

Miroslava VAŠKANINOVÁ, Jana PERÁČKOVÁ

Slovak University of Technology in Bratislava, Slovakia

SAFE OPERATION OF GAS FACILITIES IN ENERGY-SAVING BUILDINGS

House insulation and insulation of apartment houses is carried out in order to improve energy efficiency in buildings. Insulation is often carried out along with the windows replacement, which means that the building becomes sealed and excludes the natural air infiltration through window gaps. However, people do not pay enough attention to control if the places with gas equipment meet all requirements for safe usage. This article focuses on conditions and requirements for the safe using of the gas equipment under the current legislation.

Keywords: gas equipment, safe operation of gas installation

INTRODUCTION

Although the emphasis is laid on the energy usage from renewable energy sources, almost 94% of the population in the Slovak Republic uses natural gas for everyday cooking, water heating or cooling. Its use is comfortable (an unlimited supply 365 days a year and 24 hours a day) and financially advantageous. As Slovakia lacks large reserves of natural gas, gas is imported from distant places several thousand kilometers far away. The natural gas is transported either by pipelines or tankers, similarly as liquefied gas from transmission system through gas distribution equipment to our homes. Concerning the properties of natural gas, such as flammability and explosiveness, we should not forget the risks that arise from the transportation and usage of natural gas, which contravene the rules and regulations of the current legislation. The media increasingly report information about fires and explosions of objects where a gas leak was the main cause. Therefore, questions emerge such as what are the causes of gas pipeline accidents and how to avoid such accidents.

1. CAUSES OF GAS EQUIPMENT ACCIDENTS

The accidents with gas equipment (pipeline system, gas appliances, fittings, etc.) are mostly caused by poor technical conditions of the equipment, breach of the rules for the safe operation of the equipment, and an intentional damage of the equipment.

1. Under the term poor technical condition of equipment is understood:
 - corrosion damage,
 - operational wear,
 - fatigue of material,
 - hidden defects in material,
 - inappropriate design.
2. Unsatisfactory operational rules for the safe operation of the equipment:
 - pressure, heat and power equipment overload,
 - encroachment into equipment,
 - neglected or inappropriate maintenance and installation.
3. Intentional damage to the device (is treated as an intentional offense):
 - intentional opening of the burners without their ignition on the gas cooker,
 - intentional release of coupling nut on the gas supply to the gas appliance.

2. OPTIMIZATION OF ACCIDENT GAS APPLIANCES

In terms of current legislation, both the designers and lay people (users of gas equipment) ought to follow these steps:

- appropriate a location for the gas appliance,
- ensure sufficient ventilation of the area with gas appliances,
- ensure professional installation by a person with authorization to pursue that activity,
- ensure the correct operation of gas equipment,
- ensure regular revisions of gas installations,
- ensure regular controls of gas installations,
- adhere the time for cleaning and control of chimney.

Principles for placement of gas appliances and requirements for ventilation of area with gas appliances

European scheme for the classification of gas appliances according to the method of evacuation of the combustion products (types of appliances) TNI CEN/TR 1749 classifies the gas appliances to the 3 types: type A, type B and type C.

Appliances of type A (Fig. 1) are appliances not intended for connection to a flue or to a device for evacuating the products of combustion outside of the room where the appliance is installed. Appliances of type B (Fig. 2) represent an appliance intended to be connected to a flue that evacuates the products of combustion outside of the room containing the appliance. The combustion air is drawn directly from the room. Appliances of type C (Fig. 3) are devices where the combustion circuit (air supply, combustion chamber, heat exchanger and evacuation of the products of combustion) is sealed with regard to the room in which the appliance is installed [1].

Appliances of type A

As the gas appliances of type A draw air and produce the combustion products into the room in which they are installed, it is important to ensure sufficient room volume and sufficient air supply for combustion and flue gas from this room.

Infringing these basic conditions, the accumulation of combustion gases, the decreased concentration of oxygen, and deterioration of the combustion process occur in the room, which results in an increased concentration of harmful substances, particularly CO (carbon monoxide poisoning).

It may as well cause turning off the burner and gas leakage into the room. It is therefore necessary to locate these appliances in directly ventilated areas with an average ground clearance room of 2.3 meters.

