

BS EN 12007-1:2012



BSI Standards Publication

# Gas infrastructure — Pipelines for maximum operating pressure up to and including 16 bar

Part 1: General functional requirements

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**National foreword**

This British Standard is the UK implementation of EN 12007-1:2012. It supersedes BS EN 12007-1:2000 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GSE/33, Gas supply.

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

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ISBN 978 0 580 68890 4

ICS 75.200

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2012.

**Amendments issued since publication**

Date	Text affected
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EUROPEAN STANDARD

**EN 12007-1**

NORME EUROPÉENNE

EUROPÄISCHE NORM

August 2012

ICS 23.040.01

Supersedes EN 12007-1:2000

English Version

## Gas infrastructure - Pipelines for maximum operating pressure up to and including 16 bar - Part 1: General functional requirements

Infrastructures gazières - Canalisations pour pression maximale de service inférieure ou égale à 16 bar - Partie 1: Exigences fonctionnelles générales

Gasinfrastruktur - Rohrleitungen mit einem maximal zulässigen Betriebsdruck bis einschließlich 16 bar - Teil 1: Allgemeine funktionale Anforderungen

This European Standard was approved by CEN on 24 May 2012.

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## Foreword

This document (EN 12007-1:2012) has been prepared by Technical Committee CEN/TC 234 "Gas infrastructure", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2013, and conflicting national standards shall be withdrawn at the latest by February 2013.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12007-1:2000.

Annex B provides details of significant technical changes between this European Standard and the previous edition.

EN 12007 *Gas infrastructure — Pipelines for maximum operating pressure up to and including 16 bar* consists of the following parts:

*Part 1: General functional requirements*

*Part 2: Specific functional requirements for polyethylene (MOP up to and including 10 bar)*

*Part 3: Specific functional requirements for steel*

*Part 4: Specific functional requirements for renovation*

*Part 5: Specific functional recommendations of new service lines<sup>1</sup>*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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<sup>1</sup> To be published.

## 1 Scope

This European Standard describes the general functional requirements for pipelines up to the point of delivery, and also for buried sections of pipework after the point of delivery, for maximum operating pressures up to and including 16 bar for gaseous fuels in accordance with EN 437:1993+A1:2009, Table 1. It applies to their design, construction, commissioning, decommissioning, operation, maintenance, renovation, extension and other associated works.

This European Standard does not apply to the materials, design, construction, testing and commissioning of gas infrastructures in use prior to the publication of this European Standard. However, this European Standard does apply to the operation, maintenance, renovation and extension of all gas infrastructures.

Specific functional requirements for polyethylene pipelines are given in EN 12007-2, for steel pipelines in EN 12007-3 and for the renovation of pipelines in EN 12007-4. Functional recommendations for pipework for buildings are given in EN 1775. Functional requirements for service lines are given in prEN 12007-5.

Functional requirements for pressure testing, commissioning and decommissioning are given in EN 12327.

Functional requirements for measuring systems are given in EN 1776.

Functional requirements for pressure regulating stations are given in EN 12186.

Functional requirements for pressure regulating installations are given in EN 12279.

Functional requirements for gas transmission are given in EN 1594.

This European Standard specifies common basic principles for gas infrastructure. Users of this European Standard should be aware that more detailed national standards and/or code of practice may exist in the CEN member countries. This European Standard is intended to be applied in association with these national standards and/or codes of practice setting out the above-mentioned basic principles.

In the event of conflicts in terms of more restrictive requirements in national legislation/regulation with the requirements of this European Standard, the national legislation/regulation takes precedence as illustrated in CEN/TR 13737 (all parts).

CEN/TR 13737 (all parts) give:

- clarification of all legislations/regulations applicable in a member state;
- if appropriate, more restrictive national requirements;
- a national contact point for the latest information.

## 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 1776, *Gas supply systems — Natural gas measuring stations — Functional requirements*

EN 12007-3, *Gas supply systems — Pipelines for maximum operating pressure up to and including 16 bar — Part 3: Specific functional recommendations for steel*

prEN 12007-5, *Gas infrastructure — Pipelines for maximum operating pressure up to and including 16 bar — Part 5: Specific functional recommendations for new service lines*<sup>1</sup>

EN 12186, *Gas supply systems — Gas pressure regulating stations for transmission and distribution — Functional requirements*

EN 12279, *Gas supply systems — Gas pressure regulating installations on service lines — Functional requirements*

EN 12327, *Gas infrastructure — Pressure testing, commissioning and decommissioning procedures — Functional requirements*

### 3 Terms, definitions and abbreviations

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

#### 3.1 General terminology

##### 3.1.1

##### **gas infrastructure**

pipeline systems including pipework and their associated stations or plants for the transmission and distribution of gas

##### 3.1.2

##### **pipeline**

system of pipework with all associated equipment and stations up to the point of delivery

Note 1 to entry: This pipework is mainly below ground but includes also above ground parts.

##### 3.1.3

##### **gas**

gaseous fuel which is in gaseous state at a temperature of 15 °C under atmospheric pressure (1,013 25 bar absolute)

##### 3.1.4

##### **point of delivery**

point of a gas network where the gas is transferred to the user

Note 1 to entry: This can be at a means of isolation (e.g. at the outlet of a LPG storage vessel) or at a meter connection.

Note 2 to entry: For this European Standard, the point of delivery is typically nominated by the distribution system operator and can be defined in National Regulations or Codes of Practice.

##### 3.1.5

##### **pipeline operator**

private or public organization authorized to design, construct and or operate and maintain the gas infrastructure

##### 3.1.6

##### **competent person**

person who is trained, experienced and approved to perform activities relating to gas infrastructures

Note 1 to entry: Means of approval, if any, will be determined within each member country.

##### 3.1.7

##### **lower explosive limit**

##### **LEL**

concentration of flammable gas or vapour in air, below which the gas atmosphere is not explosive

### 3.1.8

#### **pipeline components**

elements from which the pipeline is constructed

Note 1 to entry: The following are distinct pipeline elements:

— pipes, including cold formed bends;

— fittings;

EXAMPLE 1 Reducers, tees, factory-made elbows and bends, flanges, caps, welding stubs, mechanical joints.

