

environmental engineering

Municipal Infrastructure

Jarosław Müller



Cracow University
of Technology

Kraków 2020

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Table of Contents

Part 1

Gas networks (p. 5)

Part 2

Construction and maintenance (p. 82)

Part 3

General information (p. 141)

Part 4

Piping (p. 193)

Part 5

Calculations, compensation (p. 212)

Part 6

Substations (p. 269)

References (p. 332)

Part 1

Gas networks

Fuel

High-methane natural gas

E (GZ50) from Carpatia and Russia

(> 90% CH₄)

Nitrogen-rich natural gas

L_s (GZ35) and L_w (GZ41.5)

From Greater Poland

(35–84% CH₄)

Fuel – properties

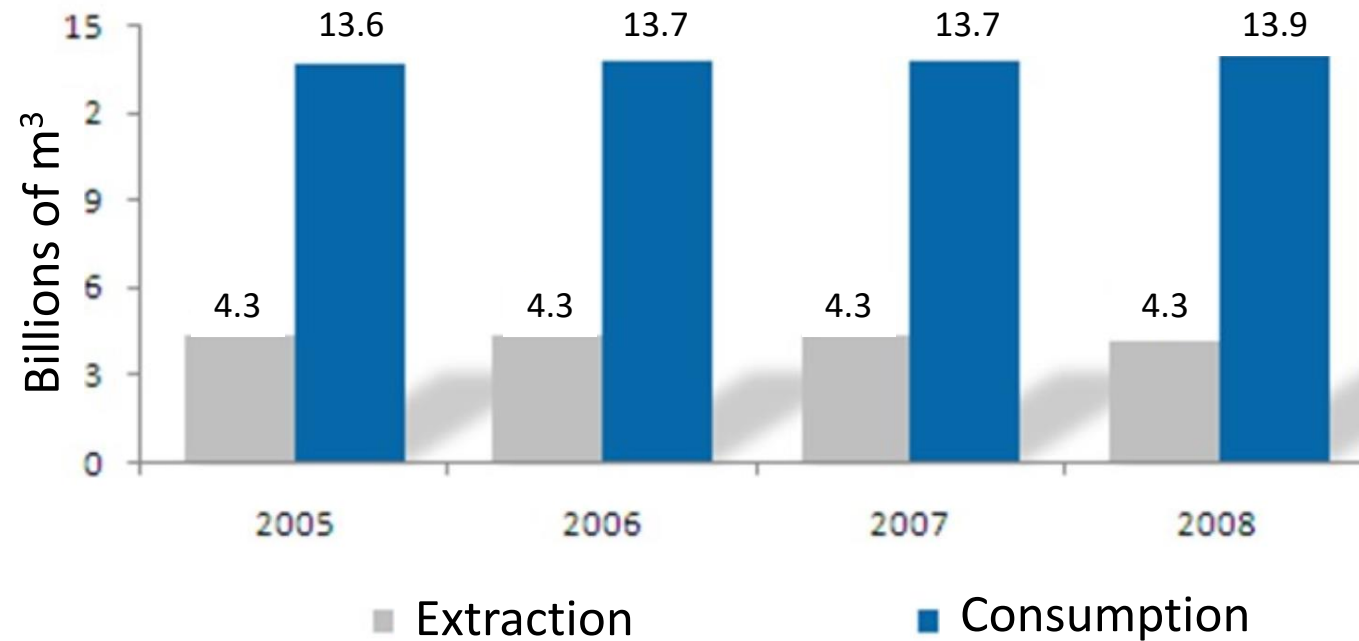
Methane density: 0.7 kg/m^3 Lighter than the air

The calorific value: 36 MJ/m^3

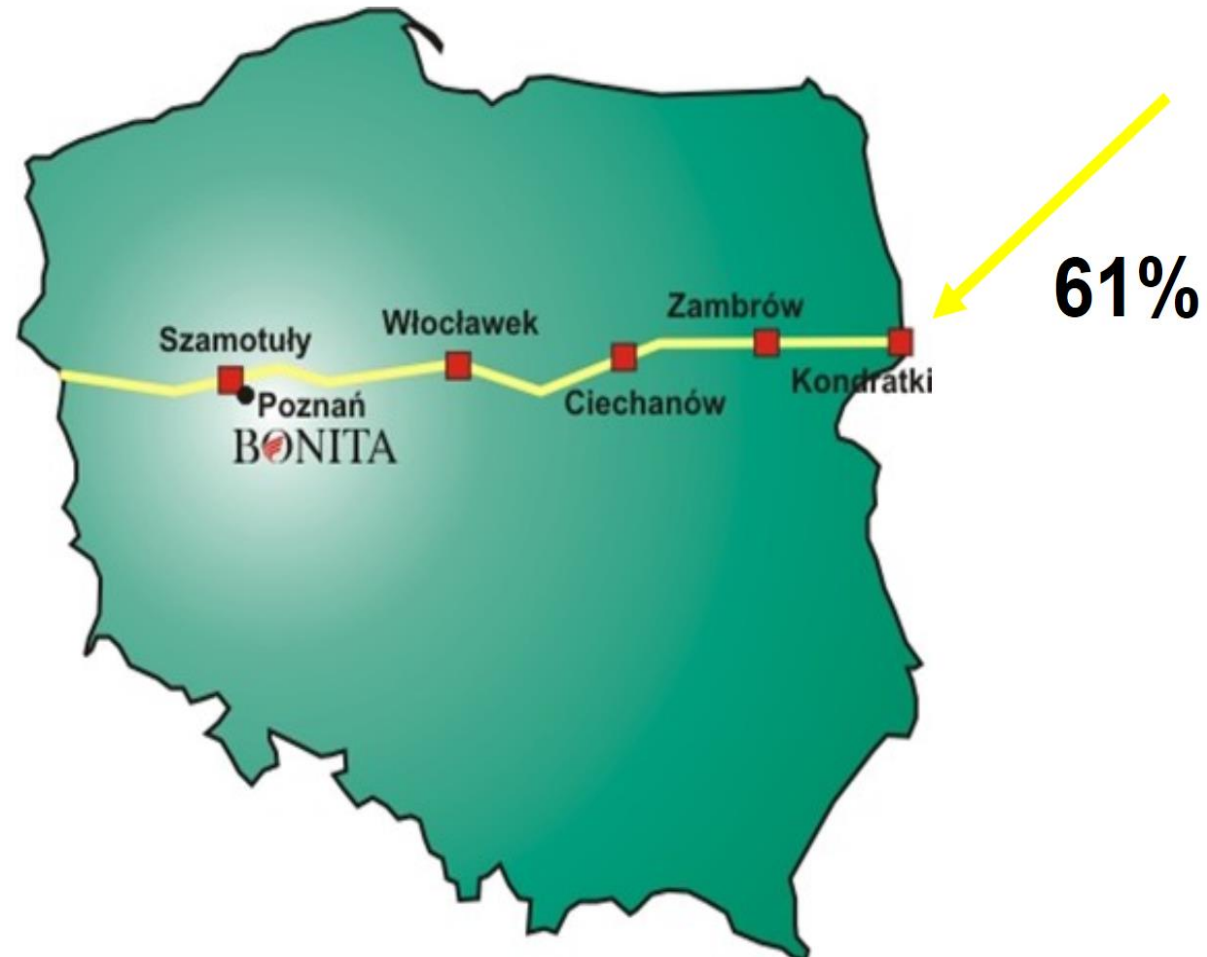
Explosive in mixture with air with 5–16% participation

It can be liquefied and transported under pressure as LNG (Liquified Natural Gas)

Extraction and consumption of natural gas in Poland



Gas pumping stations on the Yamal pipeline in Poland



LPG – Liquefied Petroleum Gas

LPG – Liquefied Petroleum Gas

Propane (24–29%) + Butane (66–72%)

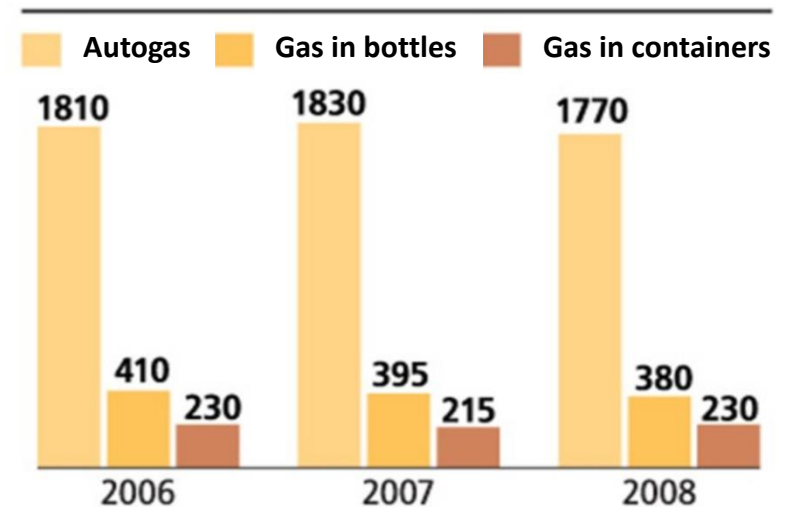
Gas density: 2.0 + 2.7 kg/m³ – **heavier than air**

Liquid density: 0.53–0.60 kg/dm³

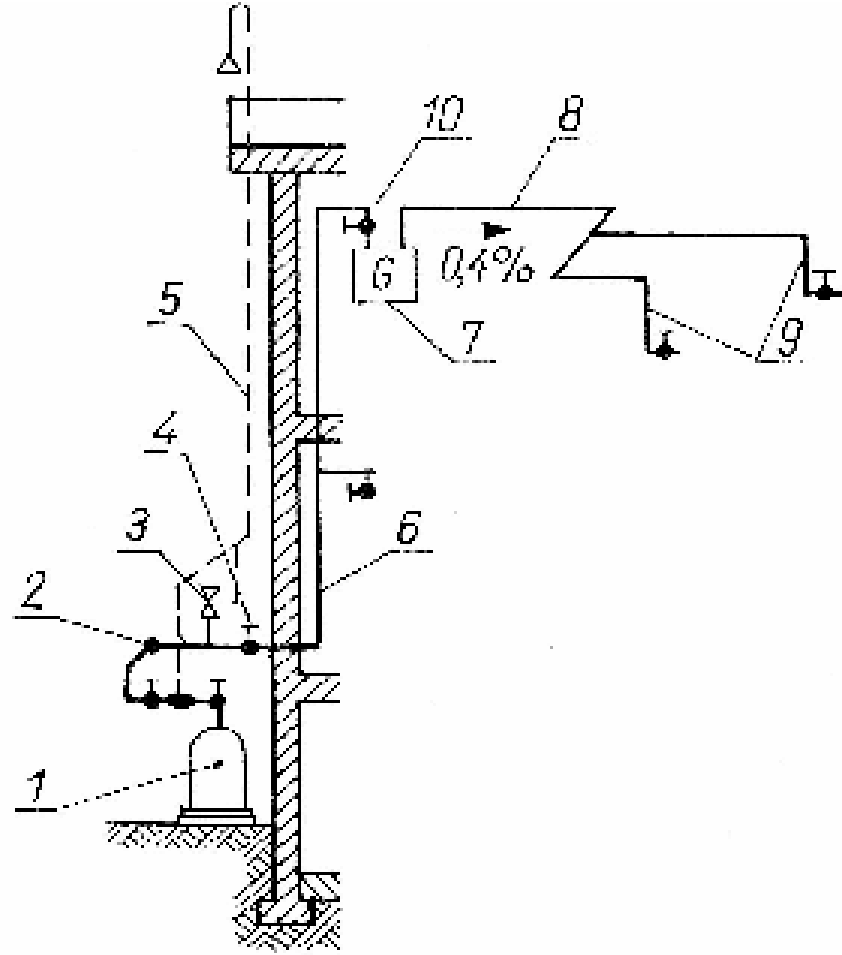
The calorific value 12.8 kWh/kg
(94 MJ/m³)

LPG – sales structure

[thousands of tons]



Cylinder installation



Cylinder installation

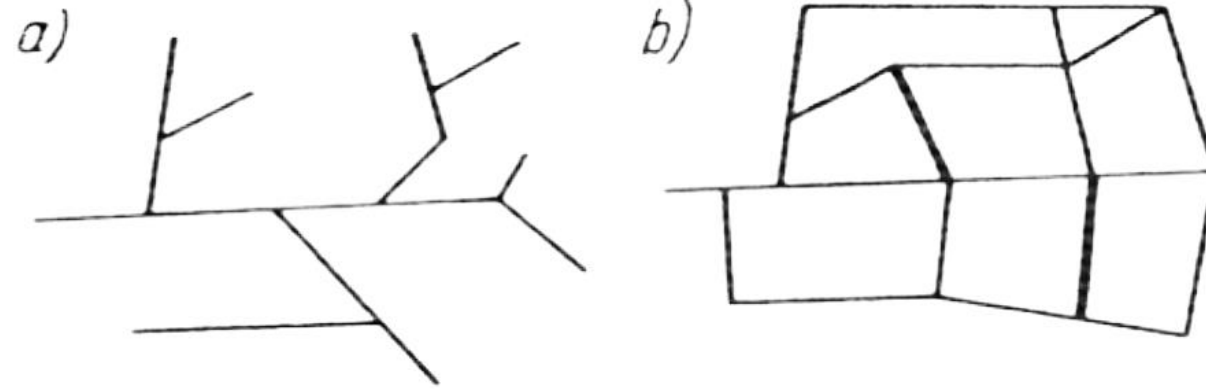
Operation

- Cylinders and tanks can not be completely filled with liquefied gas, but only up to 85% – as a temperature increase of 1°C causes a pressure increase of 7–8 bar and may lead to bursting of the cylinder.
- Tanks must be supervised by UDT every two years, and every 10 years – internal revision and pressure testing must be done.

