marcogaz
TECHNICAL ASSOCIATION
OF THE EUROPEAN NATURAL GAS INDUSTRY

General practices for managing risk increasing structures in the vicinity of high-pressure gas pipelines

Table of content

1. **Background**

Third-party activities in the close vicinity of underground gas infrastructure can induce additional risks for the gas transmission system. Apart from work executed by third parties, also third-party installations and infrastructure in the vicinity of underground gas infrastructure can result in increasing the risks. The MARCOGAZ document *"General practices for managing external interference on underground pipelines"* (WG_TP-121) gives more details about the management of the third-party interferences in general.

Installations in the vicinity of pipelines such as wind turbines, solar installations, large industrial plants and mines may have impact on the integrity of a pipeline or even cause its failure. The same applies for infrastructures like railways, motorways and high-voltage transmission cables. The EGIG database (https://www.egig.eu/reports) does not cover such failure causes for underground pipelines. However, they should be identified as having the potential to threaten the integrity of buried pipelines if they are located close to the gas transmission pipelines.

MARCOGAZ recognizes the necessity for neighboring installations and infrastructures relatively close to gas infrastructure. When proper precautions are respected e.g. minimum separation distances, risks for the gas infrastructure remain acceptably low. These guidelines provide high-level general requirements to prevent mechanical and electromagnetic harm to the gas transmission system from neighboring installations or infrastructure.

The following topics are addressed:

A. Installations
   a) Wind turbines
   b) Solar Systems
   c) Airports
   d) Large industrial plants
   e) Mining area's
   f) Storage facilities for hazardous materials (e.g. flammable, corrosive or explosive materials)

B. Infrastructures
   a) High Voltage Cables
   b) Railways
   c) Motorways
   d) Waterways
   e) Water pipelines
   f) Other pipelines with dangerous content (fuels, chemicals)
   g) Sewers

C. Soil pollution

2. **Definitions**

Term	Meaning
High voltage system	Any high-voltage line, cable, tower, grounding system, etc. ≥1 kV
Solar system	Any solar panel, solar farm
Wind turbine installation	Any wind turbine, wind turbine farm
Large industrial plant	Plant with heavy industry that has the potential to damage objects outside of its fences
Mining area	Area subject to mining activities
Pipeline operator	Private or public organization authorized to design, construct and/or operate and maintain the gas infrastructure

3. **General requirements installations and infrastructures**

When a third-party installation or infrastructure is built close to a gas pipeline, hazards for this pipeline that might occur during the construction have to be considered. This includes digging activities, lifting operations, movements of heavy vehicles, use of explosives and other actions. The details regarding the precautions that should be taken during the digging activities have been covered in the MARCOGAZ document "*Guidelines for safe working in the vicinity of high-pressure gas pipelines*" (WG_TP-144). Besides that, the consequences in the operational phase of the installations or infrastructure for the pipeline shall be considered.

Generally, the following requirements must be met for installations in the neighborhood of a pipeline:

- In case of any malfunction of the mechanical construction of the third-party structure, the risk for the pipeline shall remain acceptable;
- The installation grounding networks should not shield the pipeline from the cathodic protection system and must not affect the ground potential near the pipeline in such a way that the cathodic protection system becomes ineffective;
- The pipeline must be accessible by the pipeline operator at any time

The gas pipeline operator has usually a very limited control on its environment. It is therefore recommended to protect (underground) infrastructures like high-pressure gas pipelines against third-party structures by national legislation or by law.

3.1. Communication

It is advisable to establish a communication framework between the neighboring operator and the pipeline operator in order to keep each other informed about operational changes or emergencies that may affect the safety of either the installation or the pipeline. E.g. an increase in current of a solar system may cause electromagnetic interferences on the pipeline.

Prior to any plans regarding placing wind turbines, solar systems or high voltage systems, the pipeline operator should be contacted in order to confirm the exact location of the pipeline in the vicinity of the planned systems.

