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SELECTED ISSUES OF GAS SUPPLY SAFETY

Safety of gas supply is considerably depended on failure occurrence. Gas network constitute large assets of gas company, therefore it is crucial for them to maintain safe and reliable functioning of gas infrastructure. The disaster caused by gas explosion may cause very large material and human losses. The presented approach can be used to describe the losses being a result of failure of gas network. It can provide information for assessment between gas supply systems in regards to the cost and losses of failure occurrence on gas pipes. The analysis was based on the operational data obtained from the operation of gas network.

Keywords: gas network, gas losses, gas network failure, gas network functioning

1. Introduction

The current technical progress influences the growing requirements for the safe operation of critical infrastructure, including the gas supply system [21].

According to European Gas Pipeline Incident Data Group through the period of the five year moving average and overall failure frequency have reduced consistently over the years with the tendency to stabilization [4, 5]. But at the same time increased gas consumption affects the continuous development of gas pipelines. Recently, the requirements of customers referred to the reliability of the operation of gas systems are growing [23, 24].

It should be emphasized that the subjects discussed is important from the point of view of domestic customers, who were most strongly represented group which accounted for 97% of the total group of recipients [1, 10]. On the other hand, taken into account the quantity of natural gas sold, most of it was purchased by industrial customers, as much as 62% of which were dominated by fuel companies, including refining, petrochemical and nitrogenous chemicals companies [8, 9, 22].

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Proper functioning of gas systems constitutes the important issues, as leakage of gas into the atmosphere during the failure creates a risk of explosion and fire. Through which injured can be accidental people or customers, as well as employees of gas plants [2, 19, 20, 25].

Safety of gas supply should ensure stable supply at a level guaranteeing the supply that guarantees the recipient's needs and the accepted by the economy and the society the costs of gas supply, assuming the optimal use of domestic energy resources and by diversifying gas supply sources [14, 17 18].

Therefore the current problems are associated with increased safety of gas supplies, as well as minimizing the risks for its users and their protection during the operation of the gas system, as well as through new investments or modernization [12, 13].

The current energy policy is based on the project of the Polish Energy Policy until 2050 taking into account the provisions of Directive 2009/73 / EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for internal gas market and aims to provide the following issues diversification of sources of supply through differentiation of supply, the stability of the political situation, as well as draw attention to the geographical location of sources of supply, national or foreign [3]. Also attention is focus on fuel storage, ownership of energy sector companies and supply system, indication if it is state or commercial, supervision and regulation of the system by the state through scope and efficiency of supervision. The important issue is to control supply system condition, through transmission capacity, technical condition and reliability, what is associated with forecasting, planning, development and investment decisions [15].

Therefore in the paper the analysis concerning undesirable events occurrence emerged in gas supply system were examined, as well as issue connected with costs of modernization and failure of gas network.

2. Case studies of undesirable events resulting from gas network failure

Transport of natural gas by gas pipelines is one of the safest way of transport of this fuel. However, during this type of transport failures occur, which sometimes have very serious consequences [2, 11]. A particular danger is the unsealing of the gas pipeline located in the ground, because of the location of the fault is noticeable after a long time.

The most common causes of unsealing of underground gas pipelines are [1]:

- splitting welds,
- mechanical damage, eg excavator bucket during construction work,
- unsealing of threaded connections,
- corrosion of gas pipelines,
- improper gas composition, which damages the gas pipeline from the inside.

The fastest is detected pipeline leak caused by mechanical damage, because such a failure is immediately noticeable by the perpetrator. Leaking gas from a gas pipeline in the ground can cause a number of negative effects, the size of which depends on the leak - it depends on the possibility of migration of gas at the mouth of the pipeline and this in turn depends on the geological conditions and underground infrastructure next to the site of damage of the pipeline.

The typical negative effects of unsealing the underground gas pipeline include the destruction of vegetation (due to the negative impact of methane on the root system of the plant), a fire that can occur if the slits in the ground penetrate the outside. A particularly dangerous situation is when the gas from the underground gas pipeline enters the underground sewerage, telecommunications infrastructure, etc. Through these channels, gas can enter the buildings and unpredictably can lead to poisoning of people staying there or when they reach the appropriate concentration for explosion. Migrating gas from a damaged gas pipeline to buildings was often a cause of catastrophe in buildings even without a gas installation.

The escaping natural gas from the damaged underground gas pipeline probably contributed to the gas explosion in a multi-family building in Pruszcz Gdański and the event took place in 2016. As a result of the gas explosion in the multi-family building collapsed the top of the building collapsed, which according to the inspectors further inhabiting this building due to significant damage is not possible. As a result of the accident there were no fatalities but one person was hospitalized. The building in which the explosion occurred was not connected to the gas network. Natural gas to the building probably got from the cracked gas pipeline running under the building.