Cylinders for LPG



Division of gas networks due to the structure



- Branched
- Ring-shaped
- Mixed

Division of gas networks due to their functions

- Transmission high-pressure gas pipelines – over 1.6 MPa
- Supply
 - ✓ medium pressure – over 10 kPa, but less than 0.5 MPa
 - ✓ medium – elevated pressure – up to 1.6 MPa
- Distributing – medium or low pressure – up to 10 kPa;
Diameter = 50–100 mm
- Gas connection: Diameter = 25–32 mm

Network objects

- The reduction station is the boundary between the transmission and supply networks.
- Supply network becomes distributing in a distributive building.



Source: RZOUNG Gaz-Technika Sp. z o.o.

Location classes

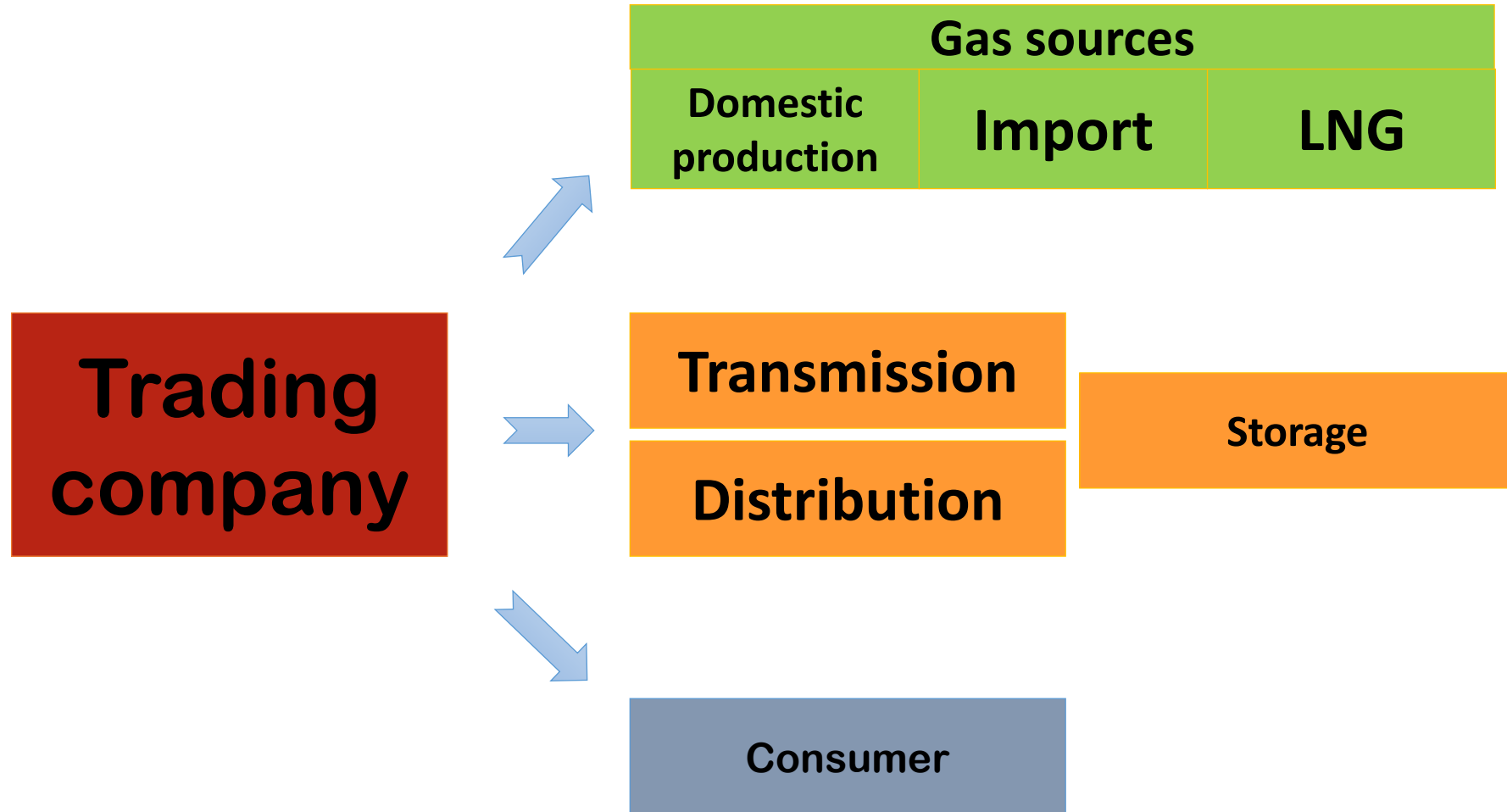
1st class – Areas with residential buildings and public utility buildings, single- or multi-family buildings, intensive traffic, developed underground infrastructure, such as water supply, sewage, heating, gas, energy and telecommunications, as well as streets, roads related structures and mining areas.

2nd class – Terrains with single-family and farm buildings, development with individual recreation buildings, as well as the necessary infrastructure.

3rd class – Undeveloped land and areas where only single-family, farm and livestock buildings and infrastructure necessary for them may be located.



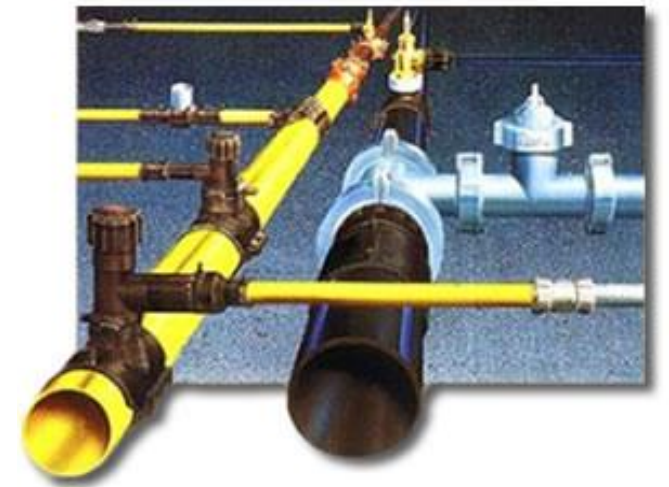
The gas market model in Poland



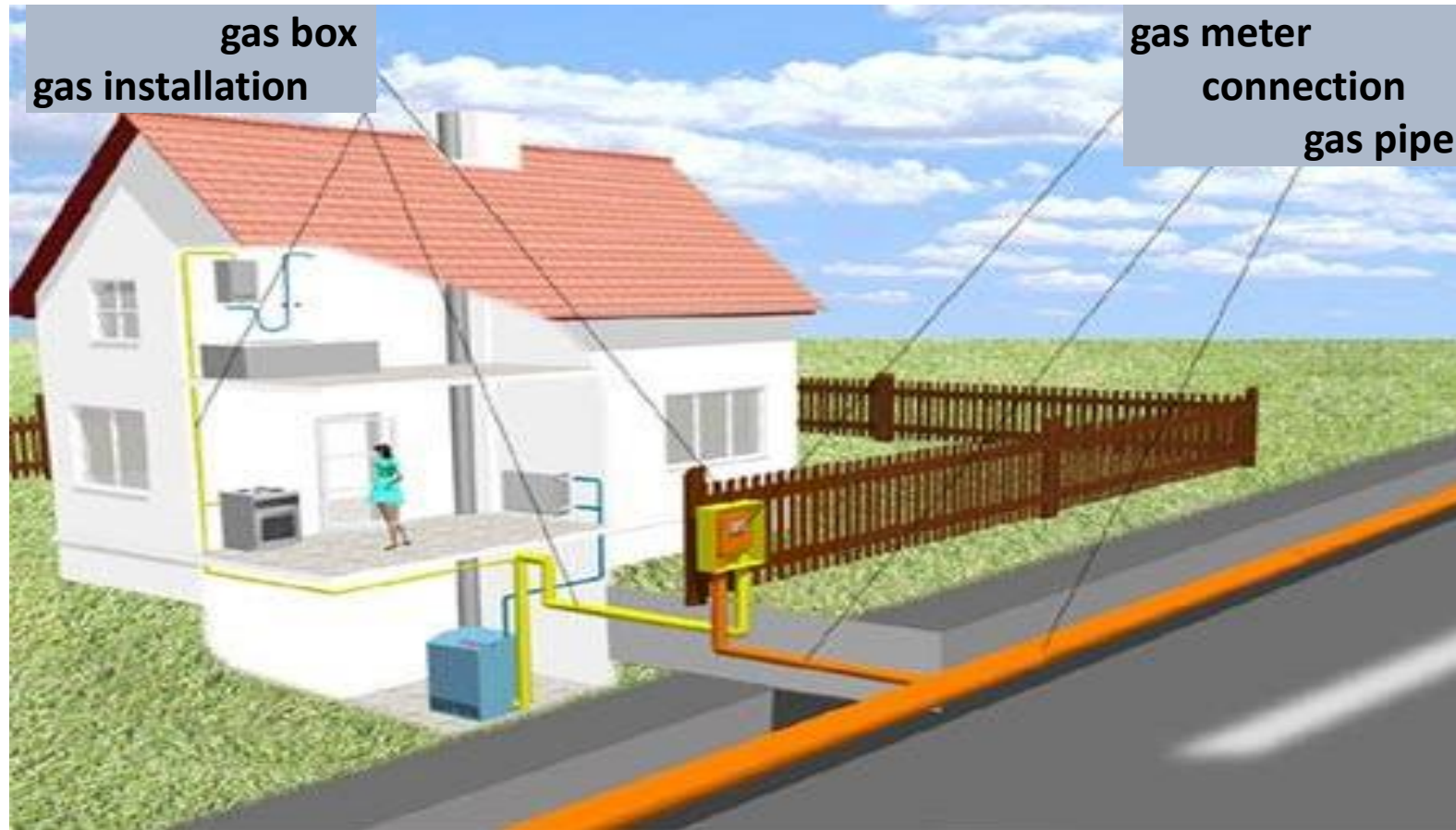
The investment process

Construction of a gas network with gas connections:

- Gathering information about the **potential consumption** of gaseous fuel,
- Development of the gasification **concept** along with economic and technical analysis,
- Issuance of connection **conditions** to the gas network,
- Signing connection **agreements**,
- Execution of the gas network **project** with gas connections,
- Obtaining a **permit** for the construction of a gas network,
- Execution of the **gas network** with gas connections.



Network – connection installation



Internal installation

Construction of an internal gas installation:

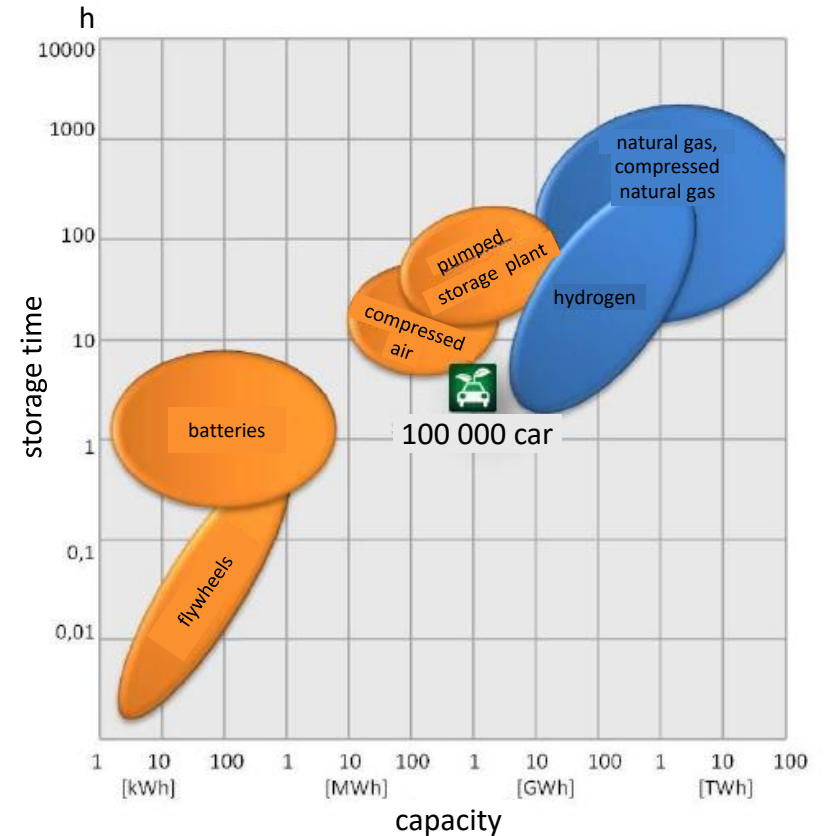
- Filling the **application form** for issuing the conditions for connection to the gas network,
- Execution of the internal gas installation **design**,
- Obtaining a **permit** for the construction of an internal gas installation,
- Execution of the internal gas **installation**,
- Signing a **contract** for the supply of gas,
- Gaseous **fueling** of the internal gas installation.

