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BSI Standards Publication

Industrial Gas Installation — Guideline

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National foreword

This Published Document is the UK implementation of CEN/TR 16787:2014.

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (CEN/TR 16787:2014) has been prepared by CEN Sector Forum Gas.

Introduction

Gas industry leaders acknowledge the strategic role of European and National Standards in their efforts to ensure the safety of gas installations in industrial premises. This Technical Report has been prepared to explain to those involved with industrial premises some of the relevance of a range of Directives that affect their operations. In addition guidance is given on the terms and definitions widely in use throughout the European Union, together with some important information on how a consumer of gas can ensure safety in operating their site. Minimizing the adverse effects on the environment is also an important consideration.

European and National legislation and the related framework of standards are complex and changing at an ever increasing pace. For industrial plant engineers, finding the relevant standards can be a difficult task, demands specific knowledge, and can consume a considerable amount of time. A number of the principal standards are highlighted in this Technical Report, but EU Member States may have similar or equivalent standards covering the application. Additionally, member states may have slightly different legal systems and requirements that demand compliance.

Both designers and installers play an important role in applying the current standards for design, construction, testing, commissioning and operation of all industrial gas installations. Safety is therefore improved and the full energy efficiency potential of industrial thermal processes can be utilized.

It is recognized that the main reference is this Technical Report is to Natural Gas but many standards equally apply directly to LPG and LPG/Air mixtures. This Technical Report is also applicable to many bio-gases, and other flammable gases, and the user will need to ensure they are aware of any different requirements needed to ensure safety. For example some gases may be very hot or corrosive, some may be ‘wet’ and others may contain significant quantities of toxic gases such as carbon monoxide. Hydrogen rich gases may also require special attention to material selection.

Finally, due to the complexities and special needs of some types of process plant, it may be necessary to adopt higher standards of safety and to use risk assessments to ensure reliable judgements on plant safety.

In applying the recommendations contained within this Technical Report it is important that the relevant requirements of national guidance standards and legislation are considered.

In some cases where a lack of information is available in a member state, guidance from other member states or by other recognized national bodies such as ASME or API may be used.

The range of industrial thermal process and heating equipment providing energy solutions to customers for a diverse range of applications is significant.

1 Scope

This Technical Report applies to safety and operational topics for equipment and pipework systems installed within industrial premises which may be used for process and non-process applications such as Heating, Power Generation, Incineration, etc.

It is applicable to a range of combustible gases used within an industrial environment. The gas plant may include normal combustion with air and/or oxygen, catalytic oxidation or cracking (e.g. as in a refinery).

The user of gas equipment and pipework systems has a responsibility to ensure the safety of the design, of plant operation and plant maintenance.

For piped supplies of gas to a site this Technical Report applies to the system downstream of the 'point of delivery'. The term, 'point of delivery' refers to the isolation valve (or combination of regulator and isolation valve) located before or after the metering station, as will be defined by the particular EU member state national legislation.

The guidance in this Technical Report may also apply to gases generated for the sites own use, such as coke oven gas, site bio-gas plant, site LPG/air plant etc.

2 Normative references

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

EN 1775, *Gas supply — Gas pipework for buildings — Maximum operating pressure less than or equal to 5 bar - Functional recommendations*

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 — Part 1: Detailed functional requirements for design, materials, construction, inspection and testing*

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 — Part 2: Detailed functional requirements for commissioning, operation and maintenance*

EN ISO 6976, *Natural gas — Calculation of calorific values, density, relative density and Wobbe index from composition (ISO 6976)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE These terms and definitions are given for information as they are widely used in the gas industry.

3.1 General terms

3.1.1
air gas ratio
ratio between the flow of combustion air and the flow of the fuel gas

Note 1 to entry: Sometimes fuel/air ratio is used. It can either be expressed in terms of volume or mass flows.

3.1.2
air factor
ratio between the actual flow of combustion air and the stoichiometric flow of combustion air

Note 1 to entry: It can be expressed in terms of volume or mass flows.

3.1.3
components
any item from which a gas supply system or installation is constructed

Note 1 to entry: A distinction is drawn between the following groups of components:

— ancillaries (for example; pressure regulators, valves, safety devices, expansion joints, and insulating joints);

— pipes, including bends made from pipe;

— instrumentation pipework;

— fittings (for example; reducers, tees, factory-made elbows, flanges, dome ends, welding stubs, and mechanical joints).

3.1.4
flexible appliance connector
fitting of flexible pipe to be fitted between the end of fixed pipework and the appliance inlet connection

3.1.5
gas appliances
appliances burning gaseous fuels used for cooking, heating, hot water production, refrigeration, lighting or washing and having, where applicable, a normal water temperature not exceeding 105 °C, except those specifically designed for use in industrial processes carried out on industrial premises

3.1.6
HAZOP
hazard and operability study (HAZOP) is a structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation

3.1.7
industrial appliances
appliances burning gaseous fuels installed in industrial premises and are subject to specific national health and safety regulations

3.1.8
pressure
gauge pressure of the fluid inside the system, measured in static conditions

3.1.9
design pressure
DP
pressure at which the design calculations are based

Note 1 to entry: This is equivalent to the maximum allowable pressure (PS) as given in the PED.

3.1.10
maximum allowable pressure
PS
maximum pressure for which pipework is designed in accordance with the strength requirements

3.1.11
maximum incidental pressure
MIP
maximum pressure at which a system can experience during a short time, limited by the safety devices

3.1.12
operating pressure
OP
pressure which occurs within a system under normal operating conditions

3.1.13
maximum operating pressure
MOP
maximum pressure at which a system can be operated continuously under normal operating conditions

Note 1 to entry: Normal operating conditions are: no fault in any device or stream.

3.1.14
tightness test pressure
TTP
pressure applied to a system during tightness testing

3.1.15
strength test pressure
STP
pressure applied to a system during strength testing

3.1.16
combined test pressure
CTP
pressure applied to a system during combined testing

3.1.17
risk assessment
identification, evaluation, and estimation of the levels of risks involved in a situation, their comparison against benchmarks or standards, and determination of an acceptable level of risk

Note 1 to entry: In this sense Risk is, 'the likelihood and consequence of a hazard being realized'.

3.1.18
point of delivery
point of transfer of ownership of gas from the supplier to the customer

Note 1 to entry: This can be at a means of isolation or at the meter outlet connection.

Note 2 to entry: This can be isolation valve (or combination of regulator and isolation valve) located before or after the metering station, as defined by the particular EU member state.

3.1.19
user(s)
person (s) responsible for the safety of the gas installation and associated risks on a site

Note 1 to entry: Normally the user will be the site occupier or owner. It should be assumed that every user has a responsibility for work performed on their site, whether or not the work is performed directly for the user or not. This does not mean that they cannot take advice from an independent specialist.

3.1.20
pipework
assembly of pipes and fittings

3.1.21
installation pipework
pipework downstream of the point of delivery terminating at the appliance inlet connection

Note 1 to entry: This pipework is normally the property of the customer.

3.1.22
ventilated space
space where the air is continuously changed by natural or mechanical means

3.1.23
safety zone
area around the pipework from which persons who are not involved in the strength test are excluded during testing

3.1.24
equipotential bond
means of ensuring that metallic gas pipework and other metallic parts of the building are at the same electrical potential

Note 1 to entry: For safety reasons, this equipotential bonding is connected to earth.

3.1.25
duct
space specifically designed and constructed for the passage of building services

EXAMPLE Building services include gas pipework, water systems, power and telecommunication cables.

3.1.26
ventilation duct
duct forming part of the structure of the building and intended exclusively for ventilation purposes

3.1.27
means of isolation
device which is intended to interrupt the gas flow in pipework

EXAMPLE Manually operable valve.

3.2 Definitions relating to jointing methods

3.2.1
joint
means of connecting elements of a gas installation

3.2.2
flanged joint
joint in which gas tightness is achieved by compression of a gasket between the faces of two flanges

3.2.3
threaded joint
joint in which gas tightness is achieved by metal-to-metal contact within threads with the assistance of a sealant

3.2.4
mechanical joint
joint in which gas tightness is achieved by compression, with or without a seal and which can be disassembled and reassembled

Note 1 to entry: This definition includes twin ferrule type joints.

3.2.5
pressed joint
joint in which tightness is achieved by using a specific tool for either compressing a fitting to form the joint or expanding a pipe to enable forming the joint

3.2.6
brazed joint
joint formed by brazing

3.2.7
welded joint
joint formed by welding

3.2.8
electro fusion joint
joint formed between polyethylene components using fittings which have an integrated electric heating element

3.2.9
butt fusion joint
joint formed between polyethylene components where the two pipe ends are heated and brought together to be fused directly without the use of a separate fitting or filler material

3.2.10
compression joint
type of joint in which gas tightness is achieved by compression within a socket with or without a seal

3.3 Definitions relating to components

3.3.1
regulator
device which reduces the gas pressure to a set value and maintains it within prescribed limits

3.3.2
appliance connection
flexible pipe or length of rigid pipework connecting an appliance's means of isolation with the appliance inlet connection

3.3.3
insulating joint
fitting installed to insulate electrically one section of pipework from another

3.3.4
sleeve
protective pipe through which a gas pipe passes

3.3.5
vent pipe
pipework connected to a safety or control device to release gas at a safe location

3.3.6
creep relief valve
device designed to release a limited flow of gas in the event of an unacceptable pressure being detected within the system it protects

3.3.7
safety slam-shut device
device designed to quickly shut off the gas flow in the event of an unacceptable pressure being detected within the system it protects. This often referred to an over-pressure or under-pressure shut off device

3.3.8
instrumentation pipework
pipework required for the proper functioning of the ancillaries installed within the pressure regulating installation

EXAMPLE Sensing, measuring, auxiliary and sampling lines.

3.3.9
DN
alphanumeric designation of size for components of a pipework system, which is used for reference purposes

Note 1 to entry: It comprises the letters DN followed by a dimensionless whole number, which is indirectly related to the physical size, in millimetres, of the bore or outside diameter of the end connections.

Note 2 to entry: The number following the letters DN does not represent a measurable value and should not be used for calculation purposes except where specified.

Note 3 to entry: Where DN designation is used, any relationship between DN and component dimensions are given, e.g. DN/OD or DN/ID.

3.4 Definitions relating to tests

3.4.1
strength test
specific procedure intended to verify that the pipework meets the requirements for mechanical strength

3.4.2
leak-tightness test
specific procedure intended to verify that the pipework meets the requirements for leak-tightness

3.4.3
combined test
specific procedure to verify that the pipework and/or installation meets the requirements for mechanical strength and leak-tightness

3.4.4
leak detection fluid
specially formulated fluid and foaming product that gives a clear indication that a leak exists when applied to an element of pipework

3.5 Definitions relating to assembly processes for metallic materials

3.5.1
welding
joining (union) of two or more parts by heat or pressure or a combination of both, (fusion, arc or oxy-acetylene) such that the materials form a continuity

Note 1 to entry: A filler metal having a melting point similar to that of the materials to be welded can be used.

3.5.2
brazing
operation in which metal parts are joined by means of capillary action of a filler metal in the liquid state with a melting temperature, higher than 450 °C, lower than that of the parts to be joined and wetting the parent metal(s), which does not participate in the making of the joint

Note 1 to entry: This is often referred to as hard soldering.