In September 2013, in the village Dormowo there was a high pressure gas pipeline leaks. Due to the threat of gas explosion, 200 people were evacuated near the crash site. The pipeline was damaged in the peat field. The blast caused by the outflow of gas caused the nearby buildings to overflow with peat dust. Failure was detected by sensors that monitor the pressure in the gas pipeline. As a result of the crash, no one was injured and no fatalities occur. Probable cause of failure was construction work alongside the damaged gas pipeline [6].

In Leszno in July 2017, as a result of gas pipeline seizure, the gas entered the sewers where it reached an explosive concentration. In order to minimize the likelihood of an explosion in the area, electricity supply was halted and 100 people evacuated. Failure was reported at 22, the removal of the failure continued until the morning, and then the residents returned to their homes and resumed the supply of electricity [7].

Presented examples of some recent failures were caused by the unsealing of the gas pipeline. In the examples given, fortunately, there were no major losses, but unfortunately in the past there were gas pipeline failures, as a result of which the former fatalities occurred. An example may be the year 2013 and the failure of the high pressure gas pipeline as a result of construction work in Jankow

Przygodzkim. Two people were killed as a result of the accident, while thirteen people were injured, seven were hospitalized. As a result of the fire, ten residential buildings burned down. At this point, it should be also mentioned the biggest catastrophe associated with unsealing of the gas pipeline in Poland. This refers to the natural gas explosion in the Rotunda PKO in Warsaw, which took place in February 1979 year. Failure occurred due to rupture of the pipeline to the valve housing, causing leakage of gas to the ground as a result of a low temperature frozen ground created a gap from which gas from the damaged pipeline escaped to the technical channel and further to the building. Upon reaching the explosive concentration, there was an explosion inside the building. It is worth mentioning, that the low temperature caused the condensation of the gas deodorizing agent, which made the gas became odourless, what made it difficult to detect. It is also worth mentioning that the Rotunda building was not connected to the gas network. In this disaster 49 people were killed, 135 injured, of which 77 were hospitalized.

3. Threat to the proper functioning of the gas network

The result of gapping is pipeline leak gas. If the escaping gas in the air will reach a suitable concentration and the ignition sources emerge (for eg. sparks), the ignition, as well as fire or explosion occurs.

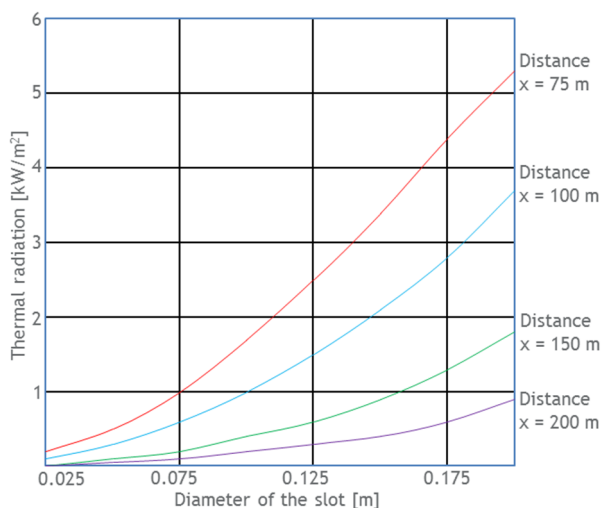


Fig. 1. Thermal radiation according to the diameter of the gas pipeline at a pressure of 1.5 MPa, own work on the basis of [16]

Rys. 1. Promieniowanie ciepłe w zależności od średnicy szczeliny dla gazociągu o ciśnieniu 1,5 MPa, opracowano na podstawie [16]

An explosion will occur if the combustion of gas appear almost simultaneously in the entire volume of the gas mixture with air. In this case, the effect of the shock wave, will cause the greatest damage. However, gas explosion is not always a result of the leak. In the case where combustion takes place gradually there is a fire which causes much damage through radiation.

On the Figure 1 the value of thermal radiation depending on the diameter of the gap in the gas pipeline where the gas pressure is 1.5 MPa was presented.

It is obvious that the larger the gas leakage gap, the higher the heat radiation value. At the same time, with the given gas gap diameter and closer to the leakage source, the value of the heat radiation increases. For example, for a gap of 0.175 m at a distance of 75 meters from the source of fire, the radiant heat value is over 5 kW/m², and 200 meters from the combustion site, the thermal radiation decreases by about 1 kW/m².