Advantages of a gas installation

- Clean operation of the heating device
- No storage required
- The payment is only for used fuel
- Comfortable service
- Constant operative readiness
- Short heating time

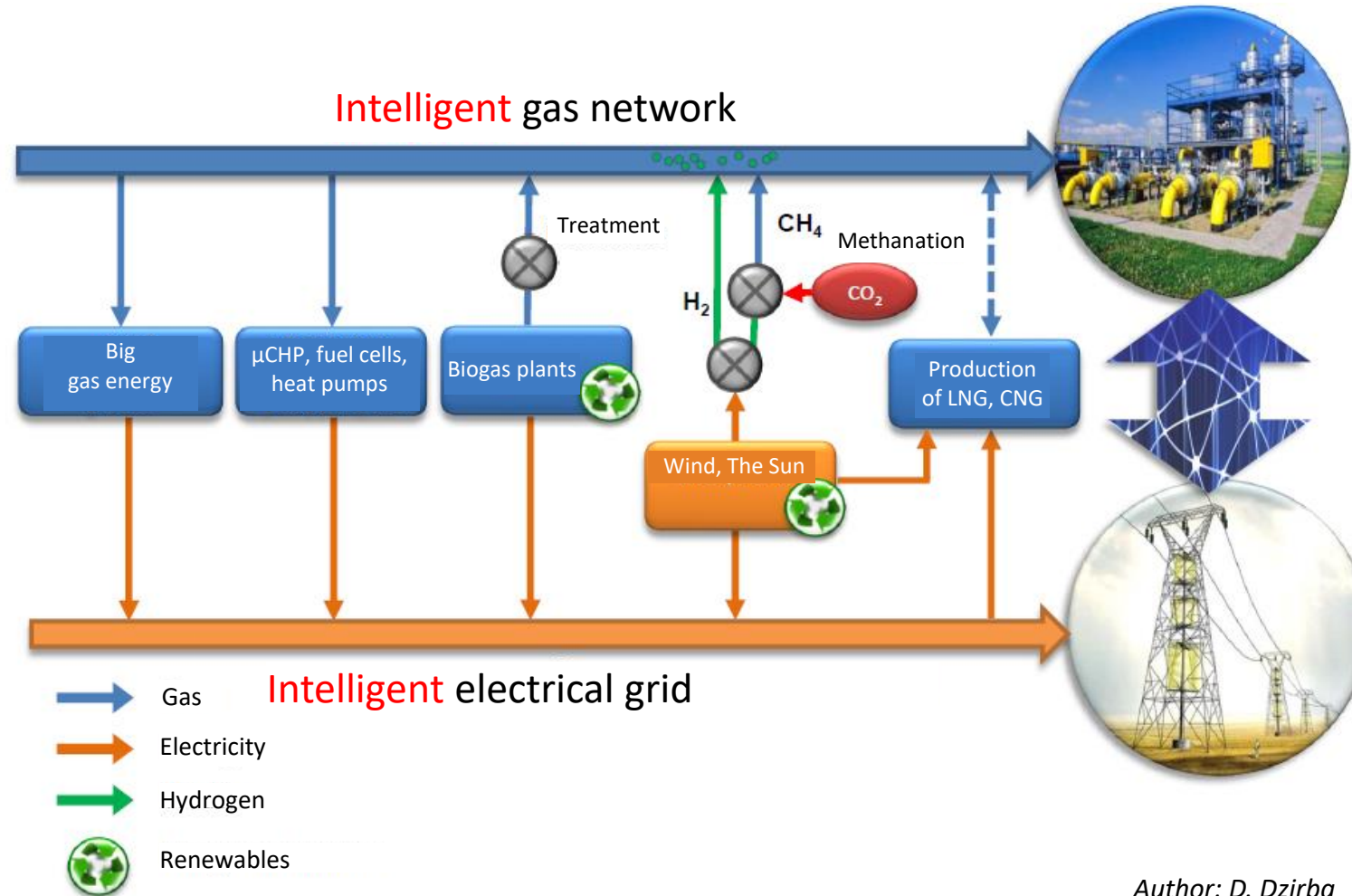
Energy storage in the gas system – a concept

- An excess of cheap energy can be used for the production of hydrogen (e.g. in an energy-consuming electrolysis process) that can be directly injected into the gas network or be a raw material for the production of methane in the methanization process.
- Therefore, energy is transferred for use from one (power) system to another (gas), where it can be easily stored and used at a later time, or used to increase energy resources.



Source: Linke, 2011

Energy storage in the gas system – a concept



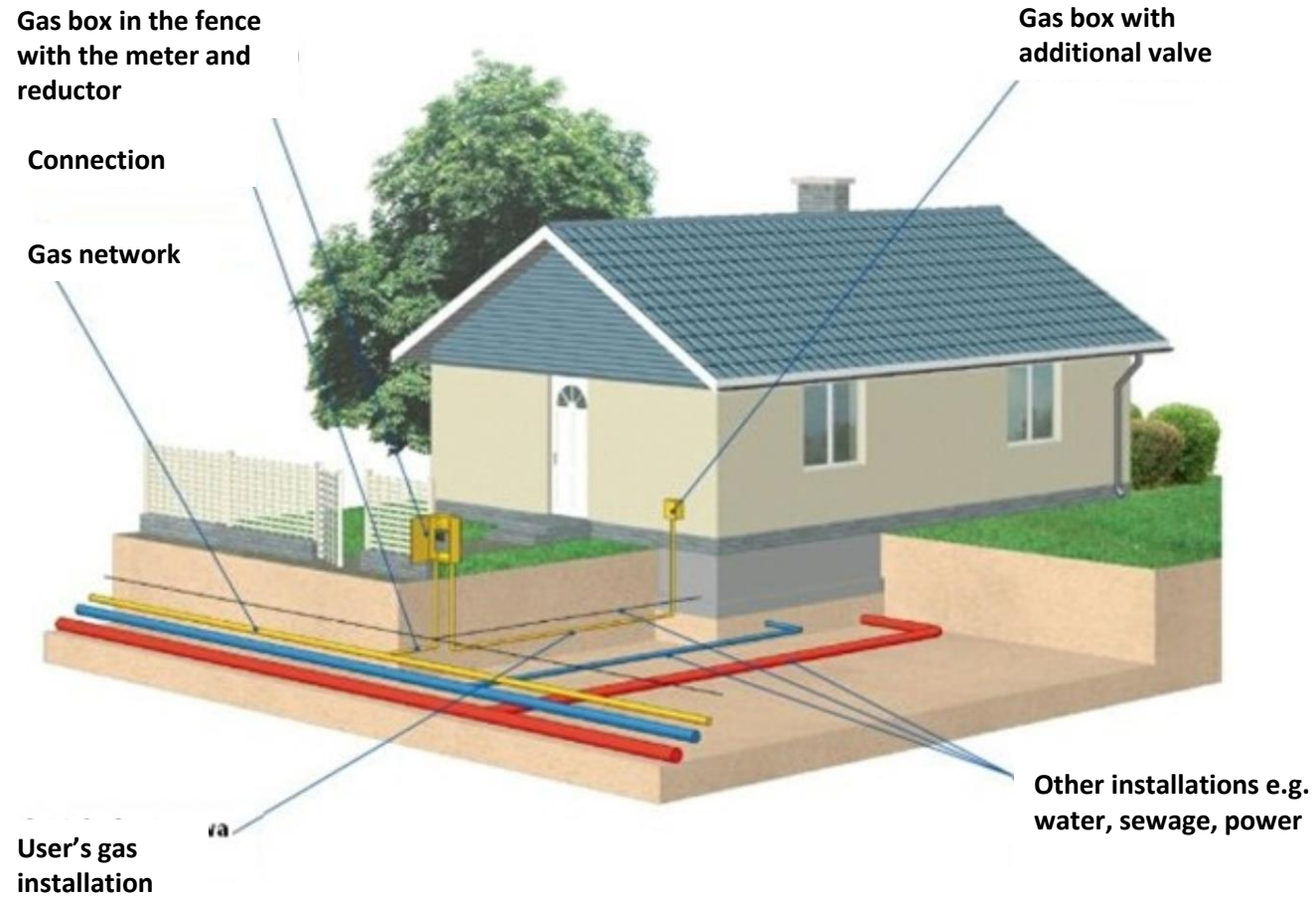
Author: D. Dzirba

How do we divide gas pipelines?

Pursuant to the Regulation of the Minister of Economy, gas pipelines are divided due to maximum operating pressures (MOP) for:

- gas pipelines of **low pressure** up to 10 kPa,
- **medium-pressure** gas pipelines above 10 kPa to 0.5 MPa in total,
- **medium high** pressure gas pipelines above 0.5 MPa to 1.6 MPa in total,
- **high pressure** gas pipelines above 1.6 MPa to 10 MPa in total.

Gas connection



Definition of connection

The gas connection is a section of the gas network from the last disconnection from the gas pipeline supplying to the main gas tap (included).

The main gas tap can be located:

- in an **external** cabinet on the building,
- in an **interior** cabinet in the building's wall,
- in a **free-standing** cabinet, located in the fence line from the street or general pedestrian route with access to it from the outside.

Definition of connection

In gas lines supplying gas to the external wall of a residential building, collective residence, public utility and individual item, there should be no pressure higher than 500 kPa, and to external walls of other buildings higher than 1,600 kPa.

In connecting the internal gas system to the medium pressure gas network, a pressure reducer should be incorporated within the gas connection box.



Basic information

The gas installation in the building should ensure the **supply** of gaseous fuel in the amount corresponding to the **needs** of use and the appropriate pressure before gas appliances, **depending on the type of gas fuel** used to power the building. According to specific Polish standards for gaseous fuels, this pressure should not be higher than 5 kPa.

It is forbidden to use LPG and gas from the gas network in one building. The gas installation of the building powered from the gas network **should have a main tap installed on the connection**, enabling the gas supply to be shut off.

Basic information

Gas connections made of polyethylene at the location of the main tap on the building wall are made according to the solution shown in the drawing. In this case, the gas connection to the building on the section from the gas supply pipeline to the distance of approx. 1.2–1.5 m from the building **is made of polyethylene**. At a distance of approx. 1.2–1.5 m from the building wall on the horizontal section of the connection, an **adaptive PE/steel fitting** is mounted and the further horizontal section of the connection, arch to the building wall and vertical to the main wall of the building **is made of steel pipe**.



Transition PE/Steel



Where to put the box?

The vertical section of the connection located on the wall of the building can be made in two variants:

- variant I – location of the connection directly at the building's wall and secured with a steel shield (sheet or pipe) or a PE pipe,
- variant II – location of the connection in the furrow cut in the wall, after subsequently being cemented over with lean concrete.

For **brick** buildings, option II is preferred, whereas for **wooden** buildings only option I is allowed.

NOTE – PE pipes of SDR 11 class 80 or 100 series should be used for gas connections.

Where to put the box?