3.5.3
hot tapping
procedure involving the safe use of heat, e.g. welding or fusion, to affix an attachment to a section of pipework containing gas at pressure

3.6 Definitions relating to pressure regulating and metering

3.6.1
compressors
complete unit for raising the gas pressure within installation pipework above 0,5 bar to an OP greater than 5 bar

3.6.2
station
gas pressure regulating and/or metering system including (where applicable) the housing, the odourisation facilities and the fenced site

3.6.3
gas pressure regulating and metering system
system comprising all equipment, together with inlet and outlet pipework up to and including the isolating valves, which together performs the functions of pressure regulation, pressure safety and/or quantitative gas measurement, whether or not including pressure boosting and/or gas mixing facilities

3.6.4
monitor
second regulator used as a safety device in series with the active regulator which assumes control of the pressure at a higher set value in the event of the active regulator failing open

3.6.5
excess air ratio (λ)
ratio between the effectively introduced quantity of air and the theoretically required quantity of air

Note 1 to entry: The terms Lambda and air factor are also used to describe this ratio.

3.6.6
Wobbe index
Gross Wobbe index W_s; net Wobbe index W_i, ratio of the calorific value of a gas per unit volume and the square root of its relative density under the same reference conditions

Note 1 to entry: The Wobbe index is said to be gross or net according to whether the calorific value used is the gross or net calorific value.

3.6.7
gas family
group of gaseous fuels with similar burning behaviour, linked together by a range of Wobbe indices

3.6.8
gas group
group of gases with same specified range of Wobbe index

4 Safety management

4.1 General

To ensure the safety of an Industrial Installation, the equipment used shall be fit for purpose.

There is a legal requirement for equipment used in European installations to bear a CE mark as required by the various applicable Directives. A CE mark may not be required in all cases.

It is important to consider at the initial design stage of an installation, the maintenance requirements of equipment. If it is dangerous, or unacceptable to shut down parts of a plant to carry out maintenance at the required interval, redundant systems may need to be implemented.

To ensure the safety of the design and its operational suitability it is normal to carry out some form of risk assessment or HAZOP during the design and prior to commissioning. These should highlight any risk and operational issues and enable design modifications to be made at an early stage.

Maintenance procedures should be such that the release of a flammable or toxic gas during maintenance does not lead to a dangerous condition.

4.2 Maintaining records of completed gas work

In the context of Quality Management, it is important that the Technical File, Construction File, Explosion Protection Document and Conformity File are maintained and updated regularly to match with activities concerning the industrial gas installation. Here below there is an example scheme.

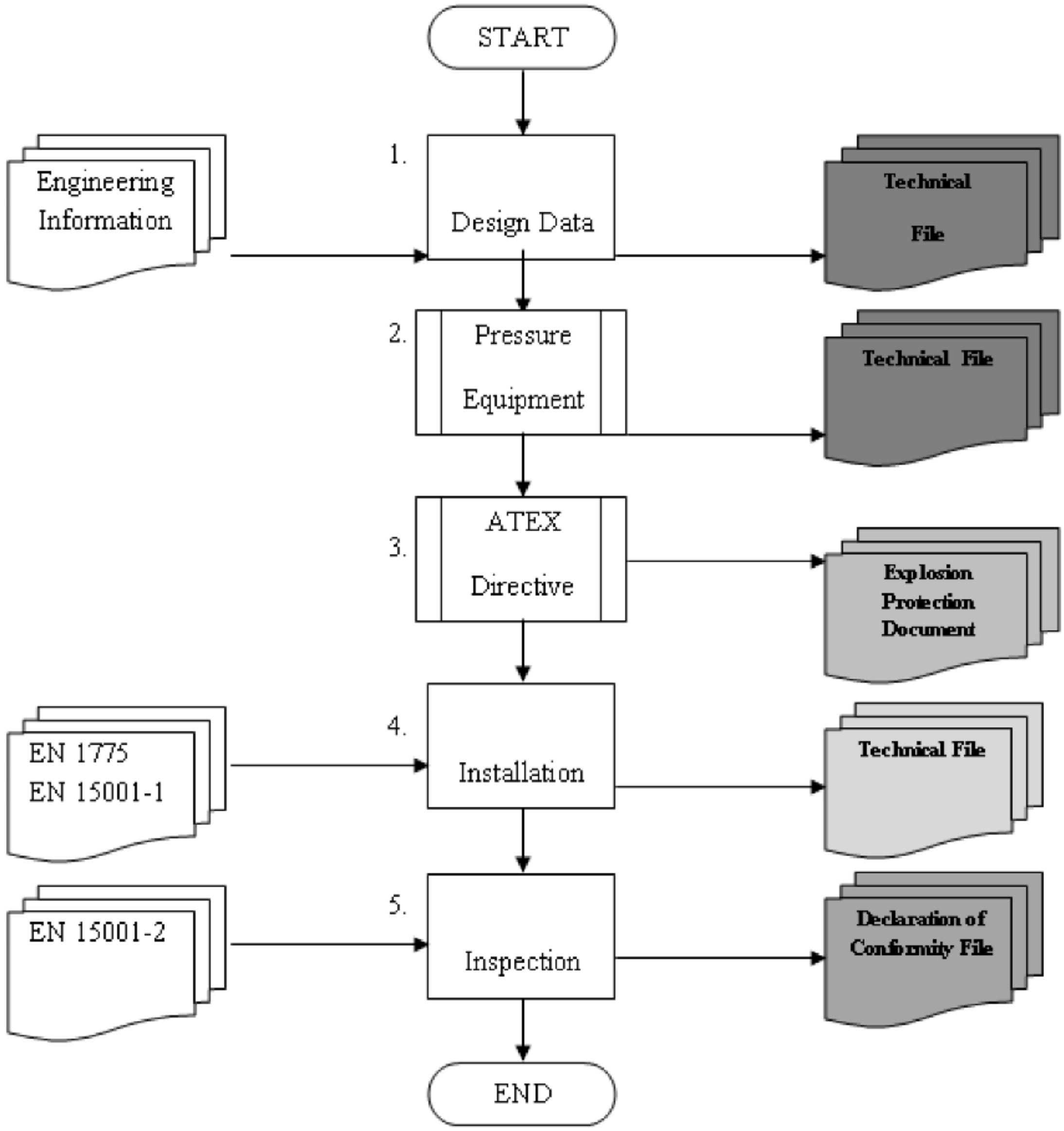

Figure 1 — Flow chart for maintaining records

4.3 The technical file

Technical files should be generated that contain some or all of the following:

— operators manual containing the equipment specification and operational procedures;

— service and maintenance manual;

— declarations stating compliance with the required European Directives, i.e. GAD, PED, ATEX, LVD, EMC, Machinery Directive etc.;

— information related to lifetime of parts used in the equipment where failure may lead to danger e.g. seals, diaphragms, flexible pipes;

— details of all settings of safety devices and controls upon completion of commissioning. Includes control safeguards (leak tightness check, gas valve closed position proving, maximum gas pressure, minimum gas pressure, combustion air pressure/flow, maximum medium temperature, maximum medium pressure, minimum medium level, flame detection and E.S.D. (Emergency Shut Down));

— details of as commissioned combustion settings such as composition of the flue gas (O_2, CO_2, CO and NO_X), flue gas temperatures;

— if necessary, a maintenance schedule for the equipment.

4.4 The construction file

The user should ensure that a Construction File is available and that it contains the following information (with parts lists where appropriate):

— type of pressure equipment, phase condition and physical properties;

— design pressure(s) PS, temperature(s) maximum and minimum and nominal size diameter;

— conformity assessment, declaration of conformity;

— welders qualification (EN 15001);

— specification and qualification of welding procedures (EN 15001);

— specification and approval of welding procedures for metallic materials (EN 15001);

— non-destructive testing (EN 15001).

4.5 The explosion protection document

The user should ensure that an Explosion Protection Document is available in order to comply with ATEX User Directive and that it contains the following information:

— risk assessment;

— list of hazard sources;

— zone classification of hazardous areas;

— technical and organisational measures taken;

— drawings with hazard sources and classified zones;

— operational procedures to maintain safety.

4.6 The declaration of conformity file

Where necessary, the user should ensure that a declaration of Conformity File is available and that it contains the following information:

— Gas pipe line:

  — examination of joints;

  — verification of materials and components;

  — the route and construction of pipework;

  — the correct use of safety markings and signs;

  — verification of corrosion protecting measurements;

- — test results (non-destructive tests, strength test, leakage test and visual inspection); and
- — Inspection report(s) with the above mentioned check and tests.

— Thermal process equipment / industrial appliances:

- — boiler/furnace location (setting, combustion air intake, flue gas exhaust);
- — setting of pressure regulator and safety devices;
- — CE-marking burner and installation and there specifications;
- — start-up sequence (purge-/ventilation time, ignition time, opening safety shut-off valves and flame detection);
- — safety times (safety time main/pilot burners, reaction time flame detection, closing time safety shut-off valves main burners);
- — execute measurements on various burner loads (e.g. minimum, maximum and two in between) measuring gas flow, gas supply pressure, gas pressure after reduction, burner pressure, combustion air pressure/flow; medium quantity (temperature, pressure), composition of the flue gas (O_2, CO_2, CO and NO_X); and
- — inspection report(s) with the above mentioned check and tests.

5 Gas composition and characteristics

5.1 Properties of gases

5.1.1 Natural gas

Natural gas is a mixture of light hydrocarbons including methane (>70 %), ethane, propane, butane and pentanes and other compounds including CO_2 and nitrogen.

Natural gas is neither corrosive, nor toxic, its ignition temperature is high, and it has a narrow flammability range, making it an inherently safe compared to other fossil fuel sources.

In addition, because of its specifics gravity lower than that of air, natural gas rises if escaping, thus dissipating upwards from the site of the leak.

The specific characteristics of the natural gas being delivered to the gas consumer are available within the gas industry.

5.1.2 LPG

This normally covers commercial Butane or commercial Propane. Both of these gases may be mixtures with other gases. For propane this may typically be 85 %+ Propane, up to 10 % Propylene/Propane, 5 % to 7 % Isobutene, 5 % to 7 % Ethane and up to 5 % Butane. The specific characteristics of the gas being delivered should be available from the supplier.

5.1.3 Non-conventional gases

5.1.3.1 Bio gas

5.1.3.1.1 Basic definitions

Bio gas is a methane rich gas with a balance of carbon dioxide produced by bacteria in anaerobic (air-free) conditions.

For most purposes it can be divided into two categories, anaerobic digestion type and land-fill type.

The anaerobic digestion type gas is generated from organic waste which is suspended in water in an air free chamber so that there is no oxygen present in the resulting gas.

Bio-gas is normally a product of a microbiological degradation processes. The primary sources of bio-gas for many years have been from waste treatment systems utilizing anaerobic digesters or solid waste landfills. Both of these waste treatment systems rely upon anaerobic bacteria to convert organic matter to methane (CH_4) 60 %–70 % and carbon dioxide (CO_2) 30 %–40 %. The major differences between these processes are that landfill sites are established over a period of years rather than days. Anaerobic digesters are typically used for treating biological sludges, manures, and other high solids wastes.