— ancillaries;

EXAMPLE 2 Valves, expansion joints, insulating joints, pressure regulators, pumps, compressors.

— pressure vessels.

### 3.1.9

#### **gas main**

pipework in a gas infrastructure to which service lines are connected

### 3.1.10

#### **service line**

pipework from the gas main to the point of delivery of the gas into the installation pipework

### 3.1.11

#### **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.

### 3.1.12

#### **sleeve**

purposely installed length of protective pipe through which a gas pipe passes

### 3.1.13

#### **casing**

protection by means of a construction around the pipeline in order to prevent external loads, or third party interference

### 3.1.14

#### **carrier pipe**

existing pipework in which a renovation system is installed

Note 1 to entry: The carrier pipe can be either a conduit pipe or a support pipe.

### 3.1.15

#### **competent authority**

body authorized by the member country to ensure that the pipeline operator fulfils the requirements of this and other relevant standards

## 3.2 Pressure related terminology

### 3.2.1

#### **pressure**

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

**3.2.2**  
**design pressure**

**DP**  
pressure on which design calculations are based

**3.2.3**  
**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 means no fault in any device or stream.

**3.2.4**  
**temporary operating pressure**

**TOP**  
pressure at which a system can be operated temporarily under control of the regulating devices

**3.2.5**  
**maximum incidental pressure**

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

**3.2.6**  
**strength test pressure**

**STP**  
pressure applied to a system during strength testing

**3.2.7**  
**combined test pressure**

**CTP**  
pressure applied to a system during combined testing

## **4 Quality**

### **4.1 Quality and safety management**

To provide a consistent and appropriate standard of quality management the pipeline operator shall have organizational, operational and administrative procedures to ensure that activities can be undertaken in a safe and technically sound manner. The pipeline operator shall have suitable systems for technical audit, safety audit and performance review to ensure that established procedures and training programmes continue to meet the obligations of the pipeline operator to users. These should take into account experiences gained.

EXAMPLE 1 Operational incidents or other relevant dangerous occurrences.

This system should include, for each activity:

- adequate numbers of competent persons; and
- adequate other resources.

EXAMPLE 2 Vehicles, communication systems and appropriate tools.

### **4.2 Competence**

The qualification of competent persons involved in the design, construction, operation and maintenance of a gas infrastructure, or parts of it, shall be in accordance with the characteristics of the pipeline system they are working on. These characteristics include, but are not limited to the following:

- family of gas;
- local conditions;
- design or operating pressure;
- materials used in the system;
- jointing techniques; and
- emergency procedures.

## 5 Gas characteristics

### 5.1 Gas quality and family

The quality and family of gas supplied through a gas infrastructure shall be specified so that its characteristics are known to system designers and pipeline operators. This specification includes all relevant characteristics which contribute to safe operation and combustion. Changes in the properties of the gas which fall outside pre-determined operating limits shall be notified to pipeline operators in advance.

Gas may also be treated or conditioned for operational and maintenance reasons.

EXAMPLE 1 For the control of leakage.

EXAMPLE 2 For the control of icing conditions at pressure regulating stations and installations.

Safe operating procedures for systems supplying gases heavier than air shall recognize the tendency for these gases to settle downwards should they escape from the system.

### 5.2 Odorization

Gas supplied to end users should possess a distinctive odour.

Where gas is to possess a distinctive odour its presence in the atmosphere shall be readily detectable at all gas concentrations of 20 % of the lower explosive limit and above. Where the gas does not possess a natural distinctive odour one shall be added for the purpose.

The odorant, where added, shall be non-toxic and harmless for the concentrations employed in normal applications, and the odour shall disappear after combustion.

An odorant may be omitted in gas delivered specifically for further processing or other special purposes. In this case alternative means shall be available to detect leaks.

### 5.3 Toxicity and lack of oxygen

The potential toxic effects of gas constituents and the potential lack of oxygen shall be considered to ensure safety in all work practices undertaken on the gas infrastructure, in using the gas and in dealing with escaping gas.

## 6 Materials

The characteristics of materials of pipes, fittings and components and the mode of construction of pipelines shall be appropriate to the types of gas being supplied and the conditions under which they are operated.

Materials and products shall conform to the relevant European Standards or, in their absence, to the national or other established standards and shall be of a quality fit for purpose. Consideration shall be given to the effects of climatic conditions on material behaviour and its consequential influence on performance. Materials can give a different technical performance in risk or long term behaviour when exposed to or stored under extreme climatic conditions.

EXAMPLE 1 At lower temperatures the critical pressure for rapid crack propagation in polyethylene pipe is reduced.

EXAMPLE 2 At low temperatures in steel pipes loss of resilience can occur, and at high temperatures disbondment of coatings on steel pipes can occur.

NOTE The critical pressure for rapid crack propagation in polyethylene pipe is tested and verified according to product standards, e.g. EN 1555.

For further information, reference should be made to the specific standards for the materials concerned.

## 7 Design

### 7.1 General

Gas infrastructures are designed to provide a safe and continuous supply of gas. This design considers technical aspects and procedures together with environmental and safety aspects.

The gas infrastructure consists of pipeline components arranged in networks or single lines, with associated pressure regulating stations or installations and connections to consumers via service lines.

NOTE During the design phase these parts of the system may be considered separately.

Basic data and design principles should be documented together with the actual data as the gas infrastructure is built. Data such as the diameter, material, design pressure, family of gas and routing maps should be available as long as the gas infrastructure is in operation, see 13.2.

### 7.2 Basic design data

The design of any gas infrastructure, or part thereof, should commence with a study collecting relevant basic data for the part of the gas infrastructure to be installed. This basic data shall include, but are not limited to the following:

- the family of gas;
- anticipated gas flow;
- design pressure;
- diameter(s);
- construction materials;
- layout of the existing gas infrastructure;
- the need for pressure regulation; and
- provisional routing of pipeline sections.