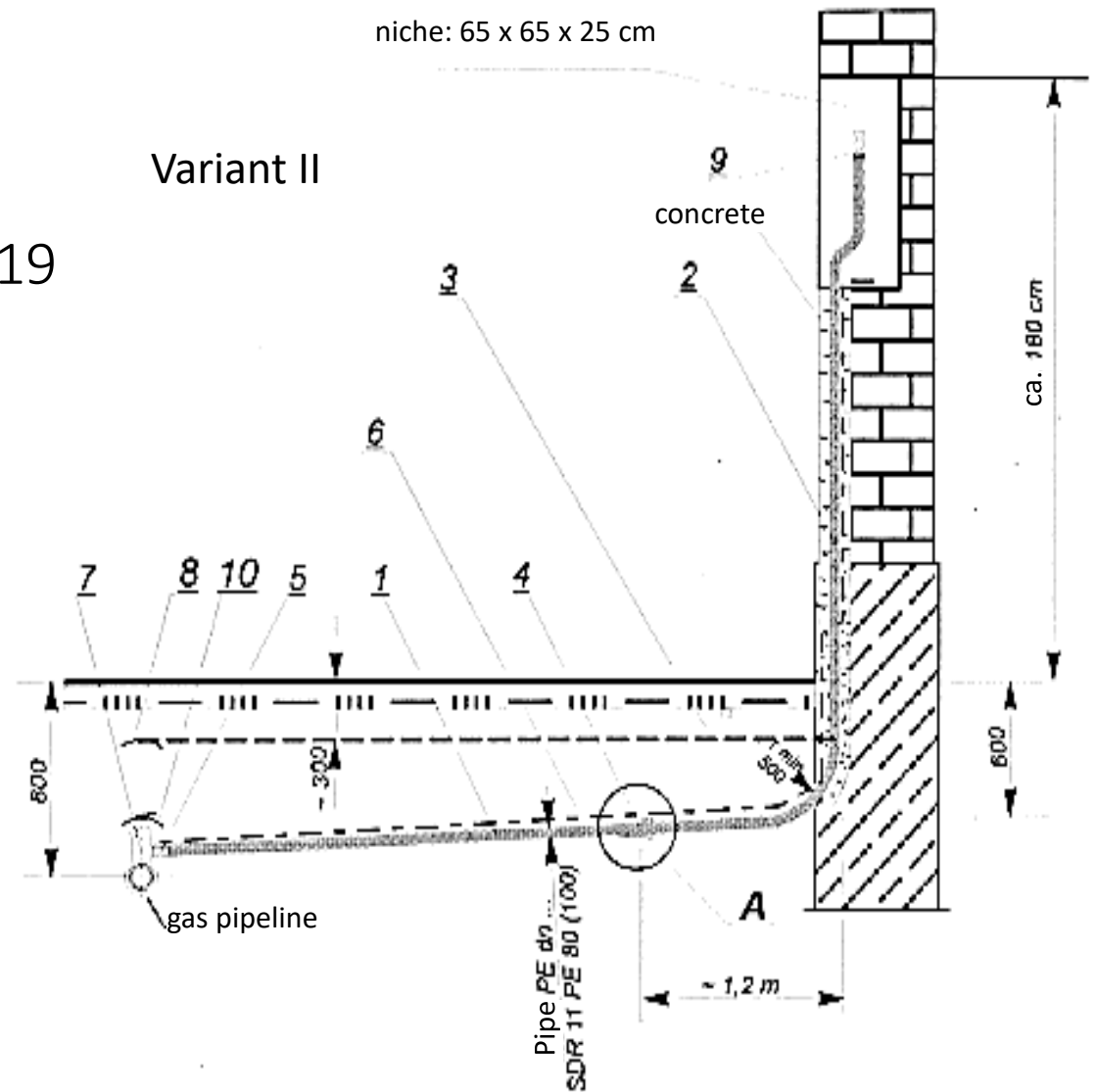
The gas box



Author: P. Trojan

Variant II

- 1 – polyethylene pipe
- 2 – seamless steel pipe acc. to PN-80/H-74219
- 3 – warning tape
- 4 – inseparable connection steel/PE
- 5 – electrofusion sleeve
- 6 – locating tape with a metal insert
- 7 – tee saddle or russet
- 8 – gas pipeline warning tape
- 9 – gas tap PN 0.6 MPa
- 10 – gas pipeline locating tape

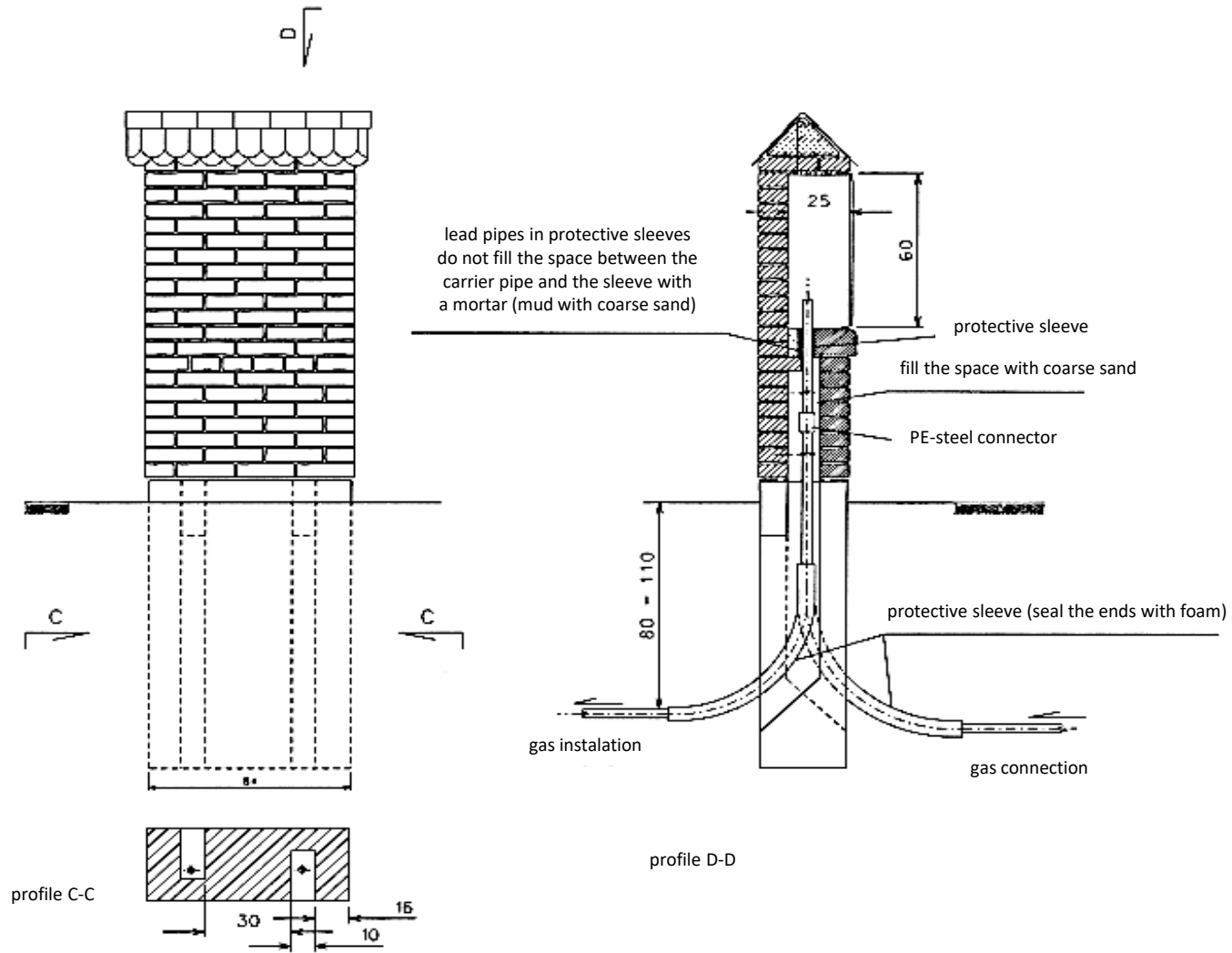


Gas connections with a main tap in a free-standing cabinet

Currently, a popular way of making connections is locating the main tap with gas meter or reducer-gas meter in a **free-standing cabinet** located in the recipient's line of fence or directly on the recipient's plot (terrain).

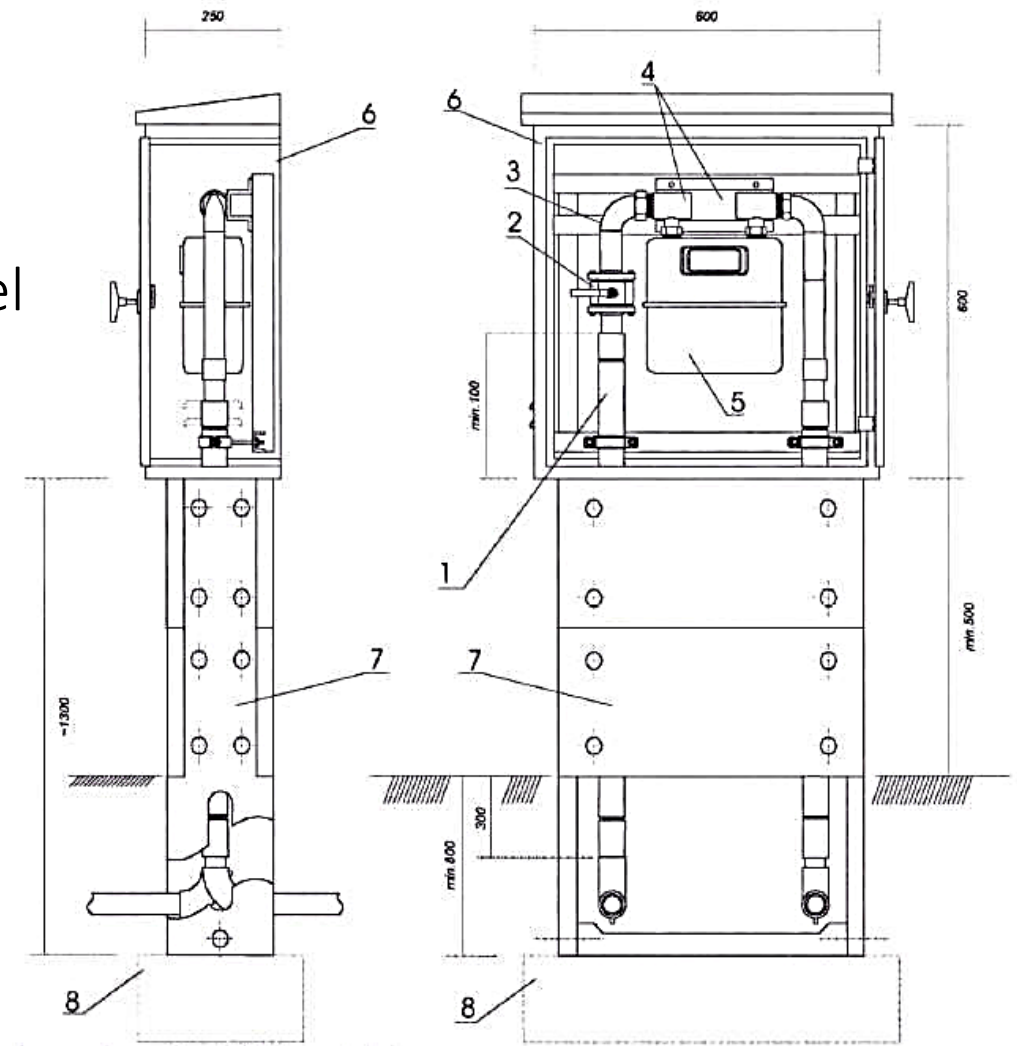
An example of such a solution is presented in the subsequent slide, where the main tap was located in a free-standing cabinet located in a brick pillar of the property fence. In accordance with the requirements, the distance from the main tap to the building must not exceed 10 m. This provision does not apply to single-family housing and farm buildings.

Free-standing cabinet

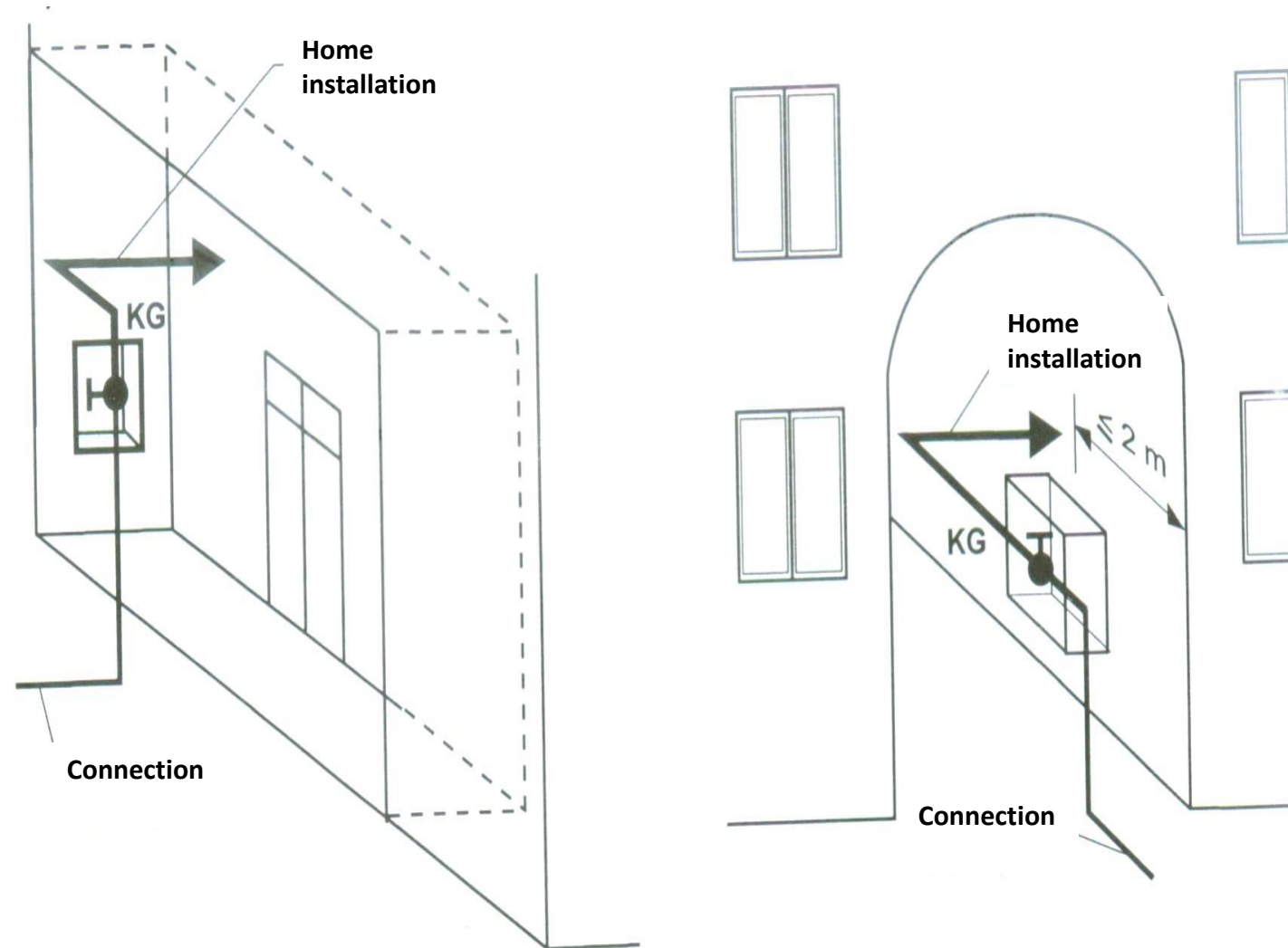


An exemplary solution of a free-standing gas cabinet on a low-pressure connection