From a safety perspective, however produced, one has to remember that Bio-gases can be odour free.

Most systems generate a methane based gas with levels varying between say about 40 % and 90 %. Typical biogas has a distinctive odour but not as pungent as natural gas odours. Since its specific gravity varies it should be treated for safety as a gas that can rise or fall in air. This means ventilation shall be considered for both heavy and light gases at the same time. Equally the location of flammable gas detectors may be preferred at low rather than high levels.

Landfill gas, when not utilized as a fuel, is usually flared at high temperatures – a process that destroys most of the toxic and odorous components. Passive venting of landfill gas to atmosphere is no longer acceptable. At all landfill sites, some landfill gas will escape to atmosphere through the surface and lining of the site. The percentage of fugitive gas escaping will depend primarily on the collection efficiency on-site, the design of the lining, the capping of the site and the volume of gas generated.

Table 1 — A typical gas is produced from a woodchip fuelled bio-mass gasifier (pyrolisis)

Constituent	%
Hydrogen H_2	16
Methane CH_4	3,3
Ethane $C_2 H_6$	0,7
Propane $C_3 H_8$	0,4
Butane $C_4 H_{10}$	trace
Pentane $C_5 H_{12}$	trace
Hexane $C_6 H_{14}$	trace
Carbon Monoxide CO	20,8
Carbon Dioxide CO_2	11,4
Nitrogen N_2	45,8

Bio-mass gasification processes generate organic contaminants in the exit gases that are generally referred to as tar. Before use of the gases in a boiler, engine or turbine, particulate matter and the organic tar shall be removed, or reduced to a level that is acceptable to end user requirements.

One of the most significant hurdles leading to the development and subsequent scale up of bio-mass gasification is gas cleaning for particulate and organic contaminant removal prior to use in boilers and particularly power generation plant such as engines and turbine applications.

Bio-gas from anaerobic digesters can be upgraded to bio-methane and injected into a gas grid. This can be the national high pressure gas transmission grid or a local low pressure gas distribution network. To be used in the gas grid, the bio-gas needs to be cleaned of impurities, dried and upgraded to a higher methane content (about 95 %) so that it resembles the qualities of natural gas. This approach is already being used in many countries including Germany, France, Austria and the USA.

Some of the fuels may also contain sulphur that can lead to acid corrosion in the flues and appliances. Some landfill may contain compounds of silicon (as a white powder in the exhaust system) that can be carcinogenic.

Anaerobic digesters can produce a wet and dusty gas even after filtration and drying.

5.1.3.1.2 Materials

If the gas has been sulphur stripped and properly dried conventional steel pipework can be used otherwise a basic stainless steel or PE materials should be considered.

5.1.3.2 Carbon monoxide rich gases

5.1.3.2.1 Blast furnace gas and coke oven gas

Blast furnace gas (BFG) and coke oven gas (COG) are by-products of thermal processes operated in steel industry. BFG is generated when the iron ore is reduced with coke to metallic iron in blast furnaces. COG is produced by the process of converting coal into coke.

Both are gaseous fuels used locally to supply different thermal equipment such as steam boilers, reheating furnaces or coke ovens. Because of its very low heating value, BFG is often combined with more calorific fuels (natural gas, COG) and sometimes directly flared by torch burners.

However when its combustion temperature is increased by preheating or by burning with O_2, then its utilization is widened.

Typical compositions (dry gas) and main characteristics of BFG and COG are given in the following table:

Table 2 — Typical compositions (dry gas) and main characteristics of BFG and COG

	BFG	COG
Carbon monoxide	18 – 22 %	4 – 8 %
Hydrogen	2 – 4 %	50 – 60 %
Methane	< 1 %	20 – 30 %
Ethane and other C_nH_m	Trace	< 2 %
Carbon dioxide	20 – 24 %	< 3 %
Nitrogen	50 – 60 %	3 – 10 %
NCV (MJ/Nm^3)	2,7 – 3,3	15,5 – 17,5
Relative density	Approx. 1,06	0,3 – 0,4
Wobbe Index (MJ/Nm^3)	2,6 – 3,2	26 – 30
FCO2 (tCO_2/TJ) [a]	259,4	44,7

[a] CO_2 emission factor: reference values given in the guidelines of the Directive 2003/87/EC. To be compared to reference value for natural gas (56,1 tCO_2/TJ)

5.1.3.2.2 Pyrolysis

Some installations use thermo-chemical processes such as pyrolysis as a means to convert the waste to a gas, similar to the old gas works. This gas can have totally different compositions to those generated by anaerobic means. Pyrolysis is thermal decomposition occurring in the absence of oxygen, a bit like a charcoal production plant.

Gasifiers are usually used to produce the gas rather than anaerobic digesters. More recently gas has been produced from waste such as woodchips or solid waste materials which produce hydrogen and carbon monoxide rich gases with only small quantities of methane. Hydrogen is very high flame speed gas and CO is potentially very dangerous. It has explosive/flammable limits that are wider than for a methane based gas, about 3 % to 30 % gas in air. The very high level of inert gases (CO_2 and N_2) has a significant effect on the performance of all gas fired plant as they delay ignition and slow down the flame speed to a great extent causing flames to be far longer than normal.

5.1.4 Town gas (not widely available in Europe)

Town gas (also “coal gas” or “manufactured gas”), typically made by the destructive distillation of coal, is still distributed in areas not connected to the natural gas grid

Table 3 — Typical composition of Town gas

	Typical composition
Carbon monoxide	15 % – 20 %
Hydrogen	40 % – 50 %
Methane	Approximately 20 %
Ethane and other C_nH_m	0 % – 5 %
Carbon dioxide	0 % – 5 %
Nitrogen	5 % – 15 %
NCV (MJ/Nm^3)	15 – 20
Relative density	0,4 – 0,6
Wobbe Index (MJ/Nm^3)	25 – 30
FCO_2 (tCO_2/TJ)*	40 – 50

Town gas is very similar to coke oven gas, although not identical: where coke oven gas is a by-product of coke production, and often used as available from the coke oven, town gas is often produced in specific "gas plants". Composition (the main components) is very similar to coke oven gas – the main difference is the town gas is cleaned and dried before it is distributed.

5.2 The Wobbe index and non combustion parameters

5.2.1 Wobbe index

5.2.1.1 General

The Wobbe index is an indicator to compare the combustion energy output of different composition fuel gases.

If two fuels have identical Wobbe indices then for the same pressure conditions the burner energy output will be identical.

Wobbe index (or Wobbe number) reflects gas composition and is a measure of burner compatibility.

The Wobbe index is seen as a critical factor to minimize the impact of the changeover when studying the use of different gases in a given appliance. That is called interchangeability of fuel gases and is frequently defined in the specifications of gas supply. It is widely used to assess gas compatibility where the composition of the gas entering the transmission system can vary from location to location.

If H is the Calorific Value of a gas, and d is its relative density, the Wobbe index W is defined as:

W = H/ (d)1/2 which may be expressed in Gross W_s or Net W_i terms

There are three ranges or "families" of fuel gases that have been internationally agreed based on Wobbe index. Natural gas belongs to the second family of gases (with high and low ranges).

Combustion equipment is typically designed to burn a fuel gas within one particular family and group: hydrogen-rich Town Gas, Natural Gas or LPG (commonly referred to as second family H-gas).

5.2.1.2 Classification of gases

Gases likely to be used are classified following EN ISO 6976 into three families in accordance with their Wobbe index.

— 1^{st} Family (manufactured gases: e.g. town gas);

— 2^{nd} Family (natural gases or substitute natural gases e.g. LPG/air);

— 3^{rd} Family (liquefied petroleum gases).

Other gaseous fuels.

These values are presented at the following table:

Table 4 — Gas families and groups

Gas Families and groups	Gross Wobbe index at 15 °C and 1013,25 mbar (MJ/m^3)	
	Minimum	Maximum
First Family		
Group A	22,4	24,8
Second Family	39,1	54,7
Group H	45,7	54,7
Group L	39,1	44,8
Group E	40,9	54,7
Third Family	72,9	87,3
Group B/P	72,9	87,3
Group P	72,9	76,8
Group B	81,8	87,3

5.2.2 Non – combustion parameters

Raw natural gas typically consists primarily of methane (CH_4), the shortest and lightest hydrocarbon molecule. It also contains varying amounts of:

— pentanes and even higher molecular weight hydrocarbons. When processed and purified into finished by-products, all of these are collectively referred to Natural Gas Liquids (N.G.L.);

— acid gases: carbon dioxide (CO_2), hydrogen sulphide (H_2S) and mercaptans such as methanethiol (CH_3SH) and ethanethiol (C_2H_5SH);

— other gases: nitrogen (N_2) and helium (He);

— water: water vapour and liquid water;

— liquid hydrocarbons: perhaps some natural gas condensate and/or crude oil.

The raw natural gas from the gas well is purified to meet the quality standards specified by National regulations and/or the major pipeline transmission and distribution companies. Those quality standards vary from pipeline to pipeline and are usually a function of a pipeline system's design and the markets that it serves.

In general, the standards with regards the natural gas and LPG specify the following:

— be within a specific range of Gross or Net Calorific Value;

— be delivered at or above a specified hydrocarbon dew point temperature (below which some of the water or hydrocarbons in the gas might condense at pipeline pressure forming liquid slugs which could damage pipes);

— be free of particulate solids and liquid water to prevent erosion, corrosion or other damage to the pipeline;

— be dehydrated of water vapour sufficiently to prevent the formation of methane hydrates within the gas processing plant or subsequently within the sales gas transmission pipeline;

— contain no more than trace amounts of components such as hydrogen sulphide, carbon dioxide, odourants (such as mercaptans), nitrogen, and water vapour.

An important variable to be controlled is the total sulphur and specially the hydrogen sulphide, a colourless, toxic gas with an odour similar to rotten eggs. It is an undesirable constituent of natural gas and LPG, and is reduced to tolerable concentrations through processing.

A low concentration of compounds which produce the smell provides safety to personnel and customers. Reducing levels of sulphur compounds reduces corrosion in pipeline of distribution systems, by preventing acidic combustion gases.

CO_2 is another important component to have under controlled condition as CO_2 in the presence of free water can be an important cause of corrosion damage to pipelines, especially at high pressure.

5.3 Industrial thermal processing equipment versus variations of gas composition

Natural gas is produced from wide range of differing sources, and thus the distributed gas may vary in composition. Although all natural gases essentially comprise methane, they do not have exactly the same characteristics or composition. These variations in characteristics have to be within the limits set in each country and normally have to comply with national regulations and/or specifications given by local Transmission/Distribution System Operators.

Most industrial combustion equipment is not sensitive to these variations. As far as low temperature processes are concerned, effects of gas variations are not particularly noticeable as long as a few precautions are taken when the initial adjustments are made. Hence, where a small heating or steam boiler is concerned, the burner needs to be adjusted with suitable excess air so that there is no risk of producing un-burnt gases if the gas should become 'richer'. Any efficiency loss should therefore be very small.

However, some high temperature processes (>700 °C) are more sensitive, e.g.