Minimum permissible volume [m^3] of rooms with gas appliances of type A is shown in Table 1. It is crucial that the combustion products from this type of appliance are taken away from breathing zone in such rooms.

Table 1. **Minimum allowable volume of rooms with gas appliances of type A and their combination [m^3] [2]**

Minimum allowable volume of rooms with gas appliances of type A and their combination [m^3]		
Gas appliances of type A	I. Residential unit with several living rooms	II. Residential unit with one living room
a) gas cooker with gas or electric oven, or built-in appliance with separated hob and gas oven	20	50
b) separate oven for baking or separate gas cooker with two burners	10	30
c) gas fridge	6	6
d) water heater (≤ 10 kW) or storage water heater (≤ 2 kW)	20	50
e) water heater (≤ 10 kW) together with appliance in accordance with paragraph: a) b) or c)	26 20	80 60
when combined appliances a), b), c) the volumes of rooms are counted		

TPP 704 01 states that it is prohibited to place these types of appliances in bathrooms, toilets, food storage and rooms for sleeping. If the extractor hood is located above the appliance and if it takes water vapor and combustion products outside of the room, it is allowed to reduce minimum volume of rooms by 25% from the values listed in Table 1.

When the room does not meet the requirements from Table 1, it is necessary to connect it with the next room removing the door or vents (0.02 m^2) on the floor and 1.8 m above the floor (optimal 30 cm below the ceiling). Both rooms must be directly ventilated [2].

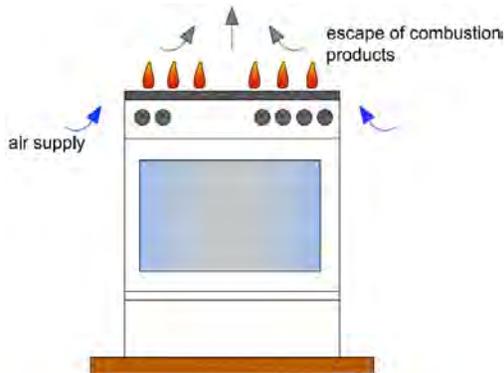


Fig. 1. Gas appliance of type A (cooker)

Every room with an appliance of type A must be vented or directly ventilated. In such rooms air exchange must be secured at least 1 time per an hour [2].

Appliances of type B

These appliances are located in ventilated areas. The appliances with atmospheric burners and draught diverters have to meet the requirement which states that for one kW of appliance power is necessary at least 1 m^3 volume of the room.

The condition for sufficient air supply is met as long as the combustion air in the volume of $1.6 \text{ m}^3/\text{h}$ for 1 kW of appliance power by air permeability of windows and doors flows into the room [2].

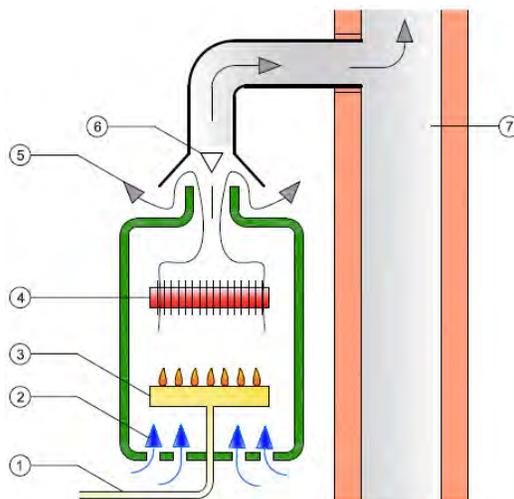


Fig. 2. Gas appliance of type B (water cooker): 1 - gas supply, 2 - combustion air, 3 - atmospheric burner, 4 - heat exchanger, 5 - escape of combustion products (in adverse effects in the chimney), 6 - draught diverter, 7 - chimney

Sufficient room volume and combustion air supply can be ensured in the following ways:

1. Location of the appliance in a separate room or in a cabinet with permanent air supply from outside by a hole, holes with a free cross-section min. 0.001 m^2 per 1 kW of power, but at least 0.02 m^2 (Fig. 5).
2. Location of the appliance in a room with a separate permanent air supply from outside by a hole or by holes with a free section of at least 0.001 m^2 per 1 kW of power, but at least 0.02 m^2 . The most appropriate solution is to locate the holes as low as possible above the floor of the room.
3. Connecting the room with an adjacent room of the same user (by means of permanent removing the inner doors or enclosable holes on the floor and 1.8 m above the floor, Fig. 3). The holes should have a minimum free cross-section 10 cm^2 per 1 kW of power of the appliance (Fig. 3a, b).
4. Connecting the appliance in an indirectly ventilated room to another room with the same user (Fig. 4).
5. Ensure air supply by means of another way (fan), which is economically disadvantageous though [2].