The design of the gas infrastructure for flow rate capacity shall as a minimum take account of, but not be limited to the following:

- a) the family of the gas;
- b) the location and number of actual or anticipated customers, the predicted customer type, consumption patterns and climatic conditions in the area to be served. Due account should be taken of the diversity of demand in establishing design flow rates;
- c) the technical operating values to be applied such as:
  - 1) the pressure, which is required to be maintained within values that permit correct functioning of pressure regulators and specific user appliances, at all parts of the system;
  - 2) the requirement to maintain a minimum pressure in the supply system according to the rules of the member countries and the normal pressure range for the system concerned to ensure the safe use of gas;
  - 3) the gas velocity in the pipes, which should be sufficiently low as to limit excessive movement of any impurities and the generation of unacceptable noise phenomena;
- d) the diameter sizing formulas, elected from those generally used according to pressure ranges. In the case of complex networks, appropriate computer calculation procedures may be used. The parameters identified above should be explicitly indicated in the design process;
- e) the dynamic variations in gas flow due to special industrial applications.

EXAMPLE      On-off burners.

### **7.3 Pressure relationships**

The relationship between pressures is given in Table 1.

Table 1 — Pressure relationships

MOP <sup>a</sup> (bar)	TOP ≤	MIP ≤	STP/CTP >
5 < P ≤ 16	1,2 MOP	1,30 MOP	MIP
2 < P ≤ 5	1,3 MOP	1,40 MOP	MIP
0,1 < P ≤ 2	1,5 MOP	1,75 MOP	MIP
P ≤ 0,1	1,5 MOP	2,50 MOP <sup>b</sup>	MIP

<sup>a</sup> These relations are only valid when DP = MOP.

<sup>b</sup> When gas appliances, tightness tested at 150 mbar, are directly connected to installation pipework, the MIP downstream of the regulator shall be limited to 150 mbar.

MOP shall be equal to or less than the design pressure of the system, including its components. The maximum set value of the active pressure regulator in the working stream shall not exceed MOP.

NOTE Where MOP is less than DP, the pressure relationships given in Table 1 may be related to DP.

EXAMPLE Where DP is equal to 0,1 bar and MOP equal to 0,075 bar TOP can reach  $1,5 \times 0,1$  bar and MIP can reach  $2,5 \times 0,1$  bar.

For information on specific pressure settings reference should be made to EN 12186 and EN 12279.

## 7.4 Pipeline sections

### 7.4.1 General

Pipeline sections shall be supported, anchored or buried in such a way that, during their lifetime the pipeline sections will not move with respect to their installed position, except for the foreseen permitted displacements.

Submerged pipes shall have enough own weight or outside loading during the construction and operation phases to guarantee horizontal and vertical stability. The pipe wall thickness selection should be based on sufficient resistance to internal pressure and also the forces expected during handling and transportation.

Additional measures should be provided as necessary to protect the pipe against third party damage, these measures include, but are not limited to the following:

- increased depth of cover;
- a control zone along the pipeline route;
- increased wall thickness;
- additional mechanical protection; and
- increased frequency of surveillance.

## 7.4.2 Routing

### 7.4.2.1 Public area

Pipelines routed along public streets should comply with legal requirements concerning consent, location and distances. Where there is a choice, gas mains should be laid preferably in footways or verges.

### 7.4.2.2 Private area

Where it is necessary to lay gas mains, or associated plant in private land, the agreement document between the landowner and the pipeline operator shall include all necessary precautions to be taken to ensure full safety of operation and permit subsequent access to the land for ease of maintenance.

The agreement should ensure that a zone of land adjacent to the gas main or associated plant remains free of any third party works which can be a potential risk to the gas main.

NOTE This includes subsequent construction and the planting of trees.

The agreement should also contain adequate provision for consultation prior to any proposed third party works. The pipeline operator may elect to exercise any option to prevent the proposed works or request modifications to them to avoid hazard.

## 7.4.3 Pipework inside buildings

For the technical requirements for pipework inside buildings reference should be made to EN 1775.

The pipework element of the gas infrastructures situated in buildings shall be designed, constructed and protected so that the effects of a fire on the pipework do not lead to an explosion or significant aggravation of the fire.

NOTE These objectives can be achieved for example by the use of one or more of the following:

- a) isolating the pipework by means of a manual or automatic means of isolation;
- b) the use of materials, components and joints that withstand high temperatures;
- c) location of all or part of the pipework in an enclosure providing protection in the event of fire;
- d) coating pipework with a protective material to enable the pipework to withstand high temperatures for a given period of time.

Consideration should be given to installing tamper-proof valves at, or near, the base of a service line laid above ground within a building. Any ducts or enclosed spaces containing a service line should be adequately ventilated. See prEN 12007-5 for specific functional requirements for new service lines.

For pipework inside pressure regulating and measuring stations reference should be made to EN 12186 and EN 1776.

## 7.4.4 Pipework above ground

Where it is necessary to install pipework above ground consideration shall be given to limiting the influence on the pipework of factors such as, but not limited to the following;

- UV degradation;
- thermal expansion;

- loads imposed by ground forces;
- interference damage; and
- corrosion.

#### 7.4.5 Bridge crossings

Where bridges are used to support pipelines, measures appropriate to the type and size of bridge shall be taken to protect the pipework against deterioration and damage due to:

- static or dynamic (thermal expansion) loads;
- traffic on, or passing under the bridge; and
- interference.

Consideration shall be given to isolation measures in the event of damage to the pipework on bridge crossings, see 7.8.

#### 7.4.6 Underwater crossing

Where gas mains and services cross under waterways appropriate methods shall be used.

EXAMPLE 1 Trenching.

EXAMPLE 2 Trenchless techniques.

EXAMPLE 3 Insertion into an existing pipe.

In the planning and laying of underwater crossings the geological conditions of the ground should be known and appropriate precautions taken.

EXAMPLE 4 Possible mobility of the waterway bed.

EXAMPLE 5 Loading or anchoring the pipework to counteract buoyancy effects.

The depth of pipework below or on the bed of the waterway shall be chosen to protect it from any foreseen activity in the use of the waterway.

EXAMPLE 6 Anchoring of vessels.

The position of pipework crossing major waterways shall be clearly marked.

#### 7.4.7 Limiting interference from external causes

##### 7.4.7.1 General

The risk of interference with the gas infrastructure by other buried plant, ground movement, trees, other structures or traffic should be minimized at the design stage considering the guidance given below.