— those processes where the flame is used as a tool (e.g. production of light bulbs or medical glassware);

— processes where the regulated temperature is only slightly lower than flame temperature e.g. glass melting furnaces or their glass feeders);

— processes where combustion products are used in the processing (e.g. direct contact firing and thermal treatment, in ceramics or for steel heat treatment);

— processes where combustion initiates a chemical reaction (e.g. lime kilns).

For these special industrial processes, the adjustments on the combustion system may need to be corrected automatically as the gas varies. Ignoring these variations could lead to manufacturing defects and to an increase in the production costs that are detrimental to the industrial customer.

The range of industrial thermal equipment is so varied, it is not possible to give precise advice on all equipment and as such if combustion problems develop on a site it will be necessary to seek advice from experts in their field.

Gas engines and gas turbines are also recognized as being potentially sensitive to variations in gaseous fuels properties as with other fired equipment to cope with these variations, corrective systems may need to be introduced into the process control system.

A resume of the possible sensitivity of industrial processes to gas variations are given in Annex B.

5.4 Industrial thermal processing equipment – environmental considerations

Many industrial activities produce gaseous emissions that are regulated and controlled by national authorities as part of the process of minimizing the quantity of greenhouse gases being emitted into the environment.

The combustion of hydrocarbon gases is a chemical reaction (oxidation) of the several hydrocarbons contained within the gas, with the resulting heat emission being used for process purpose.

The general combustion reaction is:

$$C_n H_m + O_2 + N_2 \rightarrow CO_2 + H_2O + O_2 + N_2 + \text{OTHERS} + \text{HEAT}$$

Where

$C_n H_m$ represents hydrocarbons of the fuel,

$O_2 + N_2$ represent the combustion air,

CO_2, H_2O, O_2 and N_2 are the main combustion products,

others (NO_x, CO, H_2, C...) are generally produced in very small quantities.

NOTE Some particular industrial thermal processes use only oxygen as the combustion agent.

The products of the combustion that have not been oxidized completely (CO, H_2 and C) are denominated unburned components.

The greater is the proportion of unburned components, the smaller is the amount of heat produced by the chemical reaction.

Stoichiometric combustion, theoretically occurs when the relation between the amount of fuel and the amount of air is the minimum necessary for the complete oxidation of the fuel. For natural gas, the air gas ratio is approximately 10 m^3 of air to 1 m^3 of gas (air factor $n = 1$). In reality all burners require excess air above the stoichiometric requirement.

In the case of methane:

$$CH_4 + 2\ O_2 + 8\ N_2 \rightarrow CO_2 + 2\ H_2O + 8\ N_2$$

In other words: for each unit of volume of methane (CH_4) is needed two units of oxygen (O_2).

Since the content of oxygen in the air is about 21 %; to burn a cubic metre of methane we need 10 m^3 of air.

Where the air supply is less than needed for the complete combustion, this results a sub- stoichiometric condition and consequently produces un-burned components: such as CO, H_2 and C, but no oxygen. This so called reducing type of combustion is sometimes used in some industrial processes (i.e. porcelain manufacturing) to produce certain colours in the glaze finish.

Incomplete combustion can also be caused with some burners when exposed to large amounts of excess air. This is typically caused by ‘flame chilling’ that disturbs the completion of the combustion process.

Theoretically, complete combustion with minimal quantities of excess air increases the thermal efficiency and should ensure a safe combustion (no risk of CO emission). However burners always require excess air of some proportion to prevent the production of un-burnt gases. Some plant processes require high excess air levels to operate correctly and attempts to reduce air levels may lead to danger, to loss of product quality and increased levels of rejects.

Because higher combustion temperatures can be reached with low excess air levels, there is a tendency for an increase in the levels of nitrogen oxides. Also, the optimization of the air/gas ratio may be seen as a compromise between several constraints: safety, efficiency and environment. This optimum depends upon the industrial thermal processes and on the type of fuel, combustion technology, combustion chamber configuration, operating conditions, control technology, and on maintenance and ageing.

NO_X emissions depend on the fuel composition but more strongly on other parameters (combustion temperature, length of stay in the hot area of combustion chamber, burner design). For the past 30 years, the gas companies' research centres, combustion laboratories and burners manufacturers have developed many techniques to reduce the nitrogen oxides emissions from burners (low-NO_X burners, ultra-low-NO_X burners, flameless combustion, dry and wet NO_X control and staged combustion, FGR (Flue Gas Recirculation)).

Sulphur based compounds may need to be added to the natural gas or LPG to give the gas its special smell (odorisation). The quantities are considered to be negligible (about tens of milligrams per cubic metre).

Higher concentrations of sulphur in the gas can cause problems of corrosion within the appliances or copper pipework.

Carbon dioxide (CO_2) emissions are mainly related to the fuel composition but also to those factors which affects fuel efficiency. For natural gas, the CO_2 emissions per kilowatt are lower than any other hydrocarbon fuel.

6 Environment

European environmental policy is to prevent, reduce and as far as possible eliminate pollution arising from industrial activities. Applying this environmental policy in compliance with the “polluter pays” principle and the principle of pollution prevention, a general framework for the control of the main industrial activities had become necessary to be established in Europe, giving priority to intervention at source, ensuring prudent management of natural resources and taking into account, when necessary, the economic situation and specific local characteristics of the place in which the industrial activity is taking place.

In order to ensure the prevention and control of pollution, each installation above 20 MW should operate only if it holds a permit.

National legislation within each member state determines the approach for assigning responsibilities to operators of large installations to ensure compliance with the relevant European Directives.

F.2 gives guidance with regards relevant European Directives for environment protection.

7 Installation pipework

For pipework downstream of the gas meter and upstream of the appliance isolation valve within a premise reference should be made to EN 1775 or EN 15001.

The system design should achieve a system that is gas tight over many years. The location is normally subject to a risk assessment to ensure safety.

New systems will be tested for fitness upon installation according to EN 1775 or EN 15001 or National standards.

8 Industrial thermal equipment installations

Wherever relevant, the selected industrial thermal equipment and its burner and controls systems should comply with European Standards. Prior to installation a risk assessment may be performed to ensure that the industrial thermal equipment is in a safe location and is accessible for servicing and repair.

It is vital to ensure that adequate supplies of air are available for the safe and efficient operation of the industrial thermal equipment. Equally there should be correct provision for the removal of the exhaust products e.g. into a chimney. The correct termination positions of chimneys are vital to ensure that the products of combustion cannot re-enter buildings and are dispersed to meet local environmental controls.

Industrial thermal equipment and their associated air supply and exhaust systems are normally recommended to be serviced at least on an annual basis.

9 Inspections

Inspection and maintenance should form part of the normal operations on a site to deal with any potential areas that might lead to failure and consequent escape of gas e.g. local corrosion, mechanical damage.

Some EU States have issued National Regulations and Codes for inspection of Industrial Gas Installations (IGI).

10 General safety issues

All gases require good local ventilation in areas where pipework, controls and appliances are installed. This is especially important for combustion air to ensure the burners and other plant can operate safely with the excess air requirements that they need. Air is also required in some exhaust systems for suction control via flue stabilizers or draught diverters which can limit the flue suction conditions and enable burners and appliances to work efficiently and safely.

Air is also needed for cooling of plant rooms especially locally to furnaces where high radiation and convection losses may make it too hot for the safety of operatives.

Finally, the provision of air changes is seen as a safety precaution to remove any minor leakage faults that may occur during operation of the gas systems/appliances. The consequent dilution of the small leaks will ensure the safety of personnel or the building. This topic is also relevant to the implications of the ATEX user Directive since good ventilation reduces the likelihood of having to apply electrical equipment that is classified for use in Hazardous Areas.

In this respect it is also vital to appreciate the relevance of the buoyancy of the gases since low specific gravity gases will more easily disperse at high level. In general it is considered that gases with a relative density of 0,8 (air = 1) or less will rise to high level for dispersion. All other gases such as LPG, LPG/Air, and many biogases will tend to fall to low level and thus low level ventilation is also essential.

This matter is also relevant to emissions of gas from pressure relief valves, emergency dump systems, to breathers on controls and to venting operations during purging. In the latter case, it may be appropriate to flare off the purge gases for safety.

Industrial gas installations have to comply with essential safety requirements specified in European Directives detailed in Annex F.

Annex A
(informative)

Controlling air and gas flow rates versus energy content to the gas equipment

A.1 Principles for the measurement of air and gas flows

A.1.1 General

Typical measuring devices for air and gas flows are described below on the basis of principle of operation, values measured, accuracy and application.

A.1.2 Diaphragm meters

These meters internally contain two bellows measuring chambers that act like pistons measuring the volume within the piston on each stroke. This lateral movement is transferred by gears to the index. The manufacturing standard for these meters is EN 1359. They are normally made of steel plate although some special types are made of plastic and some higher pressure (up to 5 bar) models are made of aluminium. The steel plate meters are normally installed with about a 21 mbar operating pressure. The maximum flow rate is typically declared with a 1,25 mbar pressure loss. They tend to have a very wide flow range with a starting flow as low as 0,07 % Q_{max}. They have a good accuracy across their flow range of about 150:1. They are suitable for on/off type process loads.

A.1.3 Orifice plate systems

Orifice plate systems are frequently used to measure air flow or large gas quantities.

The principle of operation is based on the determination of flow by measuring differential pressure.

The European standards EN ISO 5167 and ISO 5168 define construction specifications, conditions for use (mandatory lengths before and after the orifice) and calculation formulas.

The measuring unit includes:

— the primary unit consisting of the system (diaphragm, Venturi, nozzle) and pressure devices;

— secondary devices required for measuring (differential pressure sensor).

Other values such as downstream temperature and pressure in service conditions may be measured.

The inlet gas supply shall be filtered.

Acceptable errors according to the European standards are 1 % – 1,5 %. Prior calibration may reduce these errors to less than 1 %.

Orifice plates or Venturi are easy to install and use. They do not require regular calibration and they enable the measuring of large quantities of gas at high pressures, exceeding the maximum flows which can be measured using turbine and rotating piston meters. They are inexpensive to run. However, they can cause a significant loss of pressure. It is also difficult to measure low speeds at high pressure. Straight legs shall be fitted upstream and downstream from the orifice (minimum 10D downstream and 5D upstream, where D is the inner pipe diameter).

The use of a Venturi is preferable if lower pressure drop is required.

Such meters are not widely used for smaller process loads due to the high process turndown requirements and complexity.

A.1.4 Turbine meters

The principle of operation of flow meter turbines is based on the almost linear relation between the rotation speed of a rotor and volume flow rate. The turbine is inserted in the pipe and will rotate driven by the flow of the fluid.

Depending on the type of turbine used, measurements are obtained:

— either using pulses corresponding to the passage of the blades of the turbine wheel (high frequency); and/or

— using a mechanical index connected (magnetic coupling) to the turbine shaft, transforming the flow, via a set of gears, into volume (low frequency) or flow rate (high frequency).

Turbine meters should not normally be applied to on-off or pulsing process loads. The inlet gas supply shall be filtered. Straight lengths of pipe may be needed both upstream and downstream unless integral flow straightness are applied.