In case of industrial plants or mining area's in the close vicinity of pipelines, these pipelines shall be incorporated in the company emergency plans of the neighboring operator.

More details are identified in the MARCOGAZ document (WG_TP-161) *"Guidelines for stakeholders management regarding third part interference"*.

3.2. Safe distance

Generally, it is not preferred to cause any interference with pipeline by neighboring operators like wind turbines, solar installation and high voltage systems. The best way of preventing the pipeline being affected by external factors is to ensure that there is an intrinsically safe distance between the installation (or infrastructure) and the buried pipeline.

Keeping an intrinsically safe distance between the pipeline and other installations, like a high voltage system, is also helpful to prevent the ignition of a gas cloud (unexpectedly or purposefully) escaping from the pipeline system.

The location of the installation or infrastructure shall not lead to an (significant) increase of the failure probability of the buried pipeline.

If the intrinsically safe distance cannot be met, then the location of the installation or infrastructure is only acceptable after an evaluation of all potential risks and approval by pipeline operator.

4. **Specific requirements for installations**

Each type of installation can cause specific issues for the pipeline. In this chapter, these issues are addressed per installation type.

4.1. Wind turbines

The pipeline can be affected by a mechanical failure of a wind turbine (for example a broken rotor blade that is thrown away or the collapse of the tower or the nacelle). Direct as well as indirect (e.g. vibrations) impact on the pipeline, can result in the loss of containment. High voltage interference from wind turbines pose several threats to pipeline integrity also.

In many countries, national legislation regarding the distance of wind turbines near pipelines is applicable and shall be respected, with a wide range of criteria. A distance of two times the height of the wind turbine (mast height plus one blade length), measured from the base of the wind mill tower, is not unusual. Some studies specify an "exclusion zone", (source: http://www.ukopa.co.uk/wp-content/uploads/2013/02/UKOPA-13-012.pdf) with a distance of 1.5 times the mast height as the distance outside which the additional risk is no longer considered significant. This applies to the modern and large turbines especially, that are well protected against overspeed and unbalance. Older turbines with relatively high rotation speeds might have larger blade throw distances.

4.2. Solar Systems

The Solar Installation may affect the pipeline's cathodic protection system. Potential impacts could be as a result of:

- AC interference from buried or above ground AC cables,

- Direct current (DC) interference, see §5.1.2

In some countries, specific national legislation is applicable and shall be respected. In general, a distance equal to 200 m is considered as enough to assure proper cathodic protection in case of undiagnosed malfunction of the installation. If the mentioned distance cannot be met, then the placement of the installation should only be acceptable after evaluation of all potential risks and with approval of the pipeline operator.

It should be noted that a malfunction of the solar installation may affect the soil voltage in a DC manner, which can accelerate external corrosion much faster than AC voltage.

4.3. Airports

Aircraft crashes are only relevant for the gas industry if the pipelines are located inside the risk contours of an airport (the majority of aircraft crashes occurs during take-off or landing). The probability of such an event can be significant compared with the default probability of failure of the pipeline. Therefore, the risk contours of an airport must first be determined after which the risk for the pipeline can be evaluated.
Consequently, it is stipulated that the failure frequency of a pipeline located in the airport risk contour is increased as a result of crashing or dislocated airplanes. Crashing doesn't only mean a big crash but also planes which don't brake in time and going off the end of the air strip. Be aware of growing airports with extending air strips which comes close to pipelines. With new pipelines, this risk is easily reduced by providing the pipeline with an adequate depth of cover.

4.4. Industrial installations

4.4.1. Large industrial plants

For large industrial plants such as (but not restricted to) installations subject to the Seveso directive, land use planning will secure the prevention of unacceptable interaction between the particular plant and the neighboring gas infrastructure. Wherever the pipeline is part of the industrial plant, it shall be considered in the plant emergency plans. Due to the fact that the pipeline is underground, it is protected against heat radiation and shockwave.

