications, experience and training are needed to ensure competence.

Guidance on the selection of competent persons is given in HSL122. Users (or owners) of pressure systems are free to select any competent person they wish, but they have to take all reasonable steps to ensure that the competent person selected can actually demonstrate competence i.e. the necessary breadth of knowledge, experience and independence. In judging levels of competence, users or owners may wish to know that a national accreditation scheme has been developed by the United Kingdom Accreditation Service (UKAS) for bodies that provide services of this nature.

3.7 **PRESSURE EQUIPMENT REGULATIONS (PER)**

PER are intended to allow the free trade of pressure equipment throughout the European Union (EU). PER 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 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 PER. The classification system results in equipment being placed in one of 5 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.

3.8 **PRESSURE SYSTEMS SAFETY REGULATIONS (PSSR)**

- 3.8.1 PSSR 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 in PSSR).

3.8.2 Relevant fluids include Natural Gas at a pressure greater than 0.5 bar i.e. above atmospheric pressure. A pressure system would include bulk storage tanks, pipelines and protective devices. Once the pressure in the pipework drops below 0.5 bar, and the user/owner can show clear evidence that the system does not contain, and is not liable to contain, a relevant fluid under foreseeable operating conditions, then that part of the system is no longer covered by PSSR. This is likely to be the case after the pressure relief valve associated with a pressure reducing valve which takes the pressure to below 0.5 bar, for example at the entry to a building but note the special requirements placed on protective devices in such systems (see para 110b of HSL122). PSSR also apply to pipelines and their protective devices in which the pressure exceeds 2 bar (see Sch 1 part 1 item 5 of HSL122).

3.8.3 More information is available in HSL122 and some information is presented in INDG261 and INDG178.

3.9 **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: HSR25 provides guidance on the Regulations.

3.10 **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.

3.11 **GAS SAFETY (MANAGEMENT) REGULATIONS (GS(M)R)**

3.11.1 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.

3.11.2 The ESP has specific duties to:

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

- 3.11.3 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.
- 3.11.4 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 meter installation or installation pipework.
- 3.11.5 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 IGE/SR/20.

3.12 **CONFINED SPACES REGULATIONS**

These Regulations apply to a large 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 prevent entry into confined spaces unless avoidance is not reasonably practicable and unless there is a system of work which renders the work safe. They are also required to have specific emergency arrangements in place.

3.13 **CONSTRUCTION (DESIGN AND MANAGEMENT) REGULATIONS (CDM)**

CDM impose duties on designers, clients (and their agents), developers, planning supervisors and principal contractors. Not all the regulations apply to all construction projects. Further information is given in HSL144. 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.

3.14 **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 that went into the design of the product.

3.15 **REPORTING OF INJURIES, DISEASES AND DANGEROUS OCCURRENCES REGULATIONS (RIDDOR)**

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

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

- death or major injury arising out of the distribution, filling, import or supply of Natural Gas or LPG should be reported by the conveyor for Natural Gas and the filler, importer or supplier for LPG
- dangerous gas fittings (as defined in RIDDOR) should be reported by a "member of a class of persons".

3.15.3 Major injuries, death and dangerous occurrences must be notified immediately, for example by telephone, to the enforcing authority by the "responsible person" as defined by RIDDOR. Reports can be made to the Incident Contact Centre by:

- telephone on 0845 300 9923
- fax on 0845 300 9924
- email to riddor@connaught.plc.uk
- internet at www.riddor.gov.uk or
- via a link from HSE website at www.hse.gov.uk.

It is also possible to report to the local HSE office by telephone and then follow up with a written report on the correct F2508 form within the required timescale (10 days, or 14 days for dangerous gas fittings). Other reports should be made as soon as practicable and within 10 days of the incident.

3.15.4 HSL73 contains detailed guidance on RIDDOR, including a full list of injuries etc. that need reporting. HSE61 (rev 1) and MISC310 give some information on RIDDOR and how to report.

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

3.16 **DANGEROUS SUBSTANCES AND EXPLOSIVE ATMOSPHERES REGULATIONS (DSEAR)**

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

The following publications contain details of DSEAR and their application:

- INDG370
- HSL134
- HSL135
- HSL136
- HSL137
- HSL138.