These meters can provide accurate readings between ± 1 % or 2 % exceeding 0,2 Q_{max} at low pressures. Typical turndown is 10:1 at low pressures. Higher pressures increase the low flow accuracy point below 0,2 Q_{max}.

Turbines can cover a flow interval for diameters of between 50 mm and 750 mm, ranging from 16 m^3/h to 40 000 m^3/h, for absolute pressure of between 1 bar and 100 bar and fluid temperatures of between – 20 °C and + 50 °C .

A.1.5 Rotating piston meters (roots)

The fluid flow rotates two pistons which mutually drive each other with minimal clearance. The fluid is hence carried to the chambers formed between the pistons (eight or oval format) and the meter core. During rotation, the fluid contained in the chamber is gradually transferred from downstream to upstream. The quantity transferred per rotation (cycle volume) is a constant which is determined using calibration and corresponds to four basic volumes. The volume measured in this way is proportional to the speed of rotation of the meter.

The volume or volume flow rate is obtained either using electric pulses supplying a pulse meter or frequency meter, or via a direct reading on a mechanical totalizer.

The inlet gas supply shall be filtered, Gear housing oil levels may require to be regularly checked and mechanical parts shall be regularly maintained.

With a measurement scope of 5 % – 100 % of maximum flow, these meters provide an accuracy of ± 0,5 %.

Typical turndown range is 50:1 giving accuracies better than ± 2 %.

This type of meter can have a relatively low pressure loss and may be used for pulsing process loads.

These meters can be used for flows ranging between 3 m^3/h and 6 500 m^3/h, for a maximum pressure of about 80 bar, depending upon the materials of construction.

A.1.6 Vortex flow meters

The principle of operation of these meters involves detecting the speed of formation of vortices upstream due to an obstacle placed in the flow. These vortices, created by the passage of the flow around the obstacle, create pressure in a piezo-electric sensor speeds which vary according to the speed of the flow.

Typical turndown range is 15:1 giving accuracy better than ± 1 %.

These flow meters are sensitive to their conditions of installation (straight lengths required: 30 to 15D upstream, 5 to 10D downstream) and no interferences (pulsed flow, noise, etc.). In addition, the flow shall be turbulent (R_e > 2 000).

A.1.7 Ultrasonic flow meter

These devices measure the speed of propagation of a sound wave between an emitter and an offset receiver located on either side of the duct. These probes may both emit and receive ultrasound.

Typical turndown range is 30:1 giving accuracies better than ± 2 %.

These flow meters are sensitive to their conditions of installation (straight lengths required: 20D upstream, 10D downstream) and no interferences (pulsed flow, noise, etc.).

The fluid temperature and flow conditions may have effect on the measurement.

A.1.8 Mass flow meters

Two types of mass flow meters exist: Thermal systems and Coriolis systems.

a) Thermal systems

The operating mode of thermal flow meters is based on the measure of the transfer of calories by the fluid. The fluid for which the flow requires measurement enters a capillary tube. Temperature sensors are located at each end of the tube (heat detection resistances) and a heating coil is placed between the two sensors.

This type of flow meter has the advantage of low sensitivity to variations in gas temperature and pressure. However, use with natural gas is complex as the flow measured varies depending on the composition of the gas and properties (density and heat capacity C_p). Range is up to about 1 000 kg/h.

Typical turndown range is 50:1 giving accuracies between ± 1 % and ± 5 %.

b) Coriolis

Mass flow meters using Coriolis systems are traditionally used to measure liquids, and recent technological developments enable their use as a gas flow meter.

The accuracy declared by the manufacturers varies between ± 0,5 % and ± 1 %. They are available with a range of flows between 70 kg^3/h and 140 000 kg^3/h. Some devices may be used to measure the density of the fluid.

These flow meters are sensitive to their conditions of installation (straight lengths required: 2D upstream, 2D downstream.

A.2 Flow calculation

The measurements of air or gas flow rates may need to be corrected to enable comparison with similar data. The flow Q measured at pressure P and T is converted for a standard pressure (1 013 mbar) and a reference temperature (0 °C in some countries, 15 °C in others) using the following formula:

$$\mathrm{Qn} = \mathrm{Q}.\frac{\mathrm{P.T_0}}{\mathrm{T.P_0}}.\frac{\mathrm{Z_0}}{\mathrm{Z}}$$

Where

Q_n	is the corrected volume flow rate (m^3/h),
Q	is the measured volume flow rate (m^3/h),
T	is the temperature (K)
T_o	is the temperature in standard conditions (273,15 K or 288,15 K),
P	is the absolute pressure (bar),
P_o	is the absolute pressure downstream in standard conditions (1,01325 bar),
Z	is the compressibility factor which depends on P and T,
Z_o	is the compressibility factor in standard conditions,
Z_o/Z	approximates to 1 if $P < 3$ bar.

The measuring points for pressure and temperature will vary according to the meter type in use. Many industrial meters will have the tappings on or near to the meter element.

A.3 Control energy content

Getting calorific flow rates released by burners from flow measurements requires information about gas quality. The main needed parameter is obviously the Calorific Value which is normally displayed on gas billing information but can be obtained from the gas supplier/shipper etc.

If the employed technique for flow metering allows getting the actual corrected volumetric flow rate of the natural gas (Q_n in Nm^3/h), it is easy to calculate the released thermal energy (Q_c in kW):

$$Qc(kW) = Qn(Nm^3 / s).GCV(kJ / Nm^3)$$

WARNING — Pressure and temperature references should be the same for corrected flow rate and CV.

Also it is important to ensure that either Gross or Nett terms are used for the calculation.

A.4 Flow metering and meter performance

Table A.1 — Flow metering and meter performance

FACTOR	DIAPHRAGM	RD	TURBINE	ULTRASONIC
Range of Q_{max}	6 m^3 h^{-1} to 160 m^3 h^{-1}	25 m^3 h^{-1} to 2,885 m^3 h^{-1}	16 m^3 h^{-1} to 25 000 m^3 h^{-1}	800 m^3 h^{-1} to 85 000 m^3 h^{-1} Domestic meters are also available
Typical pressure range	0 mbar to 75 mbar	0 bar to 10 bar. Special meters available up to 38 bar.	0 bar to 38 bar.	2 bar to 38 bar.
Typical rangeability (and accuracy)	Badged: 50:1 (± 2 % to ± 3 %) Usable: > 150:1 (± 2 % to ± 3 %) Turn Down: > 1000:1.	Badged: 20:1 to 50:1 (±1 % to ± 2 %) Usable: > 50:1 (±1 % to ± 2 %) Turn Down: 500:1.	Badged: 10:1 to 30:1 (±1 % to ± 2 %) Usable: > 10:1 (±1 % to ± 2 %) Turn Down: 20:1.	Certified over 40:1 to 125:1 (± 1 %) Usable: > 40:1 (± 1 %) Turn Down: Not applicable.
Effect of gas density	Unaffected in design range within manufacturer's specification.	Insignificant	Minimum flow is lowered with increased density, increasing the usable and turn down rangeability.	Meter accuracy does not deviate over the specified working range of transducers. Certain types of transducer will not operate at low densities dependent upon meter size, line density and gas composition.
Effect of gas borne solids	Normally unaffected but coarse filter recommended at higher pressures.	Meter may stop rotating. Filter required.	Blades may be damaged and freedom of rotation may be affected. Coarse filter required.	Normally unaffected, but contamination of the transducers can affect meter performance.
Effect of gas borne liquids for example water, oil, grease etc.	Corrosion possible. Freezing may result in damage. Materials of construction may be affected. Over-registration possible.	Corrosion possible. Oil may be displaced from gears. Freezing may stop the meter. Materials of construction may be affected. Under-registration possible.	Corrosion possible. Freezing may result in damage. Lubricant dilution and rotor imbalance possible. Materials of construction may be affected. Inaccuracy possible.	Liquids settling in the bottom of the meter, or grease on the internal walls reduce the cross sectional area and cause the meter to over-read. Freezing may cause a temporary increase in uncertainty. Materials of construction may be affected.

Pressure variations	Excessive differential pressure variations will cause damage.	Rapid change of differential pressure may cause damage.	Rapid pressure changes may cause damage or registration errors. Particular problems when meters are installed interstage at higher pressures.	Normally unaffected.
Acoustic Noise	Unaffected	Unaffected	Unaffected	Can be affected by acoustic noise. Precautions need to be taken with the location of the meter and its proximity to noise sources such as control valves, pressure regulators and partially open line valves.
Pipework configuration	Unaffected	May need upstream straight flow.	Upstream and downstream conditions apply.	Upstream and downstream conditions apply.

NOTE This information has been taken from published data relating to fiscal (billing) meters and may not be applicable in all cases to applications on process loads (see A.1 above).

Flow range specified is related to actual flow through a meter at the prevailing pressure and temperature. Consequently, metering pressure has to be taken into account when selecting a meter. The flow range also affects the accuracy of the meter and needs to be taken into account.

When a meter is installed upstream of the pressure regulator, any variation in inlet pressure to the meter will have a significant impact on the turndown of the selected meter. The meter will have to cope with the maximum flow at the minimum pressure and the minimum flow at the maximum pressure. A two to one variation in pressure will result in a halving of the usable turndown of the meter.

Annex B
(informative)

Industrial thermal processing equipment

B.1 Sensitivity of gas engines and gas turbines

Gas engines are mainly sensitive to the knock phenomenon. Knock is caused by an abnormal combustion, with occurrence of a detonation that adversely affects performance, emissions, and service life of spark-ignited internal combustion engines. The occurrence of knock is dependent on many variables, including combustion chamber design, air gas ratio, and intake air temperature and pressure, and fuel properties.

As far as the fuel properties are concerned, the gas's tendency to resist detonation is characterized by a value experimentally related to the gas composition and called “Methane Number”. Comparable to the octane number for petrol, the Methane Number of a gaseous fuel is defined as the percentage by volume of methane blended with hydrogen that exactly matches the knock intensity of the fuel under specified operating conditions in a knock testing engine. A low Methane Number can lead to detonation and damage to the gas engines if no adjustment is made to the engine's operation. For most natural gases supplied in Europe, Methane Number is varying from 70 to 95.

To operate in acceptable conditions, gas turbines and more specially those using lean premix combustor, require flame stability (risk of flashback), stable flame temperature (to prevent component overheating or excessive thermal stresses), small combustion dynamics (due to the coupling of pressure oscillations in the combustion system with the energy release within the flame) and finally have to produce low levels of pollutant emissions (particularly NO_X and CO). To comply with these requirements, gas turbines are generally equipped with efficient combustion control systems that may involve gas quality measurements (e.g. by using chromatography). Nevertheless, too large variations in Wobbe index or in rate of some compounds (e.g. C_2 +) can affect the efficiency, the levels of pollutant emission and the reliability of the turbines. And because of the very high gas flow rates consumed by turbines, the rates of change of the Wobbe index are generally faster than for most industrial thermo-processes and may be also an issue (control system reaction slower than the rate of change).

B.2 Sensitivity of some industrial thermal processes

The following table describes how Gas Quality variations can influence the performances in the thermal processes and the possible measures that it could be taken.