When using a gas water heater (type B) in the area with tubs and showers, one appliance accounts for at least 20 m^3 room volume. The doors must open outwards and must be provided with holes for air supply (at the bottom of the door) and for air exhaust (at the top of the door).

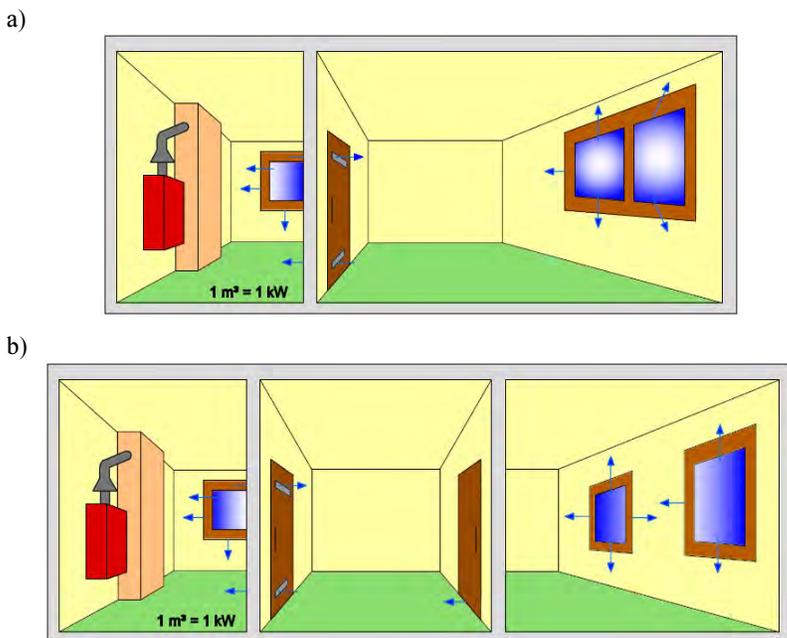


Fig. 3. The appliance is located in directly ventilated room:
 a) a connection with an adjacent room of the same user,
 b) a connection through indirect ventilated room of the same user

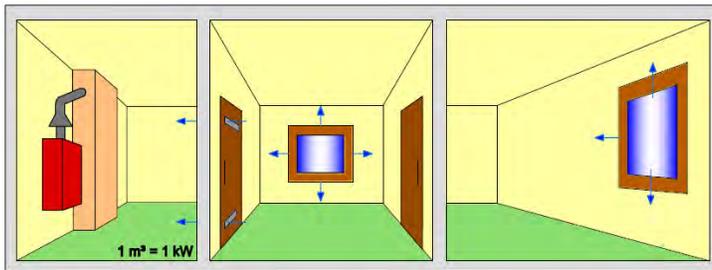


Fig. 4. The appliance is located in indirect ventilated room

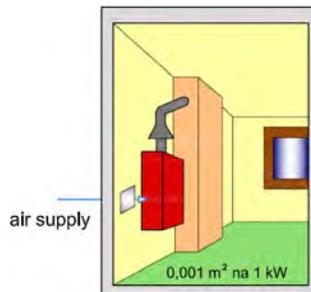


Fig. 5. Location of the appliance of type B with atmospheric burner and draught diverter in cabinet or in separate room with permanent air supply from outside

Appliances of type C

For the location of this type of appliances, there are no special requirements either for room volume or for combustion air. It is necessary to observe the conditions and requirements for fire safety. Typical appliances of type C are gas boilers with sealed combustion circuit and gas convection heaters located under windows. It is necessary to comply with the requirement for the correct height of the chimney, so that the escaping combustion products do not pollute surroundings because of their infiltration into the surrounding areas [2].