All gas systems except those in domestic parts of buildings fall within the scope of DSEAR. This requires that a risk assessment be completed for each premise to determine if any hazardous area exists and its extent. Normally, systems of MOP not exceeding 0.5 bar do not require the use of certified electrical components if correctly installed, tested and maintained.

3.17

COMPETENCY

Any person engaged in the design, installation or testing of a compressor system must be competent to carry out such work. Competency is achieved by an appropriate combination of education, training and practical experience.

Installations in GB falling within the scope of the GS(I&U)R also require persons working on gas systems to be registered as a Class of Persons recognised by HSE.

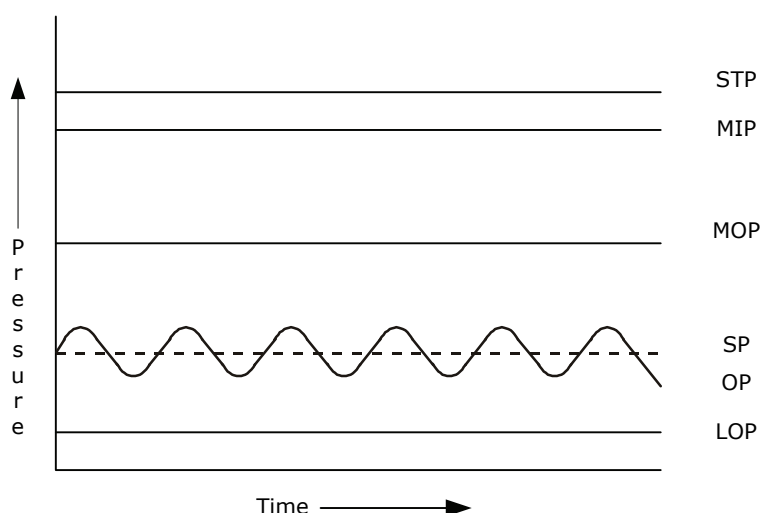
SECTION 4 : GAS SUPPLY

4.1 PRESSURE AT THE OUTLET OF THE ECV

4.1.1 The characteristics of the gas pressure at the outlet connection from the ECV shall be fully specified including any normal or abnormal variations (see Figure 2).

In some cases, it may be permissible to obtain a gas supply direct from the distribution network or national transmission system (NTS) without the application of pressure control regulators at the meter installation. Such a supply requires special permission from the GT and will, if the site is covered by GS(I&U)R, require a relaxation from GS(I&U)R. Reference should be made to IGE/GM/8 Part 1 in such cases.

4.1.2 IGE has adopted the terms and definitions used in European standards for pressure i.e. MOP, operating pressure (OP), maximum incidental pressure (MIP), lowest operating pressure (LOP) and strength test pressure (STP). Figure 1 explains these terms. Further guidance is given in IGE/GM/8 Part 1.



STP	strength test pressure
MIP	maximum incidental pressure (fault pressure)
MOP	maximum operating pressure
SP	set pressure
OP	operating pressure
LOP	lowest operating pressure

FIGURE 1 - RELATIVE PRESSURE LEVELS

4.1.3 The following factors shall be taken into account:

- maximum supply pressure (MOP) and lowest operating pressure (LOP) under normal operating conditions
- maximum and minimum operating pressure that may result under fault conditions of supply to the ECV, especially where it is an un-regulated supply.

Normally, details of these pressures may be obtained from the GT. Where the difference in the maximum and minimum pressures under normal operating conditions is significant, a "best endeavours" estimate of the anticipated variation of pressure with time should be made. For example, a pressure/time profile should be formed (see Figure 2), the time being annual, monthly and/or daily, as required.

SUPPLY PRESSURE	SUPPLY MONTH											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MIP												
MOP												
OP												
LOP												

FIGURE 2 - TYPICAL PRESSURE/TIME PROFILES**4.1.4**

Considering the information required under clauses 4.1.1, 4.1.2 and 4.1.3 and the load to be supplied, it should be decided whether the compressor is to operate:

- over the whole range of gas supply pressures, or
- over part of the range of gas supply pressure, or
- over the whole range of gas supply pressure but with the inlet pressure to the compressor regulated.

