Passage of low temperature piping through the external wall

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Abstract. The paper deals with the passage of the gas pipeline through the perimeter wall. The gas pipeline has a low temperature (the gas temperature drops significantly after the gas expansion in the regulator). When passing through the perimeter wall, the part of the wall near the internal surface will be significantly subcooled. Low temperatures in the building structure can cause local faults. The paper deals with the comparison of the course of temperatures and humidity of the passage of the gas pipeline in the protective tube with thermal insulation and without thermal insulation.

1. Introduction
Due to the type of piping and the perimeter structure, the passages of pipelines through the building envelope may have a location that meets the functional and safety needs of the pipeline. When designing buildings, when designing their architectural and structural solutions and especially in the stage of processing structural details, increased attention must be paid to the issue of possible thermal bridges. The materials used to make individual building structures have different physical properties, especially in terms of thermal insulation. Part of the problem of pipelines installation is taken over from abroad literatures. The main purpose is not to prevent the formation of thermal bridges. Due to the small number, considerable diversity and connection to the issue of several professions, these thermal bridges are not systematically solved. In contrast to possible thermal bridges in building envelope structures caused by material composition in the structure where thermal bridges are caused by transitions and installation lines, the determination of boundary conditions (medium temperature, periodicity, media properties, etc.) is also problematic, so this issue is not usually solved in project of building structure. According to Halahyja [1], the thermal bridge is a structural element with a different thermal conductivity than the whole structure. It usually has a higher thermal conductivity, the inner surface has a lower temperature.

Thermal bridges in the field of typical Slovak structures are dealt before by Sternova [2], similarly to other authors [3], [4], [5], [6], where they are solved only in connection with building structures, but not the passage of pipes through structures.

2. Boundary conditions
2.1. Temperature of the medium
The medium (mostly heating gas) has properties corresponding to its transport in the outdoor environment. The temperature is particularly important, as the medium is separated from the structure by a pipe and therefore no moisture is transferred by the transported gas. Table 1 shows approximate
values, varies according to ambient temperature, installation depth, cable length, solar radiation, operating time, etc.

| Material                                             | Temperature of the medium | Notice                          |
|------------------------------------------------------|---------------------------|---------------------------------|
| natural gas after regulation from pressure up to 0.4MPa | -15                       | winter season, average          |
| natural gas without pressure regulation               | 0                         | winter season                   |
| natural gas without pressure regulation               | 15                        | summer season                   |
| air conditioning tube                                 | 5                         | winter season, recuperation only - no reheating |

2.2. Pipeline position

Gas pipelines for public supply transport hydrocarbon heating gases (natural gas - methane; propane, butane). The gases are dehumidified during extraction; if the technological procedures for the installation of the pipeline are observed, the operation and functionality of the pipeline system will not be disrupted due to the action of residual moisture. Due to the safety requirements due to the possibility of the formation of an explosive mixture with air, the technical regulations (eg [8]) stipulate the requirements for the piping in such a way that no explosive concentration occurs. In particular, it is the piping through (un) ventilated spaces, if this cannot be observed, the piping is in a protective tube (tight piping leading to the ventilated spaces). One of the ways to prevent the formation of explosive concentrations is to run the pipeline through outdoor spaces - in the ground and on the facade of the building, respectively. its layers while ensuring constant ventilation of the grooves in which it is stored. The temperature of the heating gas (natural gas) entering the building (for heating purposes) varies according to its use, season and especially the pressure in the public part of the pipeline (before regulating the gas pressure) and fluctuates over a wide range. The temperature of the gas behind the regulation of the gas pressure is theoretically given by the equation of state of the gas (shown in the graph for methane), in reality it is significantly influenced by the transfer of heat from the surrounding environment.