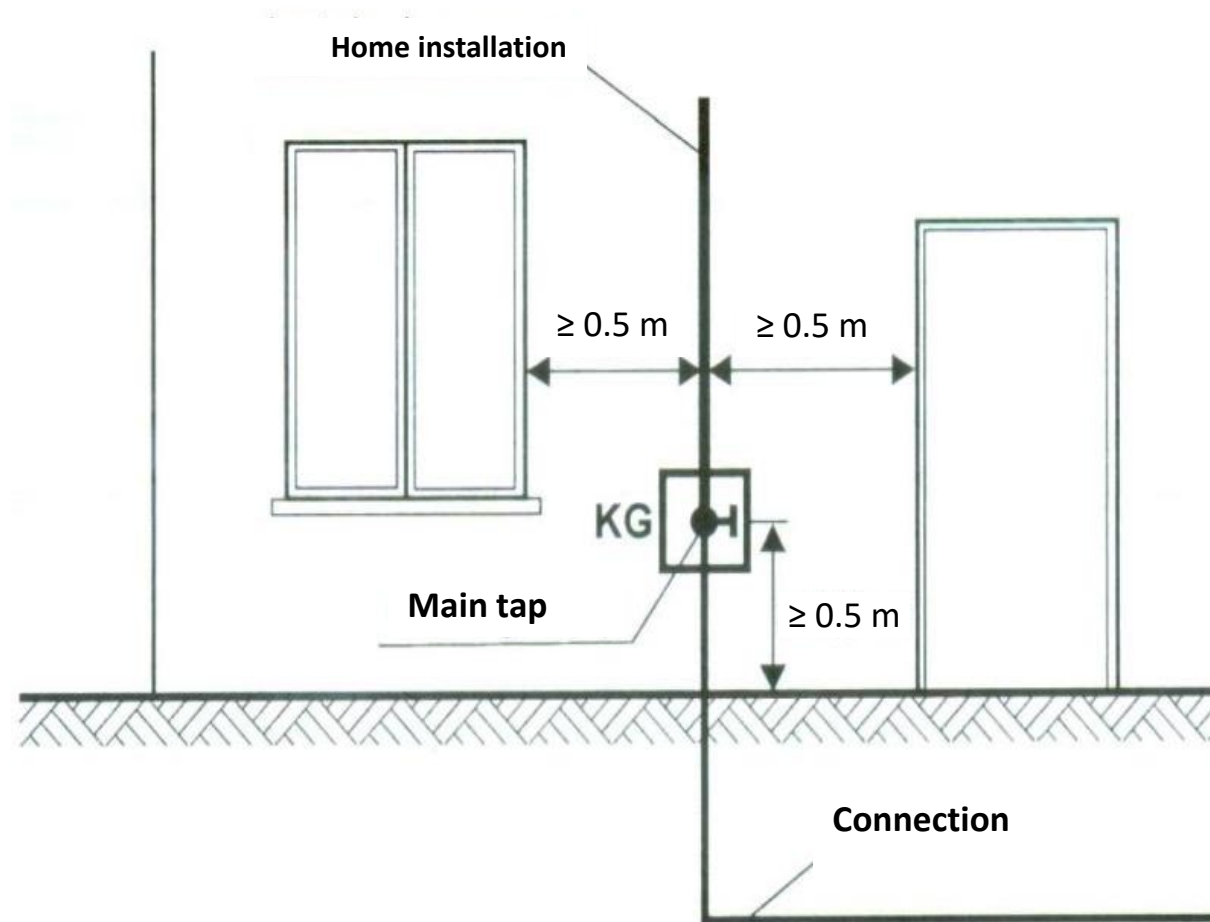
- 1 – column connection, flange connection PE/steel
- 2 – head main
- 3 – knee Hamburg – type
- 4 – manifold for gas meter with bracket
- 5 – gas meter
- 6 – holder
- 7 – concrete plinth
- 8 – foundation



Additional information about connections



Additional information about connections



Examples



Gas box for one gas meter



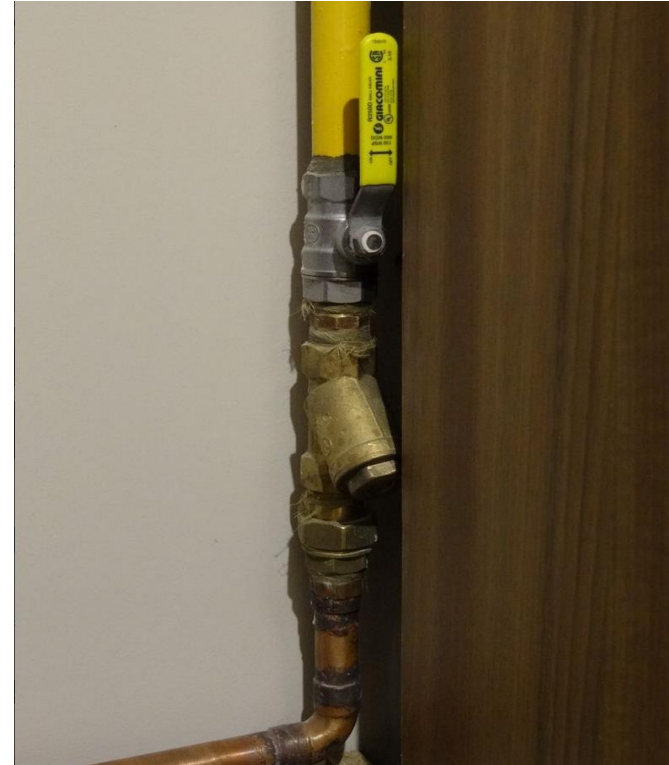
Entrance of the gas installation to the building

Sources: www.poradnikprojektanta.com;
www.pracowniasanitarna.pl

Interior installation



Bringing the installation to a dual-function gas boiler



Shut-off valve, oblique gas filter

Sources: www.poradnikprojektanta.com,
www.pracowniasanitarna.pl

Interior installation



Sources: www.poradnikprojektanta.com,
www.pracowniasanitarna.pl

Interior installation

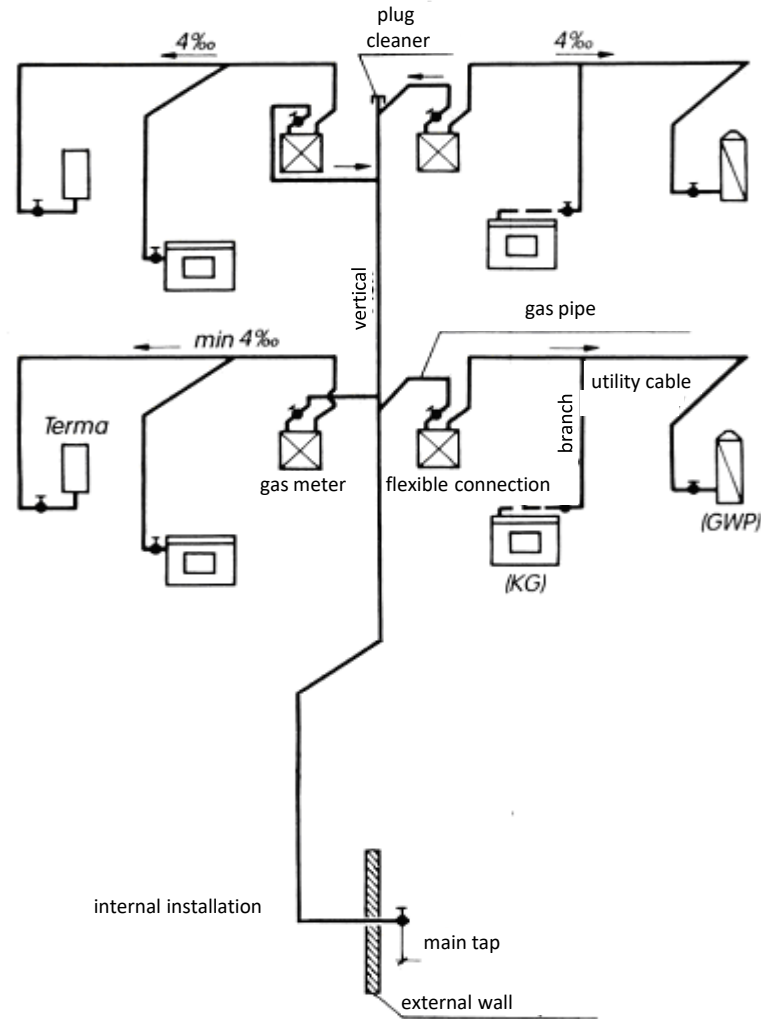
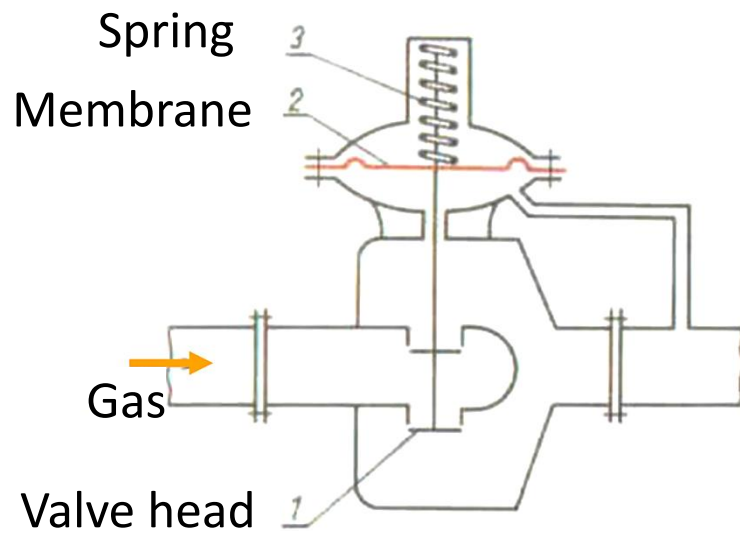


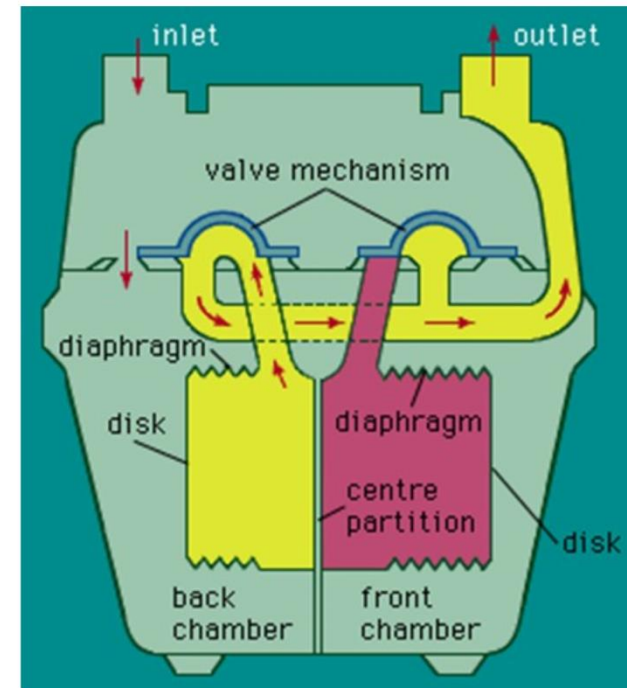
Diagram of the gas installation (KG) – gas stove, (GWP) – flow water heater