For further information on the subject the Marcogaz document “Effects of Gas Quality variation on appliances” is available on the Marcogaz website www.marcogaz.org

Table B.1 — Measures for gas quality variations

Main category	Sub categories		Comment	Sensitive	Possible solution
Low temperature (<750° C) Industrial applications	Big boilers/large scale hot water and steam			Low for efficiency. May be high for NO_X emissions	Air gas control via measurement of the oxygen in combustion products.
	Food industry	Green houses	NO_2 is a problem when combustion products are in contact with food. NO_2 is a plant hormone, and can damage crops. NO_2 emissions can also increase with gases having higher hydrocarbons (with facilitate the conversion of NO→ NO_2)	High to NO_2 emissions	Adjustment of burners for reduced unburned fuel slippage (source of NO_2 production). New burners or air/ratio control
		Drying process			
				High to NO_2 emissions	
	Infrared	Drying	Low temp. combustion with potential presence of solvents. Radiant power/efficiency dependent on burning velocity.	High to burning velocity	In premixed radiant tiles, air/gas ratio and thermal input controls can minimize this effect.
		Heating			
High temperature (>750° C) industrial applications	Ceramic/Glass	Bulk (melting feeders)		Soot formation often desired in bulk glass (heat transfer).	Gas quality (Wobbe Index, GCV) and air flow control. Air ratio and thermal input control should minimize effects. Air ratio control solves stoechiometry.
			Sensitive to flame temperature and radiative power. Finished product is also sensitive to flame geometry.	High sensitivity to burning velocity	
		Finished product (bulbs, etc.)		High sensitivity to air ratio (over/under stoechiometry). High sensitivity to	

Main category	Sub categories		Comment	Sensitive	Possible solution
		Ceramic roofing tiles, bricks, etc.	Finished glass products sensitive to flame length (burning velocity). Soot formation (composition) and increased NO_X emissions (Wobbe/calorific value) possible. Control of under-/ overstoechiometric firing essential in ceramics.	NO_X. High sensitivity to soot.	
	Metal oven		General for metal industry. Air factor, soot formation and NO_X important issues.	High to soot and NO_X and oxygen in the oven atmosphere.	Solutions may be very specific according to the application
	Lime kilns		Quality of production (reject rate) sensitive to calorific flow rate	High sensitivity to Wobbe index or GCV variations	Gas quality (Wobbe Index, GCV) and air flow control
	Oxy-gas burners		More and more used on high temperature process in order to reduce NO_X	Oxygen consumption very sensitive to gas variations	Gas quality (Wobbe Index, GCV) and oxygen flow control.
Engines	Fixed		Emissions and performances may vary. NO_X emissions and engine knock (methane number) set boundary conditions for fuel sensitivity	High to NO_x High to knock	Air ratio control minimizes NO_X variations. Readjustment of engine necessary (with efficiency loss) for knock
Turbines	Pre-mixed		Control system and machine design limit Wobbe variations, both stationary (power modulation) and dynamic (oscillations); NO_X emissions and combustion instability issues.	High sensitivity to Wobbe variation (outside control range) Some machine have compositional limits (on higher hydrocarbons, e.g.) High to Wobbe/composition-induced oscillations	New control systems
	Non –pre-mixed		NO_X (also at constant Wobbe) issue	High to NO_X Thermal overload possible.	Readjust exhaust gas treatment; retrofit combustion chamber.

Annex C
(informative)

Reverse flow of gases

The reverse flow of gases into other systems can lead to potentially dangerous conditions especially with oxygen and sometimes with air. In other cases it can lead to danger to other users or appliances or an inconvenience.

Many countries have legal requirements covering such cases often demanding the use of non-return valves or other safety systems.

Reverse flow of high pressure natural gas into a low pressure system or to a system not capable of handling the high pressures can also lead to potentially dangerous conditions. This is especially relevant to gas compression units as may be applied to gas turbine CHP installations.

Annex D
(informative)

Industrial thermal processing equipment and Environmental issues

Emission factors for CO_2

— LPG: 225 g/kWh

— Natural gas: 205 g/kWh

NOTE Other emission factors are determined by National Regulations.

Annex E
(informative)

National implementation

E.1 General/introduction

Industrial gas installations are subject of specific regulations and requirements from different origin. Where commercially put on the market, the equipment is under the applicable European Directives but even in these cases, additional requirements from other sources are potentially possible.

The following paragraphs list different possible influences on gas equipment downstream of the point of delivery.

E.2 Safety and health of workers at work regulations

The pipework in the industrial plant and the combustion equipment or other downstream gas consumer are subject to local regulations for the safety and health of workers at work. These regulations are the responsibility of the national authorities (member countries). These authorities will address the matter by the national codes and national regulations. Plant (end user) safety responsibility is handled in different ways and with different procedures.

EXAMPLE 1 Marking of pipework in a plant (different colour coding – for natural gas see EN 15001).

EXAMPLE 2 ATEX related issues: ATEX 1999/92/EC has resulted in different interpretations of the legislation in different European countries. Considering that EN 60079–10 is not sufficient, the various EU states have issued their National Regulations.

— Different system and design standards exist for different types of combustion equipment and plant (“SEVESO-plants” or high risk plants have different codes to assess explosion risk than standard industrial plant, imposed by e.g. permit for operation and permit to work requirements).

— In some countries, a systematic system for inspection of industrial gas equipment exists.

E.3 Specifications from utilities and gas suppliers

Gas suppliers and utilities may specify requirements in their contracts for downstream equipment, connected to their gas supply.

EXAMPLE 1 Maximum hourly or daily consumptions

EXAMPLE 2 Maximum rate of change of flow conditions

EXAMPLE 3 Maximum pressure design ratings of pipework

EXAMPLE 4 Procedures for new equipment to be verified before first use and serviced frequently

E.4 Protection of buildings and equipment against fire

Fire protection is the responsibility of member states and will result in different specifications depending on the type and location of the equipment.

This topic should be covered by complying with the requirements of EN 1775 or EN 15001. However local requirements may require additional features.

Different ways of handling this are:

EXAMPLE 1 Isolation valves with thermal shut off capability just upstream of specific appliances or the primary meter or at the point of entry into a building.

EXAMPLE 2 In certain types of industry safety shut off valves may be used that are connected to fire or to gas detection systems.

Annex F
(informative)

European Directives

F.1 EU Safety Directives

F.1.1 General

Industry has to comply with essential safety requirements specified in a lot of European Directives. These Directives were written to improve safety at work in Europe. They could be split in two categories: Directives for manufacturers and Directives for end-users.

F.1.2 Safety European Directives concerning products

F.1.2.1 General

For any equipment designed for use at work and covered by a Directive, the manufacturer should draw up a CE declaration of conformity for certifying the compliance of the equipment to the Directive requirements and affix the CE marking to guarantee this conformity. Generally, specific “harmonized” standards (that give a presumption of conformity) are available for helping the manufacturer to meet safety requirements. This type of Directive concerns only new equipment placed on the market and/or put into service.

Some of the “Manufacturers” Directives concern industrial equipment using natural gas or equipment that are part of gas system installations. Notably, the following Directives should be considered:

F.1.2.2 Machinery Directive 2006/42/EC

This is the 3rd Safety Directive (after those released in 1989 and 1998) fixing safety requirements for designing, constructing, installing and commissioning machineries used in industry. All industrial thermal equipment (ovens, kilns, furnaces for drying, heating, melting, annealing, firing, etc.), except boilers and building heating systems, are considered as machinery. EN 746-1, EN 746-2 and EN 746-3 give to the manufacturer’s technical specifications harmonized with the Directive. As far as combustion and gas fuel handling systems are concerned, see EN 746-2. Gas pipeworks (and components fitted on them) when they are parts of the thermal equipment shall comply with this standard.

F.1.2.3 Gas appliances Directive 2009/142/EC

This Directive is not directly applied in industry because appliances designed for uses in industrial processes carried out on industrial premises are out of its scope. Nevertheless, automatic forced draught burners and many components used for the safety or the control of gas system installations are designed and constructed in compliance with European Standards harmonized with the G.A.D. Directive.

EXAMPLE 1 Automatic forced draught burners for gaseous fuels (EN 676),

EXAMPLE 2 Safety shut off valves (EN 161),

EXAMPLE 3 Burner control units (EN 298),

EXAMPLE 4 Air gas ratio controllers (EN 12067),

EXAMPLE 5 Zero governors (EN 88-1),

EXAMPLE 6 Valve proving systems (EN 1643), and

EXAMPLE 7 Pressure switches (EN 1854).

F.1.2.4 Pressure equipment Directive 97/23/EC

This Directive applies to the design, manufacture and conformity assessment of pressure equipment and assemblies with a maximum allowable pressure greater than 0,5 bar.

Boilers for generation of steam at pressure > 0,5 bar or super-heated water at temperature > 110 °C fall within the scope of the Directive. Installation pipework would not normally fall within the scope of the directive if it is designed and installed under the direction of the site occupier. However the overall safety requirements for the design as given in EN 15001 are the same regardless of whether or not the Directive applies. Installation pipework may fall within the scope of the Directive for example if it is a project where Contractor has full responsibility of engineering, procurement and construction (“turnkey”).

Where it is determined that the gas pipework falls within the scope of the Directive, considerations should be given to the application of the Directive. The following aspects are given below:

EXAMPLE 1 If DN < 25 mm, the only requirement is to be designed and manufactured in accordance with the sound engineering practice of a Member State in order to ensure safe use. There is no CE marking.

EXAMPLE 2 If 25 < DN < 100 mm and pressure < 1000/DN, gas pipes shall be designed and manufactured in accordance with a conformity assessment procedure “Module A “ (internal production control). The CE marking is requested except if the gas pipework is part of an industrial thermal equipment compliant with Machinery Directive, because then it is supposed to meet the PED requirements.

EXAMPLE 3 In other cases, the conformity assessment procedure is more constraining and depends on the diameter and the pressure.

EXAMPLE 4 The harmonized reference standard is EN 15001-1.

F.1.2.5 Construction products regulation (305/2011/EU – CPR) – replacing the construction products Directive (89/106/EEC - CPD)

This Regulation is laying down harmonized conditions for the marketing of construction products.

Construction Products Regulation (the CPR) is to ensure reliable information on construction products in relation to their performances. This is achieved by providing uniform assessment methods of the performance of construction products. These methods have been compiled in harmonized European standards (hEN) and European Assessment Documents (EAD).

As far as combustion installations are concerned, flues should be checked that are free from obstructions, gas tight and constructed with CE marked suitable materials. Tests should cover fluepipes, joints between fluepipes, combustion appliance outlets and a spillage test as part of the process of commissioning should also be carried out as required by the Gas Safety Regulations.

F.1.2.6 Other Directives

Applicable to manufacturers in industries using natural gas:

— Directive 94/9/EC concerning equipment and protective systems intended for use in potentially explosive atmospheres.

— Directive 2004/108/EC relating to the Electro Magnetic Compatibility of equipment.

— Directive 2006/95/EC relating to Low Voltage electrical equipment.

F.1.3 Safety European Directives concerning general public and workers

F.1.3.1 General

For complying with this kind of Directive, the employer shall take the measures necessary to ensure that the work equipment is suitable for the work to be carried out and may be used by workers without impairment to their safety or health. There is neither conformity declaration nor CE marking. Generally, there are no harmonized standards related to these Directives.