Safe operating and liaison procedures shall be agreed between the pipeline operator and relevant third parties.

EXAMPLE 1 Other utilities.

EXAMPLE 2 Highway, bridge, waterway and rail authorities.

Marker tapes or other devices may be employed to help limit interference, but their limitations in operational performance should be recognized.

Any proposed construction over or in the vicinity of existing gas mains and services shall be allowed only if agreed by the pipeline operator.

#### **7.4.7.2 Interference from other underground services**

In order to safeguard the gas infrastructure from damage caused by other buried plant in close proximity, or from those engaged in laying other utilities equipment, it is essential that the pipeline operator works to a set of minimum clearance distances for both parallel and crossing plant. The pipeline operator should also have guidelines for protective measures which should be taken in the event that lesser clearance distances are required.

**EXAMPLE** Protecting pipes by laying in sleeves, under concrete protection, or steel plates.

Designs and the selection of material shall take account of the proximity to district heating systems. These conditions also apply to the buried sections of service lines.

#### **7.4.7.3 Interference from railways or tramways**

Where the gas main is laid parallel to tramways or urban railways in streets the pipeline operator should agree with the tramway or railway operator a set of minimum distances between the tracks and any pipework.

**NOTE** Generally railways require greater clearances than tramways.

#### **7.4.7.4 Interference from environmental hazards**

Special precautions shall be taken to protect the gas infrastructure against excessive stresses. When gas infrastructures are installed in areas subject to natural hazards the systems shall be designed so as to avoid or limit interference from these hazards.

Hazards which can require special precautions are, but not limited to, the following:

- areas of unstable ground such as ground where there has been recent fill, especially within the last two years, see Example 1;
- ground liable to subsidence or land slide/slip;
- areas of loose sand or gravel;
- ground liable to washout or flooding;
- areas with special ground water conditions, such as fresh water over salt water, or where the buoyancy effect can lift the buried gas main;
- areas of known or suspected aggressive ground, see Example 2; and
- areas with high seismic risk (for risk details and analysis see Annex A).

**EXAMPLE 1** Precaution: use of tensile resistance joints.

**EXAMPLE 2** Precaution: soil replacement / applying casing / choosing suitable pipe material.

#### 7.4.7.5 Interference from traffic

When above ground installations are exposed to potential damage by vehicle traffic or other similar causes the gas mains and services should be protected from accidental damage by distance, location or adequate mechanical means.

#### 7.4.7.6 Interference from electrical hazards

Care should be taken in order to avoid electrical interference from stray or induced currents, lightning, or from arcing between metallic pipework and any electrical conductors.

### 7.5 Service lines

In addition to the requirements of 7.4, the requirements of prEN 12007-5 shall apply.

### 7.6 Pressure regulating stations and installations

Pressure regulating stations shall comply with EN 12186.

Pressure regulation installations for service lines shall comply with EN 12279.

The gas infrastructure shall be equipped with suitable pressure relieving and/or pressure limiting devices to ensure that the pressure does not exceed MIP.

### 7.7 Measuring stations

Measuring stations shall comply with EN 1776.

### 7.8 Valves

In determining the location of valves, consideration shall be given to the following factors:

- operating pressure;
- pipeline material;
- pipeline diameter;
- above ground pipework;
- the need for valves for operational purposes;
- the position of the nearest connected pipeline; and
- the position of other valves.

The number of valves used shall be at least the minimum necessary to ensure a safe and continued supply of gas.

Access for easy operation of the valve should be provided.

### 7.9 Corrosion protection

7.9.1 Passive and active systems for corrosion protection shall conform to the appropriate standards as detailed in EN 12007-3.

**7.9.2** Buried gas mains and services and the buried sections of installation pipework made of steel shall be protected against external corrosion. The methods shall be passive and where necessary active.

**7.9.3** Continuous coatings for passive methods shall have adequate resistivity, adherence to metal, impermeability to water and to air, inertness in relation to chemical agents in the ground, plasticity, and mechanical resistance at the temperature to which they will be subjected during laying and operation.

The passive system should be selected by the pipeline operator to match the expected lifetime of the buried pipework.

**7.9.4** Where steel gas pipes are placed in metallic carrier pipe or sleeve, precautions against bi-metallic corrosion shall be taken to protect the pipe and its sleeve.

Suitable protection shall also be given to metallic sleeves used for plastic gas pipes.

The use of steel sleeved crossings should be minimized as they can cause adverse effects on cathodic protection systems. When steel sleeves are used, they shall be designed such that:

- a) they are capable of withstanding external loads;
- b) the gas pipe is easily installed;
- c) cathodic protection of the steel gas pipe can be provided if necessary;
- d) they can be sealed effectively or filled with a suitable material to minimize water circulation and thus reduce the oxygen supply to a minimum;
- e) the gas pipe is provided with an adequate and suitable support and provision is made, especially at the extremities of the sleeve, to avoid the possibility of contact between the gas pipe and the steel sleeve;
- f) adequate supports shall be provided considering operating and test conditions.

**7.9.5** Sections of gas mains and services made of steel installed in the open air shall be externally protected.

EXAMPLE By painting, electro-plating, coating or another appropriate method.

**7.9.6** Sections of gas mains and services made of steel shall be electrically insulated from adjacent metal structures or works except when electrical connections are intended for the corrosion protection system.

**7.9.7** Cathodic protection shall be provided for buried gas mains and services made of steel where such protection is considered necessary. Its purpose is to ensure that at all times and at all points in the gas mains and services the potential relative to the ground will be sufficiently negative to protect the gas infrastructure from corrosion.

**7.9.8** The design of cathodic protection systems shall take account of the effects of possible stray currents, especially from electric railways and other sources.

**7.9.9** When steel or other metallic pipework is installed close to any existing cathodic protection system or in an environment where stray currents can occur special care shall be taken in order to avoid electrical interference.

NOTE It is beneficial to liaise with the operators of adjacent cathodic protection systems.

## 8 Limiting environmental impact

**8.1** The design, construction and operation of gas infrastructures shall be organized so that the impact on the environment is reduced to the minimum practicable level.

**8.2** During design and construction, consideration shall be given to minimizing as far as is reasonably practicable the emitted noise level and effects on neighbours.