Interior installation

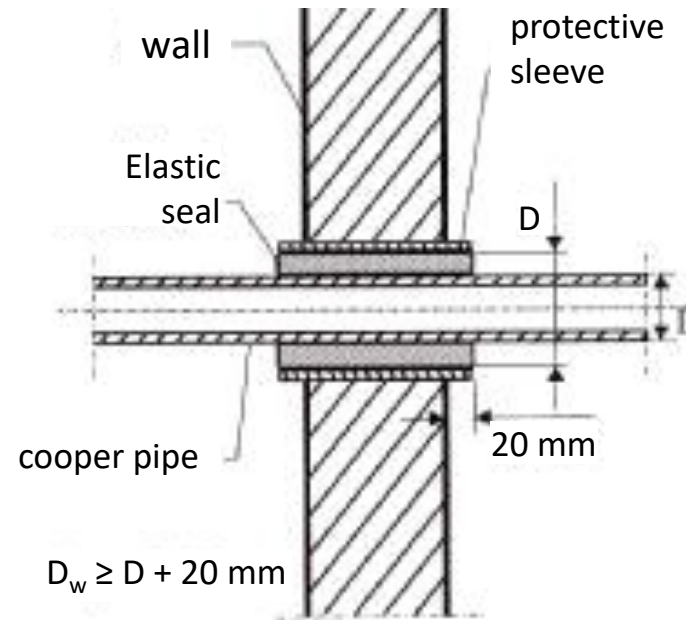
Gas pressure reducer



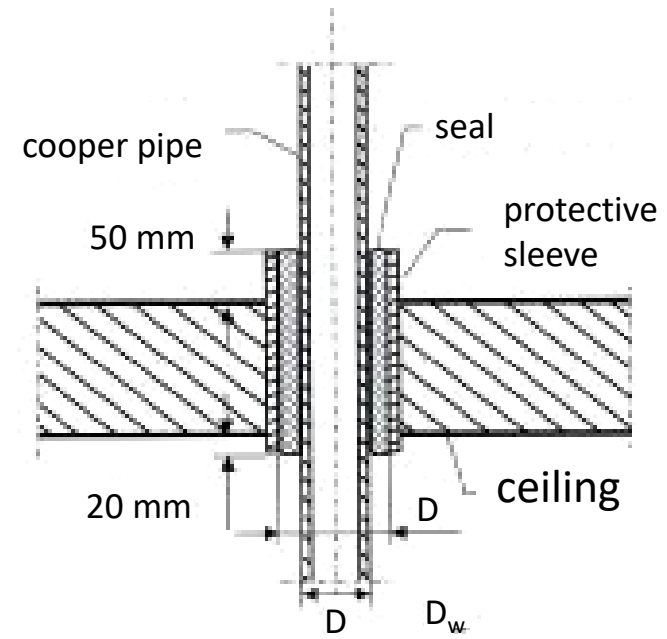
Bellows gas meter



Interior installation



Passage of the pipe through the wall



Passage of the pipe through the ceiling

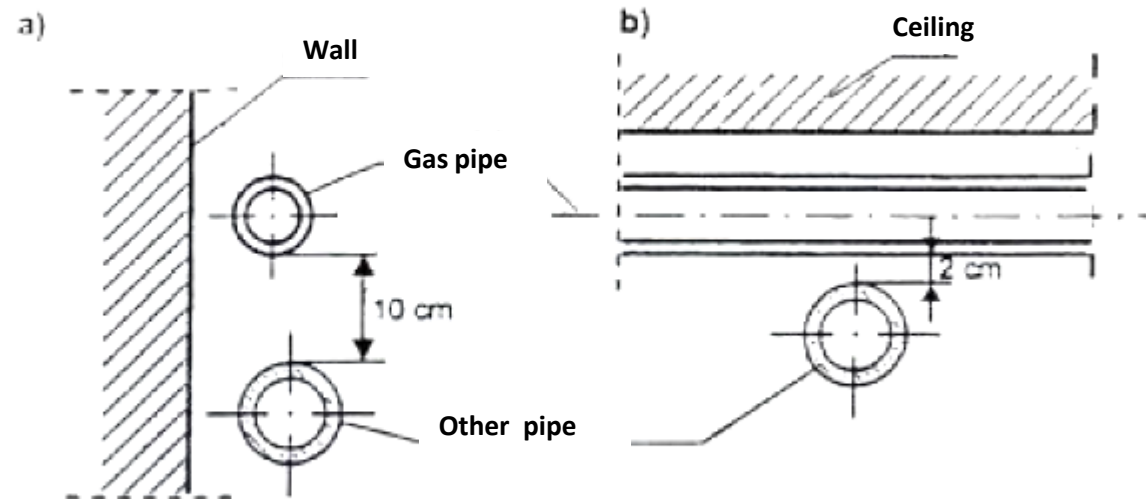
Interior installation

The pipes of the gas installation in relation to the cables of other installations constituting the building's equipment should be located in a way ensuring safety and ease of performing maintenance and inspection.

Minimum distances to wire and pipework are:

- **10 cm** from plumbing pipes, sewage pipes, domestic hot water, central heating,
- **10 cm** from electrical wiring (if the gas density is lower than air – above these ducts, if the density is higher – below),
- **2 cm** when crossing over other installations.

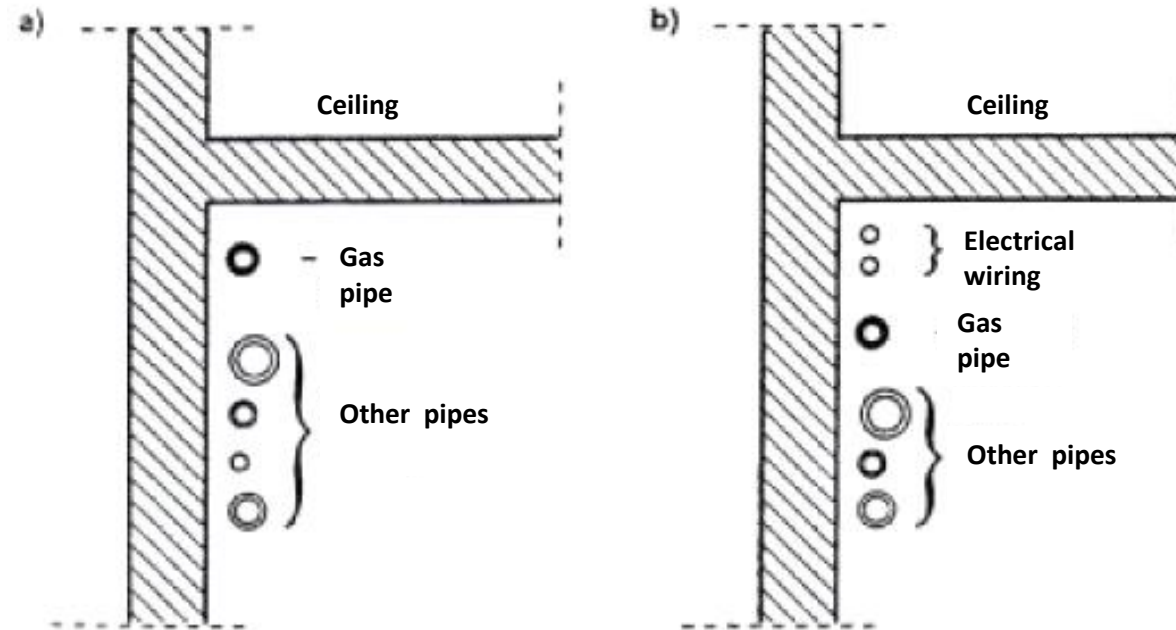
Interior installation



Minimum distances between gas pipes and other installations
a) paralel pipes, b) crossing pipes

Interior installation

Location of gas pipes

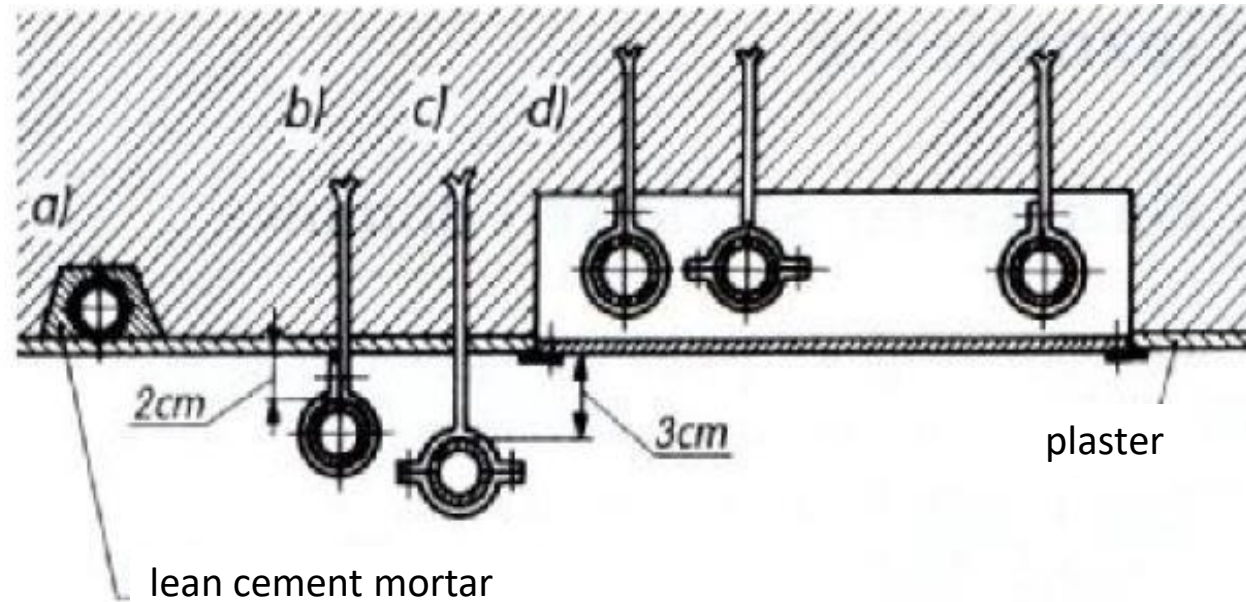


Position of gas pipes relative to other installations

a) gas **lighter** than air, b) gas **heavier** than air

Interior installation

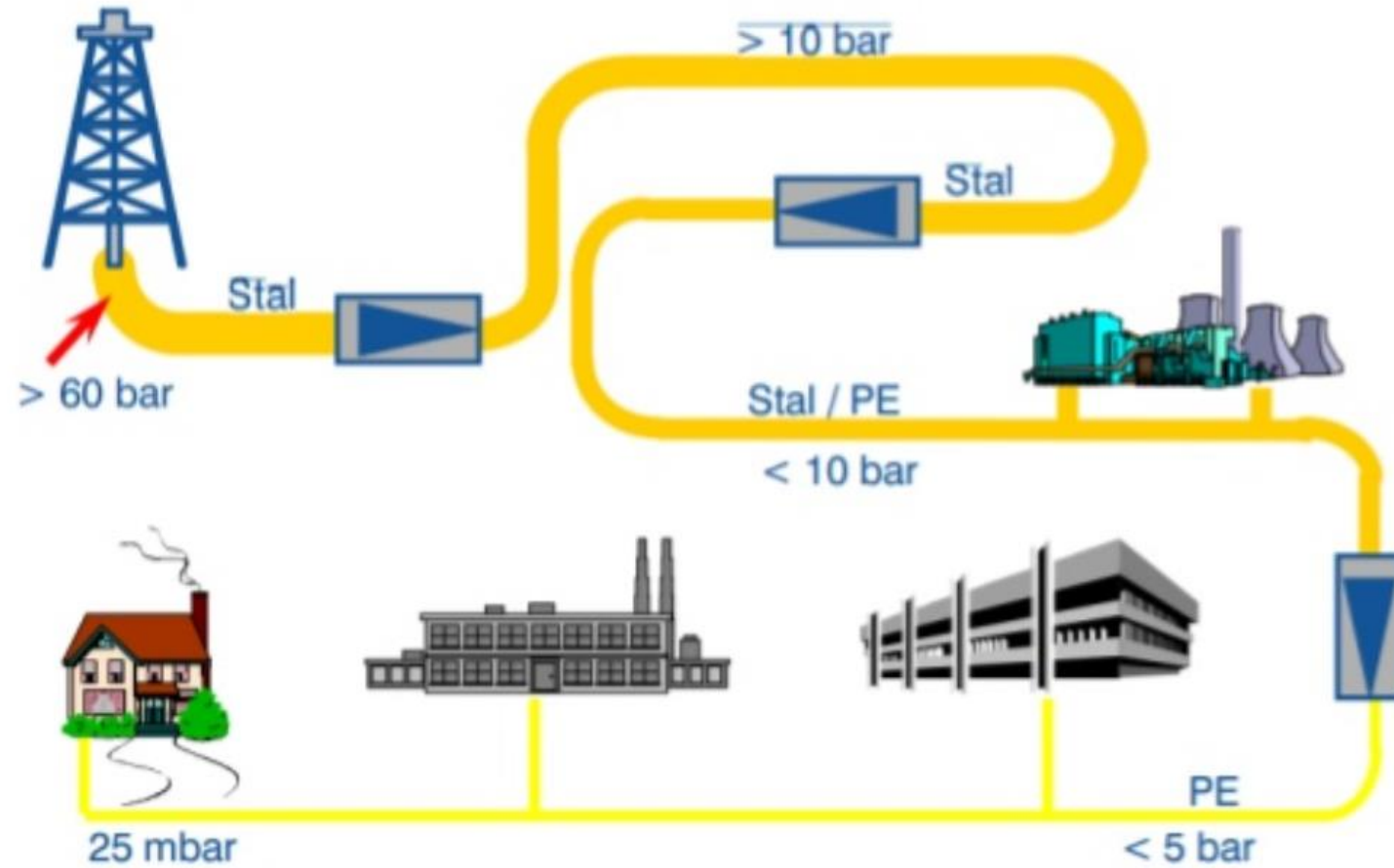
Ways of laying gas pipes



Ways of laying gas pipes:

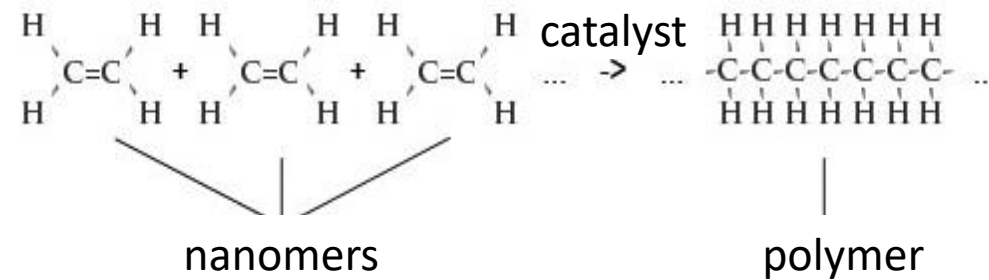
- a) Vertical pipes in the furrow
- b) On plaster with clearance 2 cm
- c) On plaster in wet rooms with clearance 3 cm
- d) In the collecting channel covered by a perforated plate

Materials for the construction of gas networks

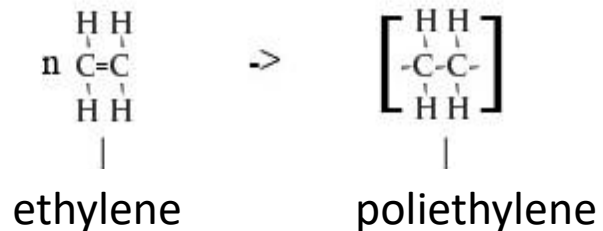


What is POLYETHYLENE?