Any equipment or workplace covered by a Directive and in operation at the date of application of the Directive is concerned, whatever the date of its first use in the undertaking. It means that sometimes equipment shall be put in conformity with a new “End-User” Directive. The Directive is obviously applicable for any new equipment used at work. Note that the date of application for existing installations already in use may be later than for new ones.

The main “End-User” Directives that concern employers in gas-fired thermal process industries are the following:

F.1.3.2 Directive 89/391/EEC

This Directive introduces measures to encourage improvements in the safety and health of workers at work and applying to all sectors of activity, especially industrial. According to the Directive, the employer shall take the measures necessary for the safety and health protection of workers, on the basis of general principles of prevention: avoiding risks, evaluating the risks which cannot be avoided, reducing the risks at the source, giving appropriate instructions and training to the workers.

Obviously, any gas-fired thermal equipment or gas system installed in industrial premises is concerned by this very general safety Directive. Article 16 provides a procedure for adopting individual Directives, in defined areas, that complete this general Directive.

F.1.3.3 Directive 2009/104/EC

This Directive concerns the minimum safety and health requirements for the use of work equipment by workers at work (second individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC. It provides general minimum requirements applicable to work equipment. In particular, all work equipment shall be appropriate for protecting workers against the risk of fire or overheating, or of discharges of gas, dust, liquid, vapour or other substances used in the work equipment, for preventing the risk of explosion of the work equipment or of substances used in the work equipment. It shall be fitted with a control to stop it completely and safe. Any industrial thermal equipment, considered as work equipment, shall comply with these safety requirements.

F.1.3.4 Directive 1999/92/EC

This Directive provides the minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16 of Directive 89/391/EEC). According to this Directive, the employer shall take technical and/or organisational measures appropriate to the nature of the operation, in order of priority and in accordance with the following basic principles:

— the prevention of the formation of explosive atmospheres, or where the nature of the activity does not allow that;

— the avoidance of the ignition of explosive atmospheres; and

— the mitigation of the detrimental effects of an explosion so as to ensure the health and safety of workers.

In this explosion risks assessment prescribed by the Directive, the priority for the employer is to take measures preventing everywhere the formation of explosive atmospheres rather than trying to avoid the ignition of likely explosive atmospheres inside classified hazardous zones, zones where a combustion activity would be hard to carry out. These preventive measures could lean on technical specifications that have been already applied for a long time. But, because there are no harmonized European standards related to the Directive, these technical specifications may differ from one country to another.

It is generally considered that the risk of formation of explosive atmospheres from pipework and combustion equipment unlikely for well-designed and well ventilated systems installed according to CEN or National standards.

F.1.3.5 Directive 2003/105/EC (Seveso II Directive)

This Directive amends Council Directive 96/82/EC on the control of major-accident hazards involving dangerous substances which aims at the prevention of major accidents which involve dangerous substances and the limitation of their consequences for man and the environment, with a view to ensuring high levels of protection throughout the Community in a consistent and effective manner.

F.1.4 Introduction to Directives

Many of the laws in EU states emanate from the implementation of Directives. Within a set period each state has to implement the Directives into their national legislation.

There are three types of standard used in the gas industry, a normal standard such as a manufacturing specification of construction and performance. There are also harmonized standards where compliance with the standard enables the user to satisfy the Essential Safety Requirements stated within a Directive. It is possible to satisfy the ESR requirements by other means but these may be less straightforward.

Finally we have Functional standards which are normally installation standards such as EN 1775 which set down the general safety requirements for the gas industry to follow whilst recognizing that customs and practices as well as legislation, in various EU states vary. Some states implement the standard as it is published whilst others adopt the requirements and options within their own national practice standards.

F.1.5 Synthesis of Directives

Industrial installations are affected during their design, construction, operation and maintenance by a variety of Directives, regulations and technical standards. The table below aims at helping to understand the main features of the most relevant Directives and the most relevant parameters associated with it.

Directive TAG	**GAD** **2009/142/EC**	**PED** **97/23/EC**	**ATEX95** **94/9/EC**	**ATEX137** **1999/92/EC**	**MD** **2006/42/EC**	**LVD** **2006/95/EC**	**EMC** **2004/108/EC**	**89/391/EEC**	**2009/104/EC**
Directive Name	Gas Appliances Directive	Pressure Equipment Directive	Manufacturer Explosive Atmosphere	End-User Explosive Atmosphere	Machinery Directive	Low Voltage Directive	Electro Magnetic Compatibility	Safety and Health of Workers at Work	Work Equipment
Previous Directives	90/396/EEC			Related to 89/391/EEC	89/392/EEC 98/37/EC	73/23/EEC 93/68/EEC	89/336/EEC		89/655/EEC Related to 89/391/EEC
Date of application	January 2010	May 2002	July 2003	New: 07/03 Existing: 07/06	December 2009	January 2006	July 2007	June 1989	October 2009
Application of the 1st Directive	July 1990				January 1993	August 1974	January 1992		December 89
Scope	Gas appliances, forced draught burners, safety and control devices	Vessels Piping Generators of steam or super-heated water with *P* > 0,5 bar	Any equipment or protective system intended for use in potentially explosive atmospheres.	Any industrial workplace with potential risk from explosive atmosphere	Machinery Partly completed machinery Safety components of machinery	Electric equipment with voltage 50 < AC < 1000 or 75 < DC < 1500 Under the condition they are out of MD scope	Appliances liable to generate electromagnetic disturbance or to be affected by such disturbance	All sectors of activity	Any work equipment used by workers at work
Main concerned industrial gas equipment or	Forced draught burners	Gas pipework, Steam boilers Hot water boilers	when there are ATEX zones: equipment	Workplaces with gas pipework	Industrial furnaces, ovens, kilns,	Electric equipment (safety and	Electric equipment (safety and	Any industrial premise	Industrial gas-fired thermal

components	and integral controls and pipes	above 105 °C	installed in these zones	and/or combustion equipment	dryers Gas turbines Gas engines	control devices)	control devices)		equipment
Main harmonized standards for gas equipment and components	EN 88 EN 676 EN 161 EN 298 EN 12067-2 EN 88-1 EN 1643 EN 1854	EN 15001-1 EN 676 EN 12952-1, EN 12952-2, EN 12952-3, and EN 12952-5, EN 12952-6, EN 12952-7, EN 12952-8, EN 12952-9, EN 12952-10, EN 12952-11, EN 12953-1, EN 12953-2, EN 12953-3, EN 12953-4, EN 12953-5, EN 12953-6, EN 12953-7, EN 12953-8, EN 12953-9 EN 14394	EN 1127-1 EN 60079-0, EN 60079-1, EN 60079-2, EN 60079-5, EN 60079-6, EN 60079-7, EN 60079-11, EN 60079-15, EN 60079-18, EN 60079-20, EN 60079-25, EN 60079-26, EN 60079-27, EN 60079-28, EN 60079-29, EN 60079-30 and EN 60079-31	No harmonized standards	EN 746-1, EN 746-2, EN 746-3, EN 1539 EN 676	EN 60204-1	EN 61000–6-2 EN 61000–6-4	Framework directive	No harmonized standards
Liability	Manufacturer	Manufacturer	Manufacturer	Employer	Manufacturer	Manufacturer	Manufacturer	End-User (employer)	End-User (employer)
CE marking	Yes	Yes except if DN < 25 (pipes) V < 2L (boilers)	Yes	No	Yes	Yes	Yes	No	No

F.2 Environment EU Directives for industrial end-users

F.2.1 General

Industrial activities produce gaseous emissions which are more and more regulated and controlled by national authorities. Among them, a full range of greenhouse gases is emitted from the combustion of fuels.

Thus European Commission has put in place European Legislation (Directives) in order to control gaseous emissions produced by Industrial activities.

The following clauses give some basic guidance to the applicable European Directives to control gaseous air emissions.

F.2.2 Emissions Trading Scheme ETS

F.2.2.1 General

Following the adoption of the Kyoto protocol in 1997, the European Commission put in place the Emissions Trading Scheme in 2005 by the adoption of the Directive 2003/87/EC entered into force in 2003. For the ETS each Member State receives a certain amount of CO_2 allowances which are further allocated to the undertakings falling under the scope of the mentioned above Directive.

The amount of allowances is revised periodically. If the undertaking needs more than the available allowances it has to buy the excess in special auctions. More details on the ETS functioning can be found in the following link: http://ec.europa.eu/clima/policies/ets/index_en.htm.

F.2.2.2 CO_2 measurement

CO_2 determination should be done accordingly to the guidelines established by the EU Commission. These guidelines, established with a Commission Decision 2007/589/EC in 2007 can be downloaded at the following link: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:229:0001:0085:EN:PDF.

Annex IV to the Directive 2003/87/EC permits a determination of emissions using either:

— a calculation-based methodology (“calculation”);

— a measurement-based methodology (“measurement”).

The operator may propose to measure emissions if he can demonstrate that:

— it reliably gives higher accuracy than the relevant calculation applying a combination of the highest tiers, and

— the comparison between measurement and calculation is based on an identical list of sources and emissions.

The operator may, with the approval of the competent authority, combine measurement and calculation for different sources belonging to one installation. The operator shall ensure and demonstrate that neither gaps nor double counting concerning emissions occur.

Calculation of emission data can be done with the following formula:

CO_2 emissions = activity data * emission factor * oxidation factor

Measurement shall be done accordingly to relevant standard CEN/TR title “Surveillance from first commissioning on measuring devices used in natural gas supply to the installations of the activities under the Directive 2003/87/EC establishing a scheme of CO_2 emissions trading”.

F.2.3 Measures to reduce emissions (CO_2, CO, NO_X, CH_4)

The Best Available Techniques Reference Documents (B.R.E.F.) detail the most common measures put in place to reduce emissions, divided per type of machinery and harmful emissions type (CO_2, CO, NOX, CH_4). Many of them are part of the so called Best Available Techniques (BAT) that can be used to reach the emission levels foreseen by the Industrial Emissions Directive (IED).

F.2.4 Industrial Emissions Directive (IED)

The Industrial Emissions Directive (IED) (2010/75/EC) recasts the following Directives into a single clear and coherent legislative instrument: Large Combustion Plants (LCP) Directive (2001/80/EC), Integrated Pollution Prevention and Control (IPPC) Directive (2008/1/EC).

The IED sets rules designed to prevent, control or where that is not practicable to reduce emissions into air, water and land as well as to prevent the generation of waste resulting from industrial activities.

In particular, the IED tightens minimum emission limit values in some sectors (e.g. large combustion plants), improves and clarifies the concept of BAT to create a more coherent application of the IPPC Directive, introduces minimum standards regarding the inspection and review of permit conditions and compliance reporting, and IED provides incentives for eco-innovation and support for the creation of lead markets.

In addition, the IED extends the scope of the IPPC Directive to cover additional installations such as combustion plants between 20 MW and 50 MW.