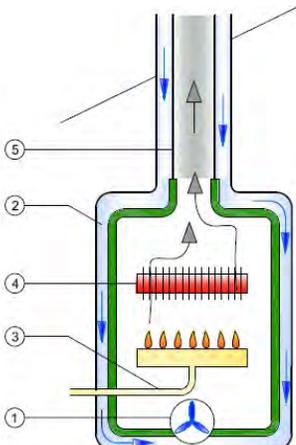


Fig. 6. Gas appliance of type C (boiler):
 1 - overpressure burners, 2 - combustion air,
 3 - gas supply, 4 - heat exchanger,
 5 - chimney

When locating the appliance A and B in one room, the minimum allowable volume of a room is determined as the higher of the two minimum volumes. The combination with the appliance C does not create any other extra requirements for the air exchange and volume of the room [2].

3. NEW MATERIAL OF GAS PIPELINE AND CORRECT INSTALLATION

The proper connection of the gas appliance is very important for the safe operation of the gas appliance.

Correct connection of gas appliances:

- connected according to manufacturer's directions,
- connected by a fixed or flexible connection,
- the length of the connection cannot not be longer than 1.5 metres,
- fitted valve is located before each gas appliance,
- cannot be installed in places where it is prohibited,
- must be located in an area where the appliance is installed,
- cannot be stressed by other forces.

The standard material used for gas distribution in buildings was up to now only steel pipeline material, to a limited extent copper material and for the above-ground storage also plastic PE material. Today, this range of pipeline materials is extended by two new types:

- the corrugated flexible pipeline that can be easily bent by hands and can be covered with an outer protective material,
- the multilayer pipeline material with the designation PE-AL-PE (composed of layers of polyethylene, aluminum and polyethylene) or PEX (cross-linked polyethylene material).

PLT pipeline

PLT pipelines for gas distribution are made of stainless steel material, are covered with yellow factory-made plastic coating, which provides protection against corrosion and mechanical damage (Fig. 7). They are flexible corrugated stainless steel tubing, which are bonded together by a mechanical bolt. Gas pipelines from these materials are conducted under the surface, in shafts, in ducts, on surface or under concealed. These pipelines cannot be used for the direct connection of appliances that are not firmly anchored. They are connected by a demountable mechanical joint.

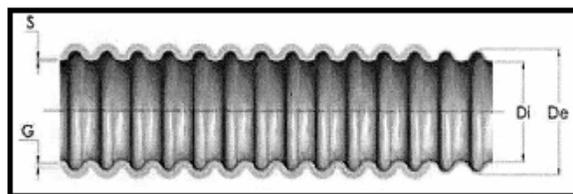


Fig. 7. Construction scheme of PLT pipeline [3]

For joining PLT pipes, a tool is used which normally consists of a manual or electric pressing equipment and facilities for the establishment of a suitable bearing surface by welding the specified number of small waves on PLT tube (eg. two waves). The mechanical bolted joint for connecting the PLT pipelines is produced by a nut and clutch. The tightness is achieved by pressing the faces of the sealing surface PLT pipes and joints using a rubber gasket. When connecting the PLT system to the existing gas pipeline of any material, the threaded outlet fitting called the connector is used. This connector is first fitted onto the existing pipeline and then is connected to the stainless steel flexible pipe by a thread. The place on the pipeline where yellow protective coating was removed due to pressing joints is covered with a protective wrapping adhesive tape. Methods for forming joints between PLT tubes are shown in Figures 8, 9 and 10.

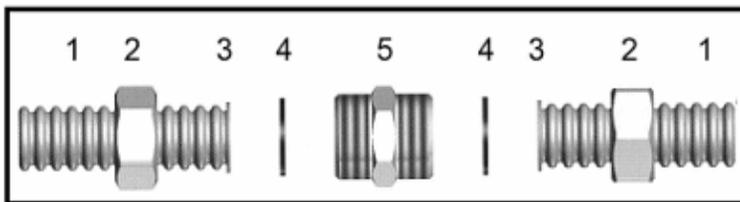


Fig. 8. PLT joint pipeline of the same size using connector with external threads [3]:
1 - PLT pipeline, 2 - neck, 3 - cap at the end of PLT tube, 4 - gasket, 5 - connector