**8.3** During the laying of gas pipelines special precautions should be taken to minimize the disturbance to adjacent drainage networks and other buried installations.

**8.4** Inconvenience to road users caused by construction, maintenance or operation of the system should be minimized by appropriate techniques.

EXAMPLE By the use of trenchless technology.

**8.5** During construction all reasonable measures shall be taken to avoid damage to trees and other vegetation. Above ground parts of the gas infrastructure such as regulating and measuring stations should be designed and located in order to reduce environmental impact as far as reasonably practicable.

**8.6** All unwanted materials or waste shall be disposed of properly in an environmentally friendly manner.

## 9 Transportation, storage and handling of materials

**9.1** Care shall be taken during the transport, handling and storage of pipes, fittings and other items to avoid damage to the materials and ensure the safety of personnel.

**9.2** At all stages damage and distortions to the materials should be avoided and the effects of environmental factors should be minimized. All materials should be stored under appropriate environmental conditions and shall be used within any specified constraints.

EXAMPLE Expiry date or UV degradation limits.

**9.3** Full attention shall also be given to the general safety of all personnel, members of the public and to adjacent property at all times during handling operations.

**9.4** For safety reasons only the correct equipment shall be employed where mechanical handling is necessary and manual handling shall be undertaken by competent persons within their weight limit capabilities. Handling equipment shall be visually checked before use.

**9.5** Particular details for transporting, storing and handling the materials for each kind of system are given in EN 12007-2 and EN 12007-3.

## 10 Construction

### 10.1 General

The safety of personnel engaged on gas supply works and of members of the public shall be ensured during the whole period of the works. Considerations shall be given to the needs of the elderly or disabled.

After transport, storage and handling and before assembly on site, the condition of pipes, their coatings, and fittings shall be checked. Before assembly and laying, all pipes and fittings shall also be checked for unwanted obstructions or blockages.

Gas mains and services lines shall be laid only by competent persons using the appropriate equipment necessary to complete the work in conformance with the relevant standards.

When installing buried gas mains and service lines the depth to which these gas mains and service lines should be laid will depend upon a number of factors. These factors include, but are not limited to the following:

- climatic conditions;
- family of gas;
- the possibility of third party interference;
- nature of soil;
- location of other buried plant;
- location of other buried obstacles;
- traffic loadings;
- laying techniques;
- MOP.

In certain conditions it is not possible to maintain the normally accepted burial depth, in these conditions additional protective measures should be considered.

The trench bottom shall be free of any sharp objects liable to damage the pipe or its external coating. If this is not possible, the pipe shall be protected by suitable means, such as stone dust, sand or mechanical protection. Excavations created in the process of constructing gas infrastructures shall be suitably backfilled and surface features such as roads and footways should be reinstated according to local requirements.

During laying and before backfilling, the pipework and any protective coatings shall be checked for defects and repaired as necessary.

EXAMPLE      Local deformations, worn spots, cuts and scratches.

## 10.2 Connections to existing systems

Checks should be carried out to identify the part of the existing system to which the connection is intended to be made.

When connecting new pipework to an existing gas infrastructure, the resultant MOP shall be limited to that of the lowest rated part.

The connection of new to existing gas infrastructures shall be planned and built in a manner that ensures the safety and continuity of gas supply and the safe carrying out of the intended work. This shall include measures to minimize the escape of gas, provide suitable respiratory and other safety equipment for personnel and measures for minimizing the risk of ignition and the control of fires should they occur.

The design and construction of the connection shall consider any special requirements of the existing pipe materials.

Specific precautions for gas infrastructures in the basic materials are given in EN 12007-2, EN 12007-3 and EN 12007-4.

EXAMPLE 1      Controlling the discharge of any static electricity from polyethylene.

EXAMPLE 2      The need for electrical continuity when steel pipes are jointed or separated.

EXAMPLE 3      The need for electrical insulation between steel pipes and cast iron pipes.

When connecting a new system to an existing system, consideration shall be given to the prevention of undue forces on either system. This can be achieved by the addition of anchor blocks or joints which provide flexibility.

## 11 Pressure testing

The pipeline operators shall be responsible for ensuring that the system being operated has undergone suitable pressure testing prior to commissioning.

Pressure testing procedures to prove the integrity of gas mains and service lines shall be selected by the pipeline operator from EN 12327 with levels of test pressure appropriate to the pipe size, materials, volume under test and MOP.

The strength test and the tightness test may be performed as a combined test with CTP equal to STP. Pressure testing shall be undertaken by competent persons. These persons may be specifically authorized by the pipeline operator and/or competent authority(ies).

Consideration shall be given to the need for any special precautions to be taken to protect persons and property if air or inert gas is used as the test medium.

Where pressure testing is undertaken or witnessed by a third party, confirmation shall be provided to show that the section of gas infrastructure concerned has been laid according to the relevant standards and/or codes of practice.

Records of pressure tests shall be kept detailing the date and results.

## 12 Commissioning and decommissioning

The systems shall be commissioned and decommissioned in accordance with EN 12327. Appropriate procedures shall be selected to commission or decommission gas mains or service lines safely having regard to their pressure range, volume and the degree of branching in the pipework and to the family of gas. These works and operations shall be carefully planned. If necessary a written procedure together with a plan of safe work shall be prepared.

All commissioning and decommissioning shall be undertaken by competent persons authorized by the pipeline operator and approval given for the use of the gas main to supply gas.

NOTE These duties may be undertaken by personnel of the pipeline operator or other persons according to local rules.

All reasonable steps should be taken by the pipeline operator to ensure that any end user affected by commissioning or decommissioning has been notified prior to the work.

## 13 Operation, survey and maintenance

### 13.1 General

Consideration should be given to the installation of devices to record the gas pressure at appropriate places in the gas infrastructure.

The pipeline operator should ensure the required odorization level of the gas, the system pressure, and the safety of the gas infrastructure is maintained by suitable means.