Polyethylene is a synthetic material, obtained by a chemical reaction called polymerization. Polyethylene monomers, which are simple organic compounds under the influence of catalysts and pressure, form macromolecules. The polymer obtained as a result of the synthesis is then processed. Pigments, antioxidants and various fillers are added to it to change its selected properties.



thus:



What are the properties of POLYETHYLENE?

Polyethylene is characterized by:

- low density compared to other plastics,
- high toughness and significant elongation when stretched compared to steels,
- good dielectric properties,
- high chemical resistance,
- good processing properties.

Other properties of POLYETHYLENE

- Chain molecules tend to regularly stack themselves. Such regular structures are called crystallites, and those distributed in the amorphous area have a strong effect on PE properties, especially on density.
- Low density polyethylene LDPE (light density polyethylene) (910 to 930 kg/m^3) achieves a degree of crystallization from 40 to 50%, while medium density polyethylene MDPE or high density HDPE (940 – 960 kg/m^3) obtains molten crystallinity from 60 up to 80%.
- For the production of gas network elements, polyethylene with density above 930 kg/m^3 is used in accordance with ISO 1872-1. The increase in density leads to the improvement of tensile strength, elasticity, hardness and chemical resistance. The negative effect is the reduction of impact strength and resistance to brittle fractures.

Properties of POLYETHYLENE

Parameter	Polyethylene		
	High-pressure	Medium-pressure	Low-pressure
Density [kg/m ³]	915–926	930–940	942–965
Degree of crystallinity [%]	40–50	60–80	60–80
Tensile strength [MPa]	10–17	20–35	20–35
Elongation at break [%]	500–600	300–800	200–900
Melting temp. [°C]	105–108	120–125	127–130
Hardness acc. Brinell [N/mm ²]	14–20	45–58	56–65

Properties of POLYETHYLENE

POLIETYLEN PE 500

(PE – HMW) High molecular polyethylene

- color: occurs as natural or colored
- durable temperature of use – 90°C
- density – 0.95 g/cm³ (DIN 53479)
- yield point – 25 MPa (DIN EN ISO 527)
- tensile strength – 40 MPa (DIN EN ISO 527)
- elongation at break – >50% (DIN EN ISO 527)
- elastic modulus from the picking test – 1,100 MPa (DIN EN ISO 527)
- modulus of elasticity with bending test: natural – 900 MPa
- ball hardness – 52 MPa (DIN 53 456, ISO 2039/1)
- toughness (DIN EN ISO 179) – without breaking

Abrasion and abrasive wear

Toughness is called impact resistance of the material, and the measure is the ratio of the work consumed to the dynamic destruction of the sample to its cross-section at the site of destruction.

High impact strength is an advantage in transport conditions, e.g. pipes.

The phenomenon of **abrasive wear** is related to the abrasion of the plastic particles by the abrasive medium, e.g. sand, hard ground, etc.

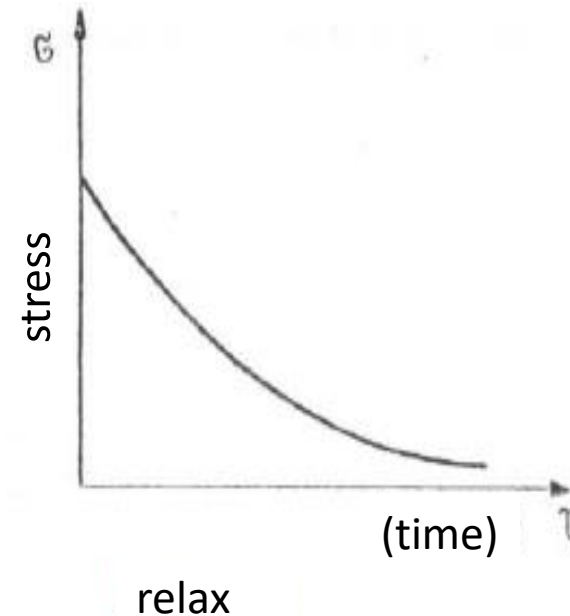
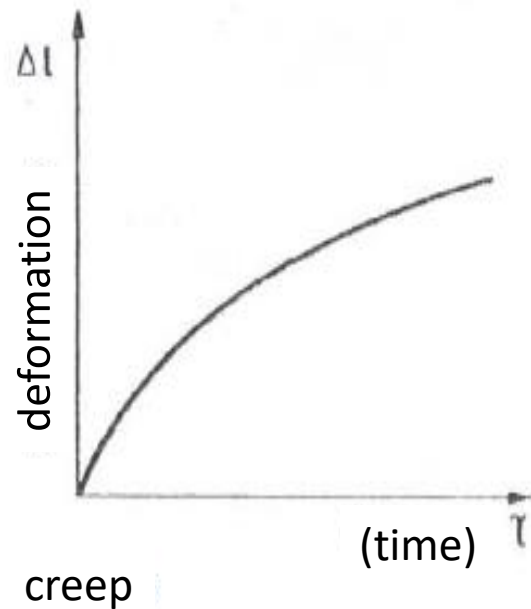
Heat influences the reduction of abrasion resistance. Lack of resistance to abrasive wear and scratches plays an important role when transporting plastic products, e.g. pipes.

Relaxation and creeping

Relaxation – reduction of stresses at constant set strain

Creep – the change in the dimensions of the sample under constant load changes over time

Relaxation and creeping are simultaneous phenomena

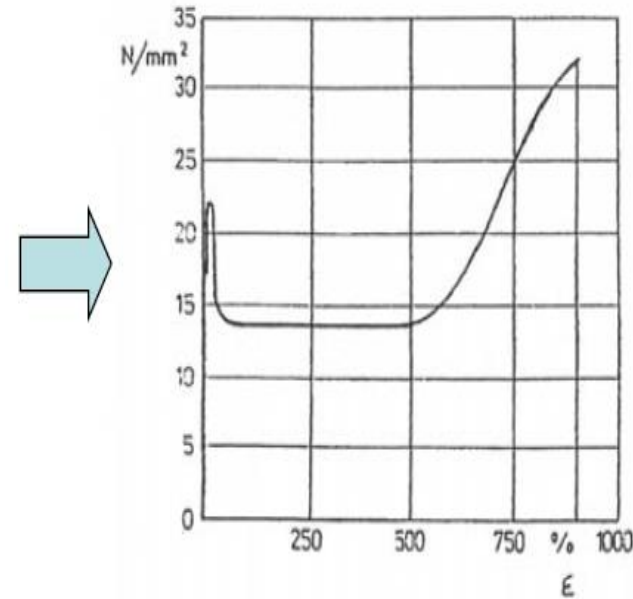


Mechanical properties

Ultimate strength

If the element is exposed to stresses for a short period of time, e.g. minutes, hours, then these are referred to as immediate strains

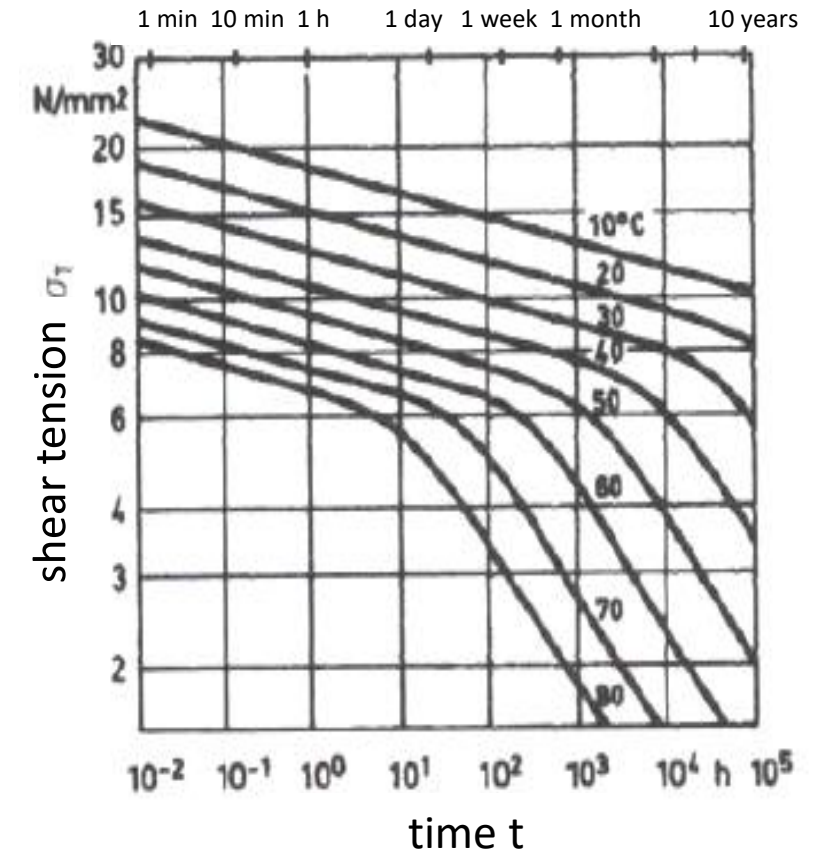
The course of deformation changes as a function of stress for HDPE. A typical graph for plastics showing the so-called cold flow (having a large elongation to breakage point)



Mechanical properties

Long-term durability

- Long-term strength tests measure the decrease of strength properties over time. The limit value of computational durability is 50 years.
- The tests are carried out using the principle of thermal-time superposition, from which it follows that increasing the temperature of the measurement is equivalent to shortening the life of the pipes.
- The following graphs are used for the tests: stress – time temperature.



What does SDR mean?

Numeric designation of a particular type of pipe, which is approximately equal to the quotient of the nominal outside diameter and the nominal wall thickness.

What is the difference between PE 80 and PE 100?

In the field of HDPE pipes, we differentiate different polyethylene materials. These groups are:

PE 63 (= MRS 6.3 MPa)

PE 80 (= MRS 8.0 MPa)

PE 100 (= MRS 10 MPa)

The term MRS means: Minimum Required Strength.

By PE 80 we mean PEHD, which at its temporary creep limit (50 years of durability) and 20°C temperature load and control water, creates a creep curve of at least 8.0 N/mm².

This intersection of PE 63 and PE 100 materials is respectively 6.3 N/mm² or 10.0 N/mm². This means that with the same dimensions, pipes made of PE 100 can be used at a higher working pressure than those made of PE 80.

What pressures can withstand pipelines?

C	PE 80		PE 100	
	SDR 11	SDR 17.6	SDR 11	SDR 17.6
2.0	8.0	4.8	10.0	6.0
3.0	5.33	3.2	6.67	4.0
4.0	4.0	2.4	5.0	3.0

According to current regulations, plastics can be used to build low and medium pressure gas pipelines.

C – coefficient of operation (design).

The coefficient has values greater than 1, and takes into account the operating conditions.

Overall operating coefficient (design) (C) and design stress (σ_s)

Design stress (σ_s)

allowable stress, in MPa, in a specific application, They are determined by dividing MRS by the coefficient C , i.e.

$$\sigma_s = \frac{\text{MRS}}{C}$$

The circumferential stress of the polyethylene gas pipeline, under static conditions, caused by the maximum working pressure (MOP), should not exceed the product of the minimum value of the required strength (MRS) and the design factor of 0.5.

Thermal expansion

When laying the pipe, its expansion should be taken into account. It can be calculated as follows:

$$\Delta L = L * \Delta t * \epsilon t$$

Where:

ΔL – expansion in mm

L – string length in m

Δt – temperature difference °C

ϵt – Coefficient of thermal expansion mm/m°C

Average coefficient of thermal expansion for various pipe materials:

- HDPE = 0.20 mm/m°C
- PCV = 0.08 mm/m°C
- PP = 0.18 mm/m°C

For example:

- Material: HDPE
- Length $L = 60$ m
- temperature difference $\Delta t = 15^\circ\text{C}$
- $\Delta L = 0.20 * 60 * 15 = 18$ cm

What are PE100RC materials?