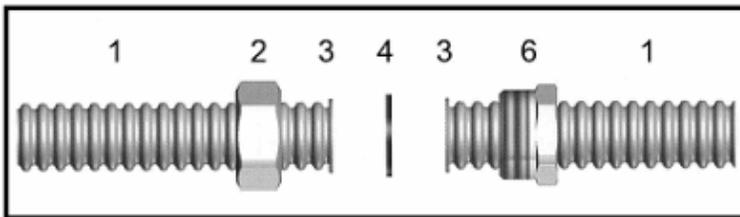


Fig. 9. PLT joint pipes of the same size by passing the external thread [3]:
1 - PLT pipeline, 2 - neck, 3 - cap at the end of PLT tube, 4 - gasket,
6 - transition with external thread

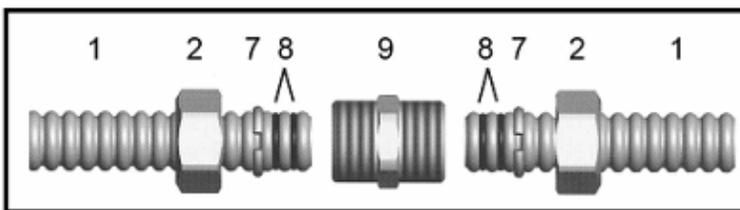


Fig. 10. PLT joint pipes of the same size by a connecting nipple with female sealing surface for O-rings [3]:

1 - PLT pipeline, 2 - neck, 7 - fixation ring of brass, 8 - a pair of sealing O-rings, 9 - connecting connector with interior sealing surface for O-rings

PLT pipelines can be easily formed and bent by hand, yet there is no change of the internal flow pipe cross-section. Anchoring these tubes is carried out by means of steel sleeves with rubber lining, which protect the protective coating of pipes from damages. Gas distribution of these pipelines can be installed as an external or internal gas pipeline. Before and during installation, you have to ensure the protective yellow coating is not impaired. Pipe joints and fittings are insulated with the protective tape by hand, including parts of the valve so that they are protected against mechanical damage and the action of aggressive substances along the whole length. PLT pipeline connection must be made by welding or soldering.

PEX-AL pipeline

PEX-AL pipeline are multilayer plastic tubes composed of 5 layers - the outer part of the pipeline from cross-linked polyethylene, adhesive layer, aluminum layer, adhesive layer and the inside of the pipeline with cross-linked polyethylene. The composition of each layer is shown in Figure 11. The supporting aluminum layer is longitudinally welded. The special adhesive layer binds cross-linked polyethylene on the pipeline, which results in high stability and low thermal expansion, increasing the service lifespan and the temperature pressure resistance of the pipe. The surface of the tubes are coated with a PE-X yellow layer.

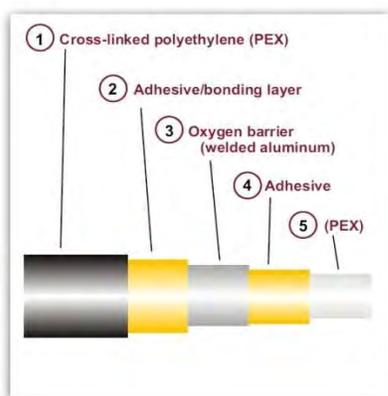


Fig. 11. Scheme for construction of multilayer pipeline ALPEX [8]



Fig. 12. Special brass fittings - ALPEX [8]

During the storage and installation, ALPEX pipes cannot be exposed to climatic influences, such as solar UV - radiation, wind, rain or snow. Therefore, they must be stored in a protective tube, in the bay, channel or concealed. These multi-layer pipes are connected by compression. The number of joints should be minimized. For gas installations shall be used only special fittings with O-ring ALPEX (Fig. 12), resistant to natural gas, propane, butane and mixtures thereof. These fittings are made of brass with press necks of stainless steel. To ensure the position against

slipping, yellow rings with holes for checking the correct position are used for the tube fixation [4].

4. CHECKING AND REVISION OF APPLIANCES

The main cause of the poor technical condition of the gas equipment (gas heaters, stoves, gas distribution pipelines, flues and chimneys) is the nonperformance of regular revisions and control of gas equipment. When the gas appliance is put into operation, it is necessary to identify the person who is responsible for the safe operation of the equipment. This person is "the person responsible for the operation". This person is obliged to ensure a regular control and revision of these installations with a person authorized for carrying out these activities as stated in STN EN 1775 Gas supply. Gas pipework for buildings. Maximum operating pressure less than or equal to 5 bar. Functional recommendations [5].