### 13.2 Record system and traceability

The pipeline operator shall establish a record system for the installed gas mains and keep it up to date throughout their period of operation. The record system can comprise, but not be limited to, the following information:

- gas family;
- initial construction, testing and commissioning data;
- the route;
- any relevant rights of way or access details;
- non standard depths of burial of the gas mains locally;
- the pipeline characteristics, valves and pressure regulating stations;
- syphons and other devices integrated into the system for operation and maintenance.

Necessary information on the location of gas mains should be made available to interested public utilities or local authorities.

### 13.3 Operation centres

In order to ensure the safety and continuity of operation, the pipeline operator shall establish a continuous facility for the control and supervision of his network. The pipeline operator shall inform any relevant competent authority(ies) of the arrangements in place for contacting this operation centre.

The operation centre shall have sufficient telecommunications to notify the pipeline operator's own personnel and, if required the public emergency services, in the event of an emergency and thereby enable the necessary safety measures to be taken in the shortest practicable time. The pipeline operator shall be in a position to supply any relevant competent authority(ies) with all information concerning the measures taken and the means employed to ensure safety in the event of an operational incident.

### 13.4 Pipeline operator's work

When work is planned on gas infrastructures there should be communication with the operators of other plant and other relevant organizations with interests near the gas infrastructure. Relevant information should be collected to plan the intended work. Personnel undertaking the work on site shall be provided with relevant details of adjacent plant together with any specific safety advice to protect it, including telephone numbers for emergency calls where appropriate.

The health and safety of personnel and the public shall be safeguarded during the course of the work according to requirements within the member countries.

Where intended work will interrupt the gas supply, the pipeline operator should make adequate provision to inform the consumers affected. He shall make the adequate provision to ensure safety during the absence of gas and the restoration of normal supplies.

Due regard shall be given to traffic using the street concerned and its influence on the timing of the intended work. Notification of the intention to undertake work shall be given for its various stages from planning to completion according to requirements within the member countries or the local authority concerned.

### 13.5 Third party work

In accordance with the legal requirement of the member country, third parties shall notify the pipeline operator in advance of any proposed work that can affect the gas infrastructures. Advance notice shall be given as early as possible but at least within any statutory time limit. Due notice within any statutory time limits shall also be given for the actual commencement of the work.

The pipeline operator shall, if requested, provide third parties such as statutory utilities, highway authorities or contractors, with information on the location of gas mains, service lines where applicable and any relevant equipment. The third party undertaking excavation or other work shall make full use of this information in order to safeguard the gas infrastructure. Work may only start after consulting the plant operator on safe working methods in the vicinity of the gas infrastructure. Pipeline operators should make clear to third parties any time validity of the information given and advise them to check if the intended work is to commence after the validity date.

EXAMPLE Manual excavations within a safety profile of the system.

Details of emergency telephone/contacts should be made available to the third party. When considered necessary the pipeline operator may inspect known work undertaken in the vicinity of his plant to monitor that the work is being undertaken safely according to any agreed procedures.

### 13.6 Pipeline maintenance

**13.6.1** The pipeline operator shall take the actions necessary to safeguard life and property during their activities, including a repair and maintenance service. All aspects of the maintenance regime shall be undertaken by competent persons using suitable methods.

**13.6.2** In order to ensure safety and continuity of operation the pipeline operator shall have an appropriate maintenance regime in place. This regime should, where applicable depend upon but not be limited to the following factors:

- pipeline material;
- operating pressure;
- pipeline age;
- operating environment; and
- pipeline maintenance history.

**13.6.3** A maintenance regime can consist one or more of, but not be limited to, the following activities:

- inspection and leak survey;
- cathodic protection;
- classification and repair of reported gas escapes.

**13.6.4** The frequency of inspection and leak survey shall be dependant on but not limited to:

- the characteristics and age of the relevant part of the gas infrastructure;
- increase of the operating pressure of the system;
- the presence of work carried out by third parties;

- the density of population;
- the history of leakage in the existing gas infrastructure;
- the nature of the ground and influences related to weather; and
- the location, in exposed positions.

**13.6.5** The cathodic protection shall be checked regularly, including a visit to the protection equipment and a check of the free potential of the protected gas infrastructure.

**13.6.6** The classification procedure should take account of, but not be limited to the following factors:

- the characteristics of the family of the gas supplied;
- the operating pressure of the gas infrastructure;
- the physical indications of leakage;
- the proximity of the gas main and the leak to property;
- the type of property concerned, including its occupancy.

**13.6.7** A procedure for classifying leaks shall be followed to rank the indications in severity for appropriate priority of repair actions

**13.6.8** A procedure shall be established for responding to reports by members of the public of escaping gas.

### **13.7 Emergency record system**

The pipeline operator shall establish a system for recording significant incidents or dangerous occurrences. The record shall be accessible to the competent authority. The following information should be recorded as a minimum:

- the kind of incident;
- the date and place where the incident occurred;
- the circumstances leading to the incident;
- the effect of the incident; and
- the measures taken to deal with the incident and restore safe conditions.

Independently of any other arrangement the pipeline operator shall inform, as soon as reasonably practicable, other concessionaires, public utilities and/or the emergency services concerned, of any knowledge of damage adjacent to gas infrastructures that can compromise the safety of persons, or property either directly or indirectly.

## **14 Emergency plan or intervention plan**

The pipeline operator shall establish, test and update internal emergency intervention plans to deal with incidents that might arise in supplying gas. The plans shall provide the following information:

- parties responsible for setting intervention procedures in motion and the parties responsible for taking charge of, and co-ordinating site actions;

- the family of the gas;
- the surveillance and alarm facilities for the gas infrastructure concerned;
- the arrangements at the operation centre for receiving early warnings of incidents and for alert and call out procedures;
- the names of the local and or national authorities in charge of co-ordinating actions;
- arrangements for co-ordinating the resources necessary to implement the intervention plan;
- the availability of competent persons and equipment for intervention according to the nature and scale of the incident and the family of gas supplied; and
- the availability of mapping data on different scales where necessary.

The emergency plan shall also have a later phase where the circumstances and cause of the incident are studied. Improvements identified at this phase to any aspects of gas supply shall be made to prevent recurrence. The pipeline operator shall implement the plan with the competent persons involved and keep them informed of amendments.