Note: Other factors that may influence the choice include:

- the estimated annual power absorption of the compressor
- the capability of the compressor type to accept variable inlet pressure
- the capital cost of overcoming inlet pressure swings
- the anticipated frequency of occurrence of the maximum and minimum supply pressures (see clause 4.1.3)
- load variations during operation of the compressor
- any constraints which may have been applied, to the operation of the compressor system, by the gas supplier and any upstream GT.

4.2**EFFECT OF OPERATING A COMPRESSOR ON THE GAS SUPPLY SYSTEM****4.2.1**

The operation of a gas compressor may cause an abnormally large and rapid change of flow in the gas supply system upstream of the primary meter installation or within the consumer's installation pipework. These changes must not create pressure fluctuations that compromise the proper operation of the gas supply for other consumers (see clause 3.1.1) or of other plant/appliances connected to the installation pipework.

4.2.2

The GT must be notified, at the earliest possible time, of the intention to connect any gas compressor to the gas supply network.

Note: Failure to notify the GT within 14 days of the intended commissioning date is a contravention of the Gas Act.

4.2.3

The following technical details of the proposed compressor system shall be provided to the GT (a typical form is shown in Appendix 13):

- outlet receiver volume
- over- and under-pressure protection devices on the inlet of the compressor
- compressor type and control system
- performance specification for pulsation damping, including inlet pipework and storage volumes
- a process and instrumentation diagram (P&ID) illustrating the safety devices and their logic of operation.
- annual and diurnal load profiles to enable the assessment of the impact of the load on the gas supply system.

Note: If adequate information is not provided, the gas supply may be disconnected (see also clause 3.1.1).

- 4.2.4 As a result of receiving the information provided as required by clause 4.2.3, the GT will, normally, require analysis to be carried out to estimate the worst case effect of the compressor load on the supply network, paying attention to steady state and dynamic situations; in particular the effect of short term dynamic pressure fluctuations in supply networks operating below 0.5 bar. If such an analysis indicates that pressure fluctuations could be excessive, the installation shall comply with any restrictions imposed by the gas supplier and relevant upstream GTs.

Note: Such restrictions may demand:

- *the need for safeguards to prevent simultaneous start up of any compressors that operate in parallel*
- *the specification of particular start up modes for the compressor*
- *the specification of a number of low and high pressure safeguards on the inlet to the compressor, as well as their settings.*

4.3 **GAS COMPOSITION AND CONDITIONING**

- 4.3.1 In the UK, the quality of normally distributed Natural Gas must comply with the statutory requirements of GS(M)R.

- 4.3.2 Any additional specification relating to the quality of gas required by the manufacturer of any particular item of equipment shall be considered in the design of the plant and pipework.

Note: Not all supplies of gas are "dry". "Wet" gas may not be acceptable unless the water is removed prior to compression.

- 4.3.3 During design, consideration shall be given to periodic fluctuations in supply composition from the gas transportation system. Advice should be sought from the GT.

- 4.3.4 Gas passing from a compressor, or its associated downstream drying system if fitted, shall have a moisture content which shall not cause hydrate/water formation in any downstream equipment or vehicle fuel system under the expected operating conditions.

It may be necessary to install a gas drying system to achieve the required moisture content, which may, in turn, reduce the odorant level. Where appropriate, Natural Gas supplied from any drying system shall be treated to comply with GS(M)R if it is to be resold, for example at a Natural Gas vehicle filling station.

- 4.3.5 Where the composition of the gas supplied is required to be within limits specified by the equipment manufacturer, details of the composition of gas and any known variations should be obtained from the gas supplier/GT and agreed with the equipment manufacturer/supplier.

- 4.3.6 Where appropriate, additional gas pre-treatment equipment should be installed. This may include liquid collection receivers ("knockout pots"), which should be installed on the gas inlet to the compressor.

Note: For example, knockout pots may be required if the supply is close to a point on the gas supply network where glycol fogging is carried out by the GT on a low pressure distribution system.

4.4 **FILTRATION**

- 4.4.1 A filter or strainer shall be fitted on the inlet to any compressor, providing filtration to the level specified by the compressor manufacturer. It shall not be assumed the gas supplier/GT provides adequate filtration.

4.4.2 Consideration shall be given to the fitting of twin stream filters with appropriate valving, to enable routine changing or cleaning of filter elements without interfering with the operation of the compressor.

4.4.3 A system or mechanism shall be employed to ensure that it is not possible to access any high pressure filter, for removal, before venting the associated pipework.

4.4.4 Consideration shall be given to:

- the provision of filter differential pressure indication and/or alarms
- protection against filter element failure.

4.5 **PROTECTION OF THE GAS SUPPLY SYSTEM**

There are specific legal duties on persons installing and operating compressors to prevent nuisance to others and to protect the gas supply system which must be complied with (see Sub-Section 3.1 and 4.2).

4.5.1 **Protection against reverse pressurisation**

4.5.1.1 *General*

4.5.1.1.1 The consumer must provide adequate protection against reverse pressures being fed back into the upstream network.

4.5.1.1.2 Any system assessment shall identify the probability and consequences of failure, as well as any specific precautionary measures that shall be taken to either prevent or reduce the effects of any such failure.

Note: Guidance on calculating potential over- and under-pressures is given below and in Appendix 10. Appendices 5 and 6 summarise the design of safety devices.

4.5.1.2 *Over-pressure protection of the supply system*

4.5.1.2.1 If the maximum settle-out pressure (see clause 4.5.1.4) is less than the maximum gas supply pressure, a minimum of one non-return valve (NRV) shall be installed.

Note 1: In the context of this Standard, a NRV is one that closes in the event of reverse gas flow and will, generally, not require manual re-setting. This NRV has to be acceptable to the GT and not be affected by the pulsing flows when used in conjunction with a reciprocating compressor, as may be the case with the simple swinging flap type valve.

Note 2: Piston type NRVs may be acceptable for screw, centrifugal and sliding vane compressors that can accept higher inlet pressure drops across such valves. In such cases, the inlet low pressure protection device may need locating upstream of the NRV.

4.5.1.2.2 If the maximum settle-out pressure does not exceed 2 bar but exceeds the maximum gas supply pressure (MOP_u), a minimum of two safety devices shall be installed. These shall include a NRV (on the outlet of the compressor) and one of the following:

- a relief valve on the suction side of the compressor
- a NRV on the inlet of the compressor
- an actuated slam-shut valve (SSV) installed on either the inlet or outlet of the compressor, with its signal taken from the inlet of the compressor. Any such valve shall close on unacceptably high pressure on the upstream side of the compressor and shall not be capable of being reset until the pressure has been restored to normal.

Note: This valve may be pneumatically (gas or air) driven or electrically powered.

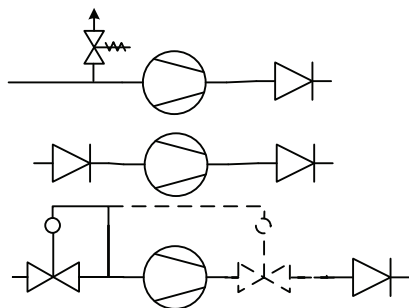
4.5.1.2.3 If the maximum settle-out pressure exceeds 2 bar and exceeds the maximum gas supply pressure (MOP_u), a minimum of three safety devices shall be installed. These shall include a NRV on the outlet of the compressor and upstream of any receiver (it need not be upstream of the filter coalescer) and at least two of the following:

- a relief valve on the inlet of the compressor
- a NRV on the inlet of the compressor
- an actuated SSV which closes on sensing unacceptably high pressure on the upstream side of the compressor which shall be fitted upstream of the compressor (and upstream of any inlet pulsation/snubber vessel).

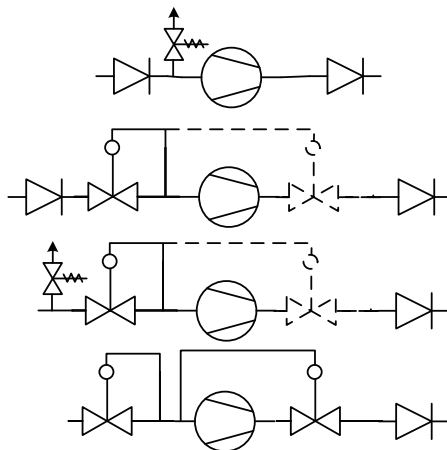
Note 1: Figure 3 shows arrangements described above.

Note 2: Other protection methods, for example a double block and bleed valve system, are acceptable provided they give at least an equivalent level of protection to that obtained in clause 4.5.1.2(b) and (c) as appropriate. A reciprocating compressor without any form of spillback or cylinder unloading may be considered as equivalent to a second non-return valve.

Note 3: In certain cases, particularly large or complex installations, it may be necessary to fit an additional NRV on the outlet of the meter installation.



(a) System protection systems for maximum settle out pressure not exceeding 2 bar (clause 4.5.1.2.2)



(b) System protection systems for maximum settle out exceeding 2 bar (clause 4.5.1.2.3)

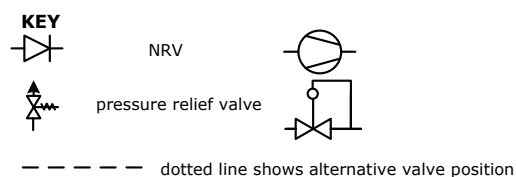


FIGURE 3 - TYPICAL CONSUMER INSTALLATIONS

4.5.1.3 Under-pressure protection of the supply system

In the event of an inlet low gas pressure condition occurring, the control system shall respond to a sensor in the inlet pipework of the compressor and shut down the compressor if the gas supply pressure falls to an unacceptable level (also see clause 4.5.2 and Table 1 in clause 6.19.2).

4.5.1.4 Determination of the maximum settle-out pressure

The maximum settle-out pressure at the ECV shall be determined by calculating the worst-case condition that can occur when the compressor discharge volume expands back into the supply installation.

$$P_{so} = [(P_{in} \cdot V_{in} / Z_{in}) + (P_{out} \cdot V_{out} / Z_{out})] \cdot [Z_{so} / (V_{in} + V_{out})]$$

P_{so}	final equilibrium pressure at the ECV (bar absolute)
P_{in}	maximum pressure at the ECV when the compressor is operating (bar absolute)
V_{in}	volume of pipework (including any snubber volumes) between the compressor inlet and the ECV (m ³)
Z_{in}	compressibility factor at P_{in}
P_{out}	maximum outlet pressure of the compressor (bar absolute)
V_{out}	total volume of the compressor outlet pipework including any receiver (m ³)
Z_{out}	compressibility factor at P_{out}
Z_{so}	compressibility factor at P_{so}

Note: Appendix 9 includes compressibility factor information for a typical UK Natural Gas. Appendix 10 gives an example of the calculation.

4.5.1.5 Potential high reverse pressures applied to the inlet system

The compressor manufacturer/system designer shall ensure that any inlet pulsation/snubber vessel is of sufficient size to limit pressure increases during any bypass flow condition to a level of at least 20% below the relief valve setting of either the inlet cylinder of the compressor or any other relief valve within the upstream pipework or meter installation system.

4.5.2 Protection against under-pressure

The gas supply network upstream of the primary meter installation must be protected from unacceptably low pressure conditions resulting from compressor operation.

4.5.2.1 An independently-wired low gas pressure cut-off switch/transducer shall be installed, which shall operate when the pressure falls below that acceptable to the GT. Automatic re-start shall be prevented in the event that the inlet pressure at the compressor falls below that acceptable to the GT.

Note: The set pressure of the pressure cut-off switch/transducer will reflect the minimum pressure acceptable to the GT as measured at the ECV.

4.5.2.2 If necessary, an additional safety device shall be installed to prevent the compressor from causing unacceptably low pressure in the gas supply to other plant i.e. boilers etc., supplied from the pipework common to the compressor suction.

Note: For example, the safety device could include a specific start-up control system, to ensure that specified rates of change of flows (ramp rates) would not be exceeded, or a "low suction pressure" SSV could be installed.

4.5.2.3 There shall be no built-in mechanical or electrical by-pass of the pressure switch.

4.5.2.4 Latching pressure switches shall not be used unless the design is such that failure of, or tampering with, the mechanism cannot lead to unsafe conditions.