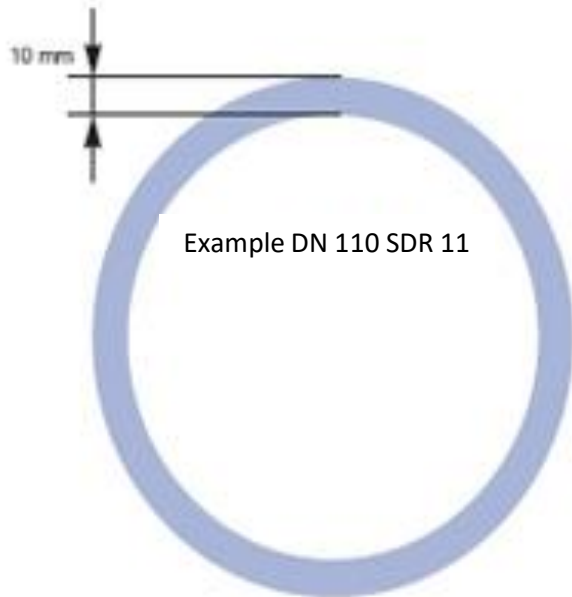
- RC means resistance to cracks from the expression "Resistance to Crack". PE 100 RC is a PE 100 type raw material that exhibits the highest resistance against crack propagation. Stress cracks can occur through concentrated loads. When using PE 100 RC, this type of situation can be avoided thanks to their outstanding resistance to stress cracks.
- Critical pressure of rapid crack propagation – pressure in polyethylene pipes at which at 273.15°K (0°C) the longitudinal cracking of the pipe wall caused by external factors occurs rapidly.
- The crack propagation test is carried out according to the standard PN-EN ISO 13479 by INiG in Cracow.
- The nominal pressures declared by the suppliers of pipes are PN 7 for SDR 11; PN 6 for SDR 17.6 (max. PN 10 for SDR 11 with C = 2).



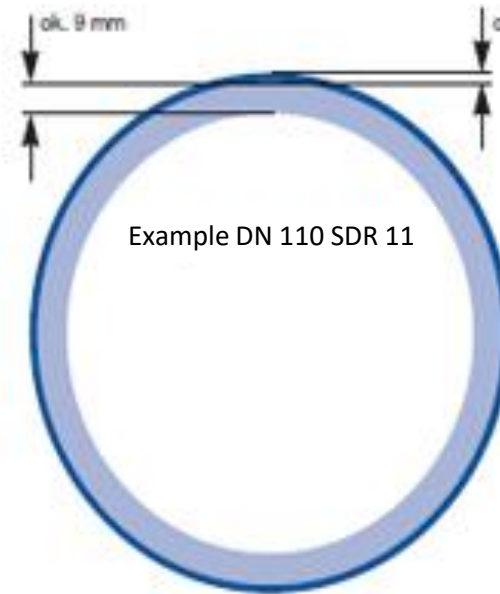
Welding of PE pipes



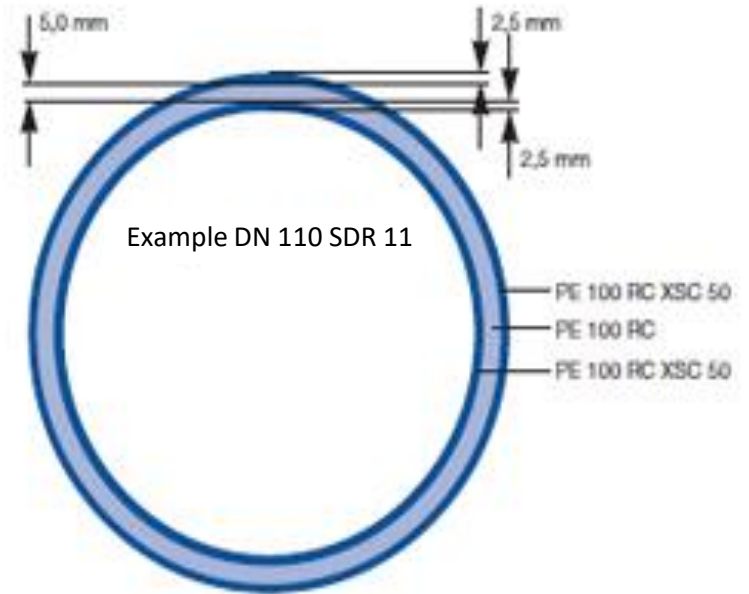
Construction of PE 100 and PE100RC pipes



contruction of the pipe type: PE100



contruction of the pipe type: Safe Tech RC₁



contruction of the pipe type: Wavin TS^{DOQ}

Polyethylene pipes with increased resistance to scratching and PE 100 class PE spot loads are used in pipeline systems intended for the transmission of gaseous fuels. Allowed maximum working pressure is up to 1.0 MPa, taking into account the condition that the working pressure of the gas should not cause circumferential stresses greater than those specified for polyethylene PE 100, maintaining the $C \geq 2$ safety factor.

HDPE pipes can not be used in interior installations of buildings.

In areas affected by mining activity, PE 100 class polyethylene pipes can be used in accordance with the conditions contained in the Technical Opinion issued on 2009/30/4 by the Central Mining Institute in Katowice.

- Designed for assembly (arrangement) without sub-ballast and sand bedding and for trenchless laying of pipes (controlled drilling). They do not require an additional shield pipe.
- From outside, 10% of normative thickness is made of orange polyethylene. As a result, it is possible to visually check the level of possible mechanical damage.

What is PAS-1075?

The PE100RC standard has not been covered by any Polish or European standards so far. The only attempt to systematize this field is the PAS-1075-4 (PAS = Publicly Available Specification) established in Germany:

Requirements PAS 1075-4 – "Polyethylene pipes for alternative pipe laying techniques – measurements, technical requirements and tests":

- 1) Notch Test according to PN EN ISO 13479. The sample withstands without damage for a period $\geq 8,760$ h.
- 2) FNCT test (Full Notch Creep Test) – according to ISO 16770. The sample withstands without damage for a period $\geq 8,760$ h.
- 3) Point load test according to Dr. Hessel. The sample withstands without damage for a period $\geq 8,760$ h.

What is PAS-1075?

As proof of what positive STATEMENTS of the PRODUCTS tests and the certificate of their conformity with PAS 1075 should be presented (conformity of pipes with PAS 1075 can only be confirmed by the accredited Institute on the basis of tests carried out by the research unit for each of the three Dimensional Product Groups, after receiving permanent testing of tubes confirming their features (see items 1, 2, 3 above).

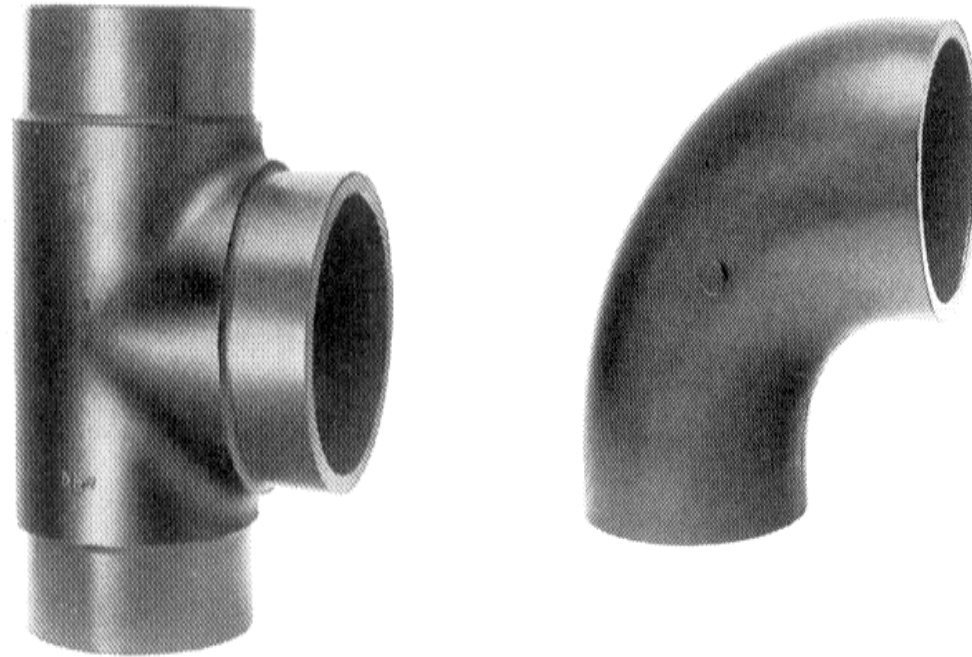
There are only two accredited Institutes in Europe that can test the compliance of products with the PAS 1075 guidelines, i.e. DIN Certco and TUV Sud. All pipe manufacturers that meet the requirements for compliance with PAS 1075 are listed on the websites of these accredited institutes.

Based on this report, INiG at the request of the manufacturer issues technical approval confirming suitability in trenchless techniques and the possibility of assembly without sand bed and sand bedding, utilizing traditional and narrow excavation methods, as well as the possibility of trenchless renovation and replacement of water supply pipelines.

Connecting pipes

- There are various types of connectors in plastic gas pipelines. They are called "fittings" and "connectors". In contrast to steel pipelines, plastic connectors are ready-made elements, mounted at the construction site.
- Types of fittings can be classified due to the *function* (knees, tees, reductions, etc.), or *assembly technology* (fittings for electrofusion welding, butt welding, muff and saddle welding).

Butt fusion fittings



Butt welding fittings Standard angles of injected knees are 90° and 45° , reductions range from 3 to 5 diameters, reduction tees have departures with a diameter smaller than 3–5 ranges of the main diameter.

Butt fusion fittings



Saddle



Tee

Butt fusion fittings

- A characteristic feature of electrofusion fittings is the presence of a heating wire on the welded surface.
- Due to their functionality, they are readily used in all types of connections. However, special attention should be paid to the quality of fittings, because the savings made here often result in increased failure rates. A valuable advantage of electrofusion fittings is the possibility of using them as repair fittings and for switching on under full gas pressure. The diameters of electrofusion fittings produced range from 20 mm to approximately 630 mm.

Marking of pipes

Each pipe must be marked permanently. On the surface there should be a caption containing basic information necessary to identify the pipe. This information can include:

- pipe manufacturer's name or symbol,
- the number of the standard (PN-EN 1555-2),
- the word 'GAS',
- PE class,
- pipe dimensions (diameter x wall thickness),
- designation of a series of dimensions (for dn bigger than 40 mm),
- date of production,
- product code (extruder number, lot designation, etc.),
- safety mark 'B'.

Example marking: XXX PN-EN 1555-2 GAS PE100 110x10 SDR11 ddmrr nnn xxx



Gas installation design in 25 steps

1. Familiarize yourself with the **technical conditions** of connection to the gas network.
2. Familiarize yourself with the current **map for design** purposes.
3. Familiarize yourself with **architectural projections**.
4. Reconcile with the architect (or investor or other customer) the **number and location** of the gas receivers.
5. Calculate the gas **demand** considering the simultaneous consumption of gas by all gas receivers.
6. Check whether the gas demand complies with the issued technical conditions (gas demand is less than or equal to the value given in the technical conditions). If everything is correct, you can proceed to the next stage if not, a plan of action must be undertaken with the customer, i.e. change of technical conditions, liquidation of part of the receivers, change in the capacity of some of the receivers – if conditions allow).

Gas installation design in 25 steps

7. Draw all gas receivers, their power and hourly gas consumption on plans.
8. Draw installation routes in plans.
9. Mark the gas installation divisions.
10. Draw an external gas installation from the pressure reduction point to the building.
11. Mark the ventilation and exhaust ducts on the plans. The ducts should meet the requirements of the technical conditions quoted at the very beginning of the documentation.
12. Draw a simplified calculation scheme – one-line deployment development.
13. Describe in the plans and in the calculation table the pre-accepted diameters and material of the installation. The initial diameters of gas pipes can be adopted on the basis of tables included in the literature on gas system design.
14. Check the gas meter selection. In the case of single-family housing, where the gas consumption is not greater than $10 \text{ m}^3/\text{h}$, the gas supplier imposes the type of gas meter.

Gas installation design in 25 steps

15. Determine the route of the gas installation for which you will perform hydraulic calculations. For this route (most often it is the appliance furthest from the main valve), perform detailed hydraulic calculations.
16. Knowing the volume of gas flow within individual sections and predefined diameters, calculate the linear and local loss on individual sections.
17. Add to the calculations the correction resulting from the difference in levels, resulting from the difference in gas and air density (recovery or loss of pressure on the vertical).
18. Knowing the pressure loss resulting from the flow resistance, maximum pressure loss on the gas meter and pressure recovery on the vertical – calculate the actual pressure loss in the system. Check if the total pressure loss is less than the permissible pressure loss in the system. The actual pressure drop in the installation is on average between 80 and 140 Pa. Remember to not oversize the installation unnecessarily. For gas installations powered by high-E gas (GZ 50), the maximum pressure loss is 150 Pa, and for gas GZ-35 this is 100 Pa.

Gas installation design in 25 steps

19. If the pressure loss is too high, correct the pre-accepted diameters and perform the calculation again.
20. Mark the final diameter of the gas installation on the plans.
21. Draw the final development of the gas installation.
22. Apply the remaining installations to the foundation. It is best to mark the foundation and other installations with gray color, and the designed gas installations with black or red color.
23. Send the project to the architect for the purpose of inter-branch coordination.
24. If you are doing a project for an architect, print the project in 4 copies and submit the complete documentation.
25. If you are in the field of obtaining a building permit, obtain from the Investor a declaration on the right to use the property for construction purposes and a power of attorney to submit an application on behalf of the investor.

Source: <https://poradnikprojektanta.pl/projekt-instalacji-gazowej-w-25-krokach/>