## Annex A (informative)

### Areas with high seismic risk

#### A.1 General

On land, seismic hazards that affect pipelines are:

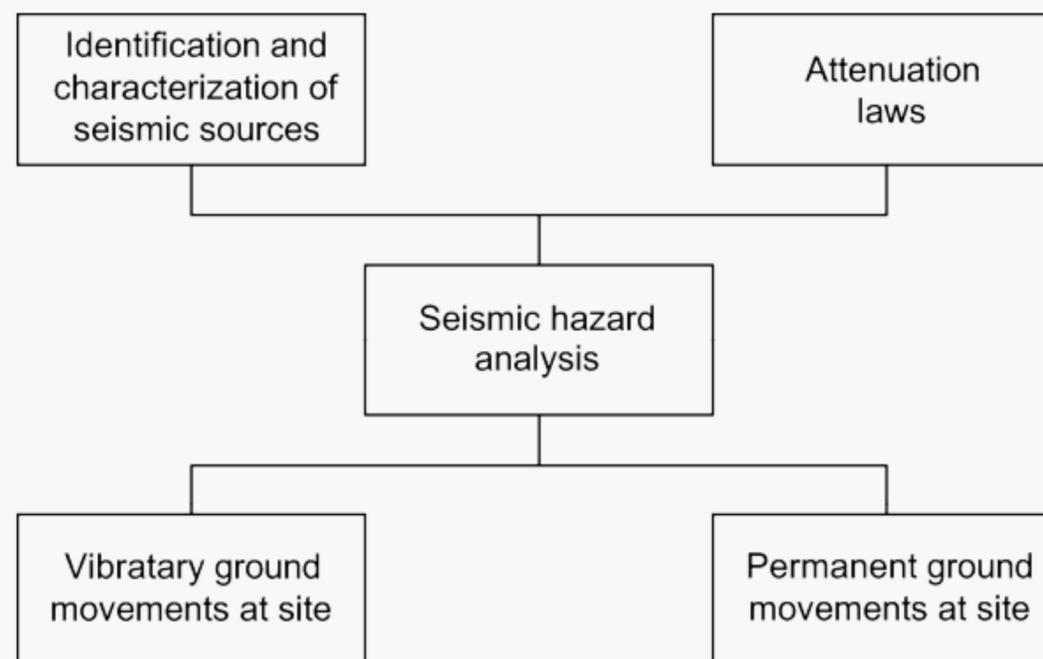
- a) vibratory ground motion due to travelling seismic waves (shaking);
- b) permanent ground movements, which include faulting, liquefaction and landslides.

Ground shaking is a major design consideration for above-ground sections of pipelines.

The seismic response of buried pipelines is strongly influenced by large, permanent soil displacements. Shaking does not cause serious stresses in straight buried pipelines except near the epicentre or in zones of strong seismic amplification. Bends and tees are more vulnerable.

#### A.2 Procedure

Where justified by the seismic activity in the area, it can be necessary to quantify seismic hazards. The principal phases of a seismic hazard analysis are illustrated in Figure A.1.



**Figure A.1 — Seismic hazard analysis**

The identification and characterization of potential seismic sources in the neighbourhood of a site involve both geological and seismological investigations and historical seismic data analysis.

Information on the characteristics of seismic sources, the geological and geotechnical conditions and site-to-source attenuation should be integrated into probabilistic or deterministic models to obtain the measures of seismic intensity at site (see Bibliography [8]).

## A.3 Strength calculation

### A.3.1 Vibratory ground motion (shaking)

Depending on the type of analysis, the following approaches can be used for defining seismic input criteria (see Bibliography [9] and [-10]):

- a) response spectra: These give the probability of various levels of ground motion being exceeded in given periods of time;
- b) seismic regionalization maps: These provide representative intensities of shaking for the response under consideration, based on their seismological and geological characteristics;
- c) ground motion time histories: These are used for the analysis. More than one time history should be used, whether real or synthetic. They should be representative of the shaking expected to occur at the site and should have the same overall intensity and frequency contents.

Three basic methods are available for seismic response analysis of above-ground pipelines and related facilities (see Bibliography [9]):

- d) a quasistatic (code type) load approach;
- e) a modal response spectrum approach;
- f) a time history analysis.

If an above-ground pipeline extends over relatively long distances, the spatial variation of incident seismic waves should be considered. Different support points along the pipeline will be subjected to excitations that differ both in amplitude and phase.

Two analyses should be carried out for pipeline bridges:

- design of bridges to resist the effects of earthquake;
- design of the pipeline in a manner similar to that for above-ground supported pipelines.

For a buried pipeline, the restraint and damping characteristics of the surrounding soil mean that dynamic amplification does not play an important role in the seismic response of the pipe. The seismic loading is therefore be considered as a pseudostatic load.

The effects induced on a buried pipeline by the seismic elastic deformation wave can be evaluated using simplified analytical approaches or numerical methods (see Bibliography [9], [10] and [11]). The selection of appropriate modelling should be made on the basis of the type and importance of the pipeline being designed and the quality of the available and obtainable geotechnical data. Simplified methods are generally adequate in preliminary design. Where the results of this evaluation suggest that special precautions will be required to ensure acceptable performance or where the pipeline is too important or too complex, the more rigorous analyses should be considered.

Straight buried pipelines are be considered as rigidly bonded to the surrounding soil; there is no relative displacement between the pipe and soil so that both have the same strains, i.e. the “free field” deformations of the soil (see Bibliography [10]). In soft soil, where the pipe is very stiff in relation to it, the above approach can lead to a very conservative design and an analysis of pipe/soil interaction is important. Pipe/soil interaction should also be considered in the analysis of buried pipelines with bends and tees. In no case should the stresses/strains in accordance with EN 1594:2009, 7.4 be exceeded.

### A.3.2 Permanent ground movement

Permanent ground effects on buried pipelines are evaluated by:

- a) locating areas of geotechnical hazard;
- b) estimating the likely soil displacement patterns;
- c) determining pipeline stresses and strains by means of models of pipe/soil interaction.

The analysis of pipe/soil interaction requires a procedure that can account for the non-linear behaviour of the surrounding soil mass, large displacement effects and inelastic pipe behaviour.