The pipeline in the building is dealt with in Slovakia [8], which sets out the requirements for the passage of the pipeline through the perimeter wall in order to maintain safety with regard to the properties of natural gas and the building:
- the passage of the gas pipeline through the wall must not disturb the statics of the wall or the building;
- masonry and plaster must not act aggressively on the gas pipeline or protective pipe;
- when transferring a gas pipeline to a building, the gas pipeline must be placed in a protective pipe preventing gas from penetrating the building structure and at the same time protecting the gas pipeline from damage (specified in national standards).

3. The comparison of solutions

With regard to the main criteria that must be met in terms of safety, the solution of thermal protection and thermal bridges is solved marginally. The gas pipeline is usually made of a heat-resistant but thermally conductive material (steel, copper), which creates a thermal bridge in the structure. This thermal bridge can be manifested by a deterioration of the thermal insulation properties of the wall, an increase in humidity and damage to the building structure or a local deterioration of the climate in the building (humidity, mould). This article deals with the comparison of piping in a protective tube without thermal insulation and with thermal insulation.

To compare the influence of the temperature course, 2 variants are selected, meeting the requirements of technical regulations:

A) piping in a protective tube, without thermal insulation
B) piping in a protective tube, with thermal insulation.

![Figure 1. Variants of passage of pipeline](image)

Table 2. Description of construction and material solution of the wall

| Num. | Material                                      | \(D\) [m] | \(A\) [W/m·K] | \(R\) [m²·K/W] |
|------|----------------------------------------------|-----------|----------------|----------------|
| 1    | interior plaster                             | 0.010     | 0.860          | 0.01           |
| 2    | Porotherm Profi Dryfix 38T ceramic brick masonry | 0.38     | 0.064          | 5.94           |
| 3    | facade plaster                               | 0.020     | 0.8            | 0.025          |

\[R_t = 5.975\]

3. Conclusions and discussion

Pipe transitions through the outer wall create a thermal bridge. As with other thermal bridges, they must be considered. In case of risks for the construction, also evaluate and adjust.

As simulations have shown, the course of temperatures in the structure is significantly deformed along the entire pipeline. The low temperature was also reflected at the inlet of the pipe to the room, by a significant cooling below the dew point temperature. Due to the excellent thermal insulation properties of PUR foam, the temperature at the surface of the thermal insulation (VAR. B)) at the inlet of the pipe to the room is significantly higher than without thermal insulation (VAR. A)).

However, the thickness of the PUR foam affects the temperature (and thus the humidity) of the absorbent thermal insulation of the structure by moving the condensation zone to the non-absorbent layer, thereby limiting the wetting of the absorbent thermal insulation of the structure.

The course of relative humidity in the structure is influenced by the temperature of the structure and the diffusion resistance of the individual layers. The area where it is raised is therefore close to the pipeline. In particular, the following are problematic:

1) Over the internal surface of the structure - a condensation zone is created during VAR. A).
2) Relative humidity> 90% with protective tube for VAR. A) along the entire pipe.
3) Relative humidity> 90% with thermal insulation VAR. B) along most of the pipe (insulation) in the masonry. Condensed water vapour evaporates throughout the year.
4) Placement of pipes in thermal insulation VAR.B) requires major structural modifications in the structure - an enlarged hole for placement of insulation.
5) Filling the hole with polyurethane foam around the pipe will positively affect the course of temperatures near the pipe.
6) In the case of the implementation of masonry from organic absorbent materials (wood and wood products) in the condensation zone, it is necessary to re-evaluate the insulation thickness, or the overall solution.
Figure 2. The comparison of temperature and relative humidity for variants A) and B), interior: $\theta_i = 20^\circ\text{C}$, $\varphi_i = 50\%$, exterior, $\theta_e = -15^\circ\text{C}$, $\varphi_e = 84\%$, pipeline -15°C, steel pipe DN25, second protective pipe around the gas pipeline DN40, wrapping around the protective pipe of the gas pipeline (VAR.B) - PUR foam 30mm - $\lambda_{iz} = 0.03$ $\text{W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$. Svoboda Cube 3D simulation program was used for the calculation [10].
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