The control of the equipment is the status review of the equipment which is in operation. It is the review which determines whether the technical requirements are fulfilled or not. The checks will control air and leakage.

The revision of the equipment is an overall review of the status of the equipment. It is controlled by testing the equipment, by measuring its safety and reliability, reviewing project documentation and examining qualifications by a person responsible for the operation. The revision control is carried out especially after a trial run, after the overhaul, after the intervention, which has an effect on the safety and reliability of equipment, after the interruption of operation of equipment for a period longer than six months, after the interruption of operation due to accidents or operational failure [6].

Time limits chimney cleaning and inspection

When checking the gas pipelines and gas appliances, be careful not to forget the cleaning, the inspection and the testing of chimneys and flues. Currently, many chimneys do not meet the requirements of modern heating systems or fire safety (Fig. 13).



Fig. 13. Destruction of chimney body [source: the Internet]

The wrong chimney draft, an inadequate thermal insulation and sensitivity on moisture represent disadvantageous features typical for older chimneys. Clogged chimneys and flues, an unsuitable usage of thermal insulation, an improper stack height, and unprofessional installations of chimney bodies are the causes of accidents with catastrophic results, i.e. an explosion of a building or a part of the building, burning out of a room in which chimney are led, the flue and escape of gas back into space - choking hazard.

CONCLUSION

The question revealed at the beginning of this article has been answered. The main causes for accidents are neglected obligations and insufficient performances in terms of requirements for safety operation. To prevent such accidents from happening, it is necessary to follow the instructions for operation, maintenance and servicing of gas appliances listed in the instructions of the manufacturer. Use the gas appliance for the purpose for which it is intended. Remember to supply enough air into the room where the gas appliance is located. Ensure ventilation of space in which the appliance is used, thus preventing leak combustion products into the room. Carry out the regular revisions and controls of gas installations according to the instructions of a person with qualification. Ensure to repair and maintain the gas appliances only by a person with professional qualifications and with required license to perform this work.

REFERENCES

- [1] TNI CEN/TR 1749 Európsky systém triedenia spotrebičov na plynné palivá podľa odvádzania spalín (vyhotovenie spotrebičov), Júl 2012 (CEN/TR 1749 European scheme for the classification of gas appliances according to the method of evacuation of the combustion products (types), July 2012).
- [2] TPP 704 01- Odborné plynové zariadenia na zemný plyn v budovách, Júl 2009.
- [3] Buchta J., Nové technologie a materiály při zřizování domovních plynovodů II, <http://energetika.tzb-info.cz/vytapime-plynem/6275-nove-technologie-a-materialy-pri-zrizovani-domovnich-plynovodu-ii>
- [4] Podniková technická norma PTN 704 05 Použitie viacvrstvových rúrok ALPEX- GAS pre rozvod plynu v budovách s pracovným pretlakom do 5,0 bar.
- [5] STN EN 1775 - Zásobovanie plynom. Plynovody na zásobovanie budov. Maximálny prevádzkový tlak menší alebo rovný 5 bar, Apríl 2008.
- [6] STN 38 6405 - Plynové zariadenia. Bezpečnosť prevádzky, Február 1988.
- [7] STN 06 1401 Lokálne spotrebiče na plynné palivá. Všeobecné požiadavky, Apríl 2000.
- [8] IVAR.CS - product catalog.

BEZPIECZNA EKSPLOATACJA URZĄDZEŃ GAZOWYCH W BUDYNKACH ENERGOOSZCZĘDNYCH

Izolację w budynkach stosuje się dla poprawy ich efektywności energetycznej. Często towarzyszy jej wymiana okien, co sprawia, że w budynku nie zachodzi naturalne przenikanie powietrza przez szczeliny okna. Jednakże użytkownicy nie poświęcają wystarczającej uwagi temu, czy pomieszczenia z urządzeniami gazowymi spełniają wszystkie warunki bezpiecznego użytkowania. Niniejszy artykuł skupia się na warunkach i wymaganiach bezpiecznego korzystania z urządzeń gazowych w świetle obowiązujących przepisów.

Słowa kluczowe: urządzenia gazowe, bezpieczna eksploatacja instalacji gazowej