The pipelines run both in places of habitat and in non-inhabited areas. If gas leakage occurs in people's home, it is obvious that the probability that a person is in the heat exchanger zone is high.

On the Figure 2 the percentage of deaths according to the time of exposure and the diameter of the gap in the gas pipeline was shown.

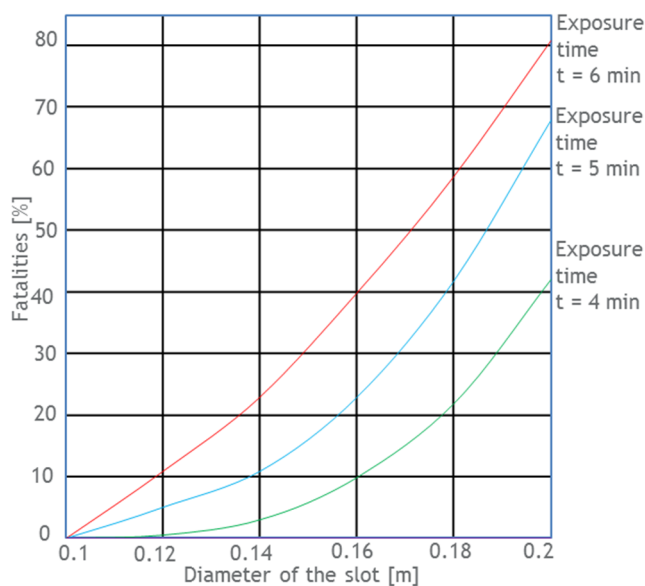


Fig. 2. Percentage of fatalities according to time of exposure for the gas pipeline at the pressure of 1.5 MPa, own work on the basis of [16]

Rys. 2. Procent ofiar śmiertelnych w zależności od czasu ekspozycji dla gazociągu o ciśnieniu 1,5 MPa, opracowano na podstawie [16]

With the increase in the diameter of the gap and the time of exposure to heat, the number of fatalities increases. For example, with a gap of 0.2 m and a radiant exposure time of 6 minutes, the percentage of deaths among people exposed to heat radiation increases to more than 80%.

From the presented facts, it results that it is necessary to avoid the location of particularly high and medium pressure pipelines in places of human habitats. Of course, in many cases this is not possible, then it had to use materials which have a small propagation of cracks, so that in case of breakage of the gap was small as possible which will result in less radiation.

4. Conclusion

In recent years, due to growing residential areas, the length of the gas networks is increasing, and the probability of their failure continues to increase. The observed development of gas supply system does not protect against the failure occurrence of the gas network. Safety assessment in the operation of gas supply system may contribute to reducing the potential consequences of emergency events. The randomness of the occurrence of the accident causes that conducting research related to the operation of the gas network is quite difficult and complex, primarily taking into account available operational data. It should also be noted that the escaping of natural gas can cause a threat to the environment.

In spite of the increase in safety-related procedures for the gas network functioning, gas network failures are still recorded as being presented in the cited examples, which have occurred recently, often they pose a serious threat to human health and life.

Therefore, as gas network forms a complex system and it is characterized by the unpredictability and randomness of failure occurrence of failure, it involves proper analysis of its functioning. As gas companies are obliged to supply gas in reliable and safe way to the recipients, it is therefore appropriate to develop new research methods that will minimize the likelihood of gas pipeline failures and reduce their impact if the breakdown is already occurring. Such approach will be helpful in performing assessment of proper functioning of the gas systems.

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WYBRANE ZAGADNIENIA DOTYCZĄCE BEZPIECZEŃSTWA DOSTAW GAZU

Streszczenie

Bezpieczeństwo dostaw gazu jest znacznie uzależnione od wystąpienia awarii. Sieci gazowe stanowią duże aktywa zakładów gazowych, dlatego kluczowe znaczenie ma dla nich utrzymanie bezpiecznego i niezawodnego funkcjonowania infrastruktury gazowej. Katastrofa spowodowana wybuchem gazu może nieść za sobą bardzo duże straty materialne i ludzkie. Przedstawione podejście można wykorzystać do opisanego strat wynikających z awarii sieci gazowej. Może również dostarczyć informacji na temat oceny systemów dostaw gazu w odniesieniu do kosztów i strat związanych z awarią sieci gazowych. Analiza oparta była na rzeczywistych danych uzyskanych na podstawie eksploatacji sieci gazowej.

Słowa kluczowe: sieć gazowa, straty gazu, funkcjonowanie sieci gazowej, awaria sieci gazowej

Przesłano do redakcji: 15.11.2016 r.

Przyjęto do druku: 15.06.2017 r.