4.4.2. Storage of hazardous materials

Storage facilities for hazardous materials and substances in the close vicinity might increase risks for pipelines too. Accidents related to the nature of the stored materials might induce an immediate risk for the pipeline. Some materials might damage the pipeline coating (ex. solvents) or chemically attack the metal of the pipe ex. acids (pure or dissolved in the ground water). This should be prevented by proper land use planning or other dedicated measures Due to the fact that the pipeline is underground, it is protected against heat radiation and shockwave.

4.5. Mining areas

Mining activities can result in vibrations and surface ground movements, such as subside or even induced earthquakes, that can potentially impact buried gas transmission pipelines because of its exposition to bending and axial stresses.

DIN 4150-3 gives more criteria about acceptable vibration levels. EN 1594 gives more details how to manage mining areas.

Subsidence from mining/exploration differs from natural subsidence in two key respects: First, the location of mining/exploration subsidence is largely known because of ongoing or planned mining activities. However, there will typically be some uncertainty regarding the direction at which mining will progress. Second, the amount of mining subsidence could be estimated based upon historical observations or analytical models.

Regular monitoring by mining company and by the pipeline operator will typically be necessary to verify mining subsidence is consistent with expectations and agreements and that alterations are properly managed.

5. **Specific requirements for infrastructures**

5.1. High voltage cables

5.1.1. AC Interference

AC influence is often caused by high-voltage cables. The interference between high voltage cables under normal condition and the pipeline can contribute to an acceleration of the corrosion damage to the pipeline. Under faulted conditions, elevated potentials of surrounding soil causing an increased potential difference (towards the pipeline) can lead to coating damage (disbonding) or pipeline damage.

Finally, pipelines can be adversely affected by temperature of the surrounding soil, caused by high-voltage cables or lines. Pipelines may suffer from coating degradation, increased corrosion rate or thermal stresses.

5.1.1.1. Overhead AC power lines

Under faulted conditions, elevated potentials of surrounding soil causing an increased potential difference (towards the pipeline) can lead to coating damage. During fault condition, damage to the pipeline or its coating can occur if the voltage between the pipeline and surrounding soil becomes excessive. There are several references regarding allowable coating stress voltage. For example, NACE SP0177-2014 "Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems" and ISO 21857 "Prevention of corrosion on pipeline systems influenced by stray current".

The pipeline can also be affected by a mechanical failure of a high-voltage tower. In general, a distance of one time the total height of the tower, measured from the base of the tower, is an intrinsically safe distance. If this is not possible, mitigation measures must be taken.

5.1.1.2. Buried AC power cables

In general, the level of interference from buried AC cables is typically lower. Depending on the type of construction, sheathing or conduit may offer some level of electromagnetic shielding. However, aboveground AC is still the primary concern for pipeline interference.

For pipelines in the vicinity of any high voltage system, an assessment must be done in order to determine whether or not there is a safe distance between the pipeline and the system.
EN 15280:2013 "Evaluation of AC corrosion likelihood of buried pipelines applicable to cathodic protected pipelines" and ISO18086 "Determination of AC Corrosion - Protection criteria" provides recommendations on evaluation of the probability of AC corrosion of underground pipelines applicable for cathodic protected pipes.
The electromagnetic interference may increase under fault conditions or after a period of time if some degradation of the cable insulation occurs. A permanent monitoring system to detect any impact on the cathodic protection system should be put in place.

By keeping the appropriate distances, unacceptable risks regarding high voltage interferences are generally avoided. For example, NEN 3654:2014 "Mutual influence of pipelines and high-voltage circuits" provides safe distances for high voltage systems.

If the safe distances cannot be met, a risk assessment showing the impacts of the effects of the installation on the pipeline should be submitted to the pipeline operator for consideration at the completion of the design phase and prior to the commencement of