Analytical procedures for straight geometry of pipes are presented in Bibliography [9], [11] and [12]. Where the pipeline configuration is complex (for example, three-dimensional), finite-element computer analysis is a useful technique. The pipeline is idealized as a beam (see Bibliography [9]), or as a shell (see Bibliography [13]). Pipe/soil interaction is modelled by simplified methods.

The predicted displacement should not lead to stresses/strains in the pipe which exceed the values in accordance with EN 1594:2009, 7.4.

### **A.3.3 Possible action to prevent the allowable/limit values being exceeded**

During the design process, the engineer should consider the following recommendations to prevent the allowable/limit values being exceeded:

- a) for above-ground pipelines:
  - 1) provide ductility at the joints and connections;
- b) for buried pipelines:
  - 1) avoid crossing soils which could cause strong amplification of seismic waves and horizontal discontinuity from firm to soft soil;
  - 2) place the pipeline in an oversized trench surrounded by loose to medium-dense cohesionless granular backfill;
  - 3) reduce the interface frictional resistance between soil and pipe;
  - 4) select a pipe alignment at a fault crossing such that compression is avoided;
  - 5) do not locate potential anchoring elements (tees, sharp bends, flanges) within the anchoring areas on either side of the fault zones.

**Annex B**  
(informative)  
**Technical changes between this European Standard and  
EN 12007-1:2000**

Clause	Change
Title	Change of "recommendation" in the title to "requirement reflecting the main character of the text.
General	Change of recommendations in the text to requirements where technically appropriate
General	Update of normative references
7.4.2.1	Addition of major guidelines for public and private area routing of gas mains.
7.4.7.4	Additions of examples of the actions to be taken in case of specific hazardous situations
7.9.4	Addition of design parameters for steel sleeves
Annex A	Insertion of new Annex A which provides guidance regarding seismic hazards
13.6	Replacement of the initial title "leakage surveys and public reported escapes" by "pipeline maintenance" which is more compatible with the content of the paragraph

## Bibliography

- [1] CEN/TR 13737 (all parts), *Implementation Guide for functional standards prepared by CEN/TC 234 Gas infrastructure*
- [2] EN 1594:2009, *Gas supply systems — Pipelines for maximum operating pressure over 16 bar — Functional requirements*
- [3] EN 1775, *Gas supply — Gas pipework for buildings — Maximum operating pressure less than or equal to 5 bar — Functional recommendations*
- [4] EN 12007-2, *Gas infrastructure — Pipelines for maximum operating pressure up to and including 16 bar — Part 2: Specific functional recommendations for polyethylene (MOP up to and including 10 bar)*
- [5] EN 12007-4, *Gas infrastructure — Pipelines for maximum operating pressure up to and including 16 bar — Part 4: Specific functional recommendations for renovation*
- [6] EN 1555 (all parts), *Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE)*
- [7] EN 437:1993+A1:2009, *Test gases — Test pressures — Appliance categories*
- [8] Cornell: "Engineering seismic risk analysis", *Bulletin of the Seismological Society of America*, vol. 58, 1968
- [9] Committee on Gas and Liquid Fuel Pipelines: "Guidelines for the seismic design of oil and gas systems", ASCE, New York, 1984
- [10] St. John, Zahrah: "A seismic design of underground structures", *Tunnelling and Underground Space Technology*, vol. 2, no. 2, 1987
- [11] O'Rourke, Grigoriu, Khater: "Seismic response of buried pipelines", *Pressure vessel and piping technology, A decade of progress*, 1985
- [12] L.R.L. Wang, Y.H. Yeh: "A refined seismic analysis and design of buried pipeline for fault movement", *EESD*, vol. 12, pp. 75-96, January/February 1985
- [13] Tawfik, O'Rourke: "Analysis of pipelines under large soil deformation", *Cornell Geotechnical Engineering*, Ithaca, New York, 1986
- [14] M. Aiqbal, E.D. Goodling jr.: "Seismic design of buried piping", *2nd ASCE Special Conference on Structural Design of Nuclear Plant Facilities*, New Orleans, December 1974
- [15] N.M. Newmark: "Pipeline design to resist large fault displacements", *Proceedings of the 1st USNCEE, EERJ*, Oakland, California, 1975
- [16] R.P. Kennedy, Chow, Williamson: "Fault movement effects on buried oil pipelines", *Transportation Eng. Journal of ASCE*, vol. 103, no. TE5, 1977
- [17] R.P. Kennedy, A.C. Darrow, S.A. Short: "General considerations for seismic design of oil pipeline systems", *ASCE, CSKLEG*, Los Angeles, 1977
- [18] Toki, Fukumori, Sako, Tsubakimoto: "Recommended practice for earthquake-resistant design of high-pressure gas pipelines", *International Symposium on Pipeline Earthquake Engineering. 4th Congress on Pressure Vessel and Piping Technology*, Portland, Oregon, June 19-24, 1983, edited by Teoman Ariman, University of Tulsa, ASME

- [19] Saito, Nishio, Katayama: "Recommended practice for earthquake-resistant design of medium and low-pressure gas pipelines", Earthquake behaviour and safety of oil and gas storage facilities, buried pipelines and equipment, vol. 77, 1983
- [20] C.L. Taylor, L.S. Cluff: "Fault displacement and ground deformation associated with surface faulting", ASCE, CSKLEG, Los Angeles, 1977
- [21] S. Takada: "Earthquake-resistant design of underground pipelines", New Delhi, 1977
- [22] J.B. Berril: "Building over faults: a procedure for evaluating risk", EESD, vol. 11, no. 3, pp. 427-436, May/June 1983
- [23] A.S. Kiremidjian: "Reliability of structures subjected to differential fault slip", EESD, vol. 12, no. 5, pp. 603-618, September/October 1984
- [24] J.A. Whitelaw, D.W. Reppond: "Design for buried pipeline can reduce seismic hazards", Oil & Gas Journal, pp. 62-70, October 17, 1988
- [25] Hindy, Novak: "Earthquake response of underground pipelines", Earthquake Engineering and Structural Dynamics, vol. 7, 1979
- [26] N. Nishio, A. Hamura, T. Sase: "Effect of ground conditions on seismic deformation in buried pipelines", 1989 International Gas Research Conference



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