Annex G
(informative)

Natural gas overview

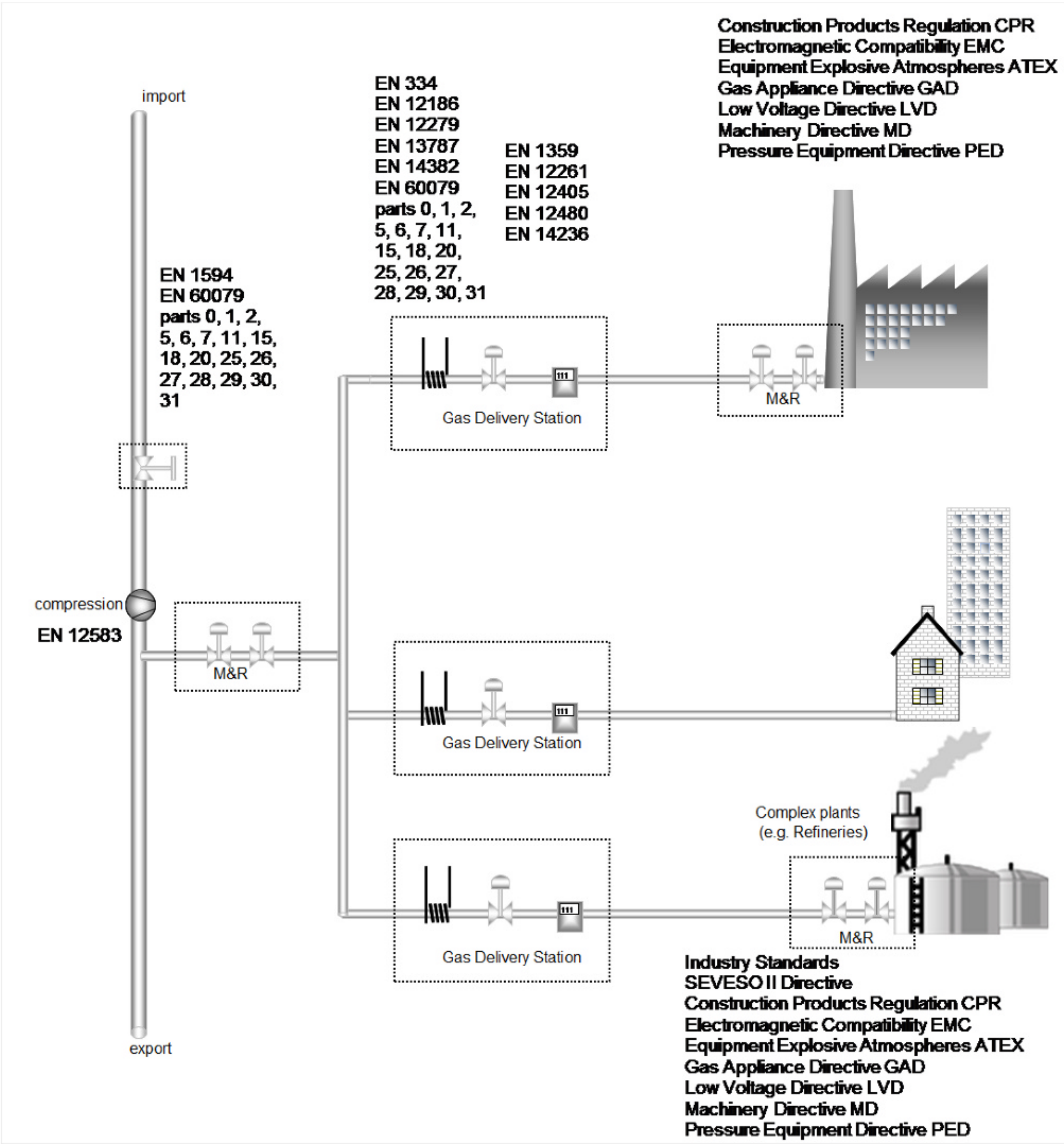

Figure G.1 — Natural gas industrial and commercial network

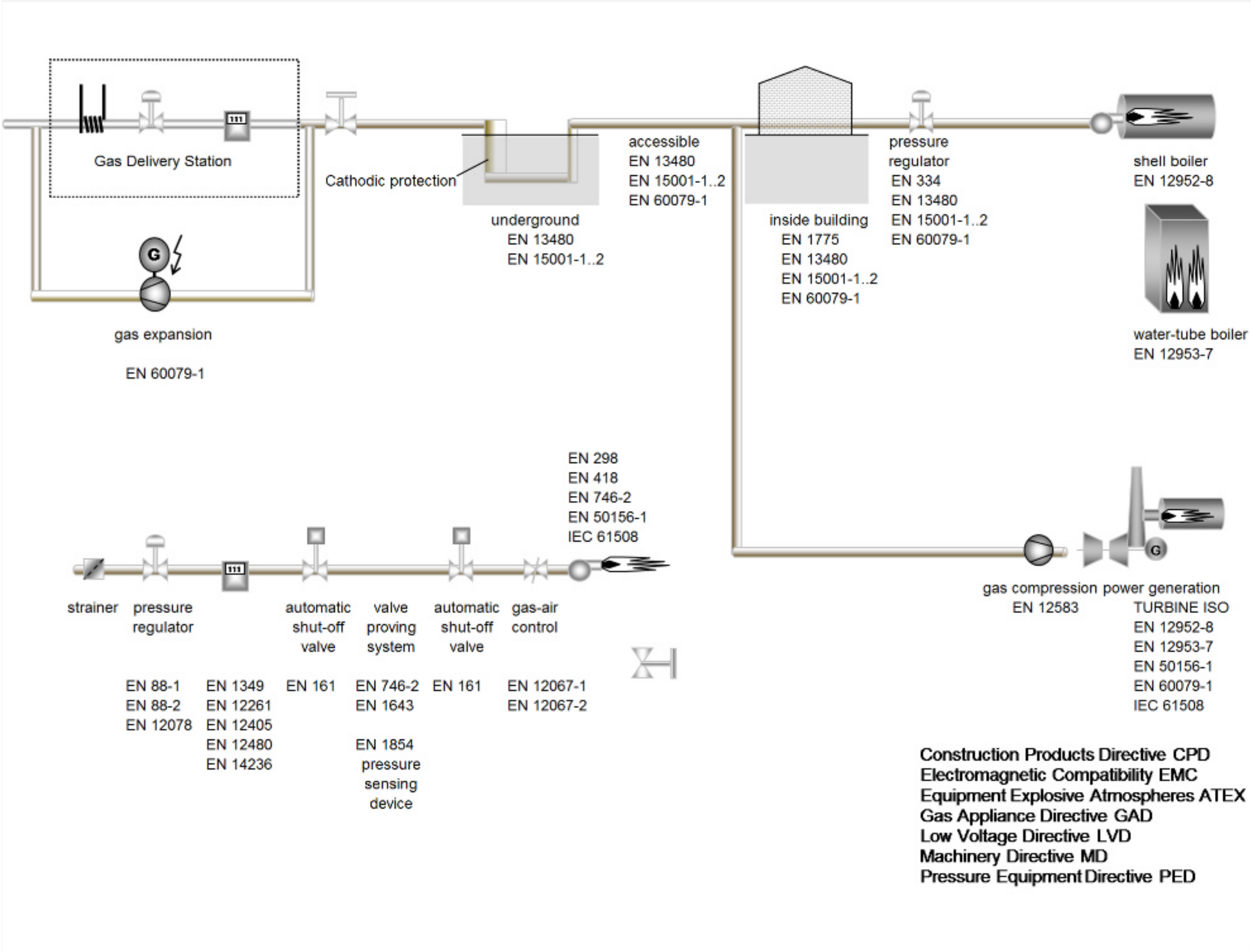

Figure G.2 — Natural gas industrial network

NOTE Meters are only for functional performance and not for billing purposes.

Annex H
(informative)

National data

Table H.1 — Benchmark Questionnaire – Inspections at Industrial Gas Installations – National Status

QUESTIONS **COUNTRIES**	**Which gas installations are under inspection at frequent intervals? Define the intervals**	**Who does the inspections?**	**Accredited Body**	**Certification?**	**Is there an applicable Regulation?**	**Exclusions** **(not applicable)**
CZ	3 or 5 years based on Ministerial Decree No.85/1978 Coll and Internal Regulations	Accredited technicians	YES	YES Equipment and Inspectors	YES (Ministerial Act)	
DE	All the equipment except for the thermo-process equipment. Every 2 to 5 years depending on the operating pressure and the volume.	Plant Operator or Certified Contractor	NO – Certified DVGW Accredited	NO	The implementation of EU Directives + DVGW rules	
ES	Pipes are inspected every 5 years. Vessels are inspected every 2 to 6 years.	DSO	NO (YES for notified vessels)	Certificate by DSO	YES (Royal Decree)	
FR	> 0,5 bar based on 15–03–2000, Ministerial Decree “Operating pressure equipment” Pipes < 40 months Boilers < 18 months	Operator	NO	NO	YES (Ministerial Decree)	

QUESTIONS COUNTRIES	Which gas installations are under inspection at frequent intervals? Define the intervals	Who does the inspections?	Accredited Body	Certification?	Is there an applicable Regulation?	Exclusions (not applicable)
GR	> 0,5 bar based on Ministerial Decree "Internal Installations with operating pressure from 50 mbar up to 16 bar". Inspection occurs every 2 years.	Installers and Authorities	NO (YES in the near future)	Recorded in the site files	YES (Ministerial Decree)	
IT	When *P* > 0,5 bar — Vessels and assemblies: inspection every 2 or 4 depending on the PED category + integrity verification every 10 years — Piping: inspection every 5 years + integrity verification every 10 years	Accredited Bodies	YES	Certification report signed by Accredited Bodies	YES (Decree 1 Dec. 2004 n. 329)	— Vessels: V ≤ 25 l and V ≤ 50 l when *P* ≤ 12 bar — Valves DN ≤ 80 — Piping DN ≤ 80 — Others (listed in the article 2 of the above decree)
UK	> 0,5 bar Competent person — Risk basis	ATEX- > Owner- > Gas Engineer/ Installer and Authorities	NO	NO – Recorded in the site files	DSEAR, PSSR, PUWER	
DK NOTE	All the gas equipment	Inspection Bodies certified by Technical Safety Council "Sikkerhedsstyrelsen'	YES	YES	National gas regulations	

QUESTIONS **COUNTRIES**	**Which gas installations are under inspection at frequent intervals? Define the intervals**	**Who does the inspections?**	**Accredited Body**	**Certification?**	**Is there an applicable Regulation?**	**Exclusions** **(not applicable)**
NL NOTE	Industrial gas and other combustion equipment Inspection is required before commissioning and further periodic inspections also is required every 4 years	Accredited Bodies by SCIOS	YES	YES	National gas regulations	
SE NOTE	Every 2 years for gas equipment	Accredited Bodies	YES	YES	ENERGY GAS NORMS (EGN) 11	
BE	Not specific regulation for gas installations					
FI	Not specific regulation for gas installations					
NO	Not specific regulation for gas installations					

NOTE For steam boilers and their gas equipment specific inspection requirements extra to the above are specified.

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[36] EN 12952-5, *Water-tube boilers and auxiliary installations — Part 5: Workmanship and construction of pressure parts of the boiler*

[37] EN 12952-6, *Water-tube boilers and auxiliary installations — Part 6: Inspection during construction; documentation and marking of pressure parts of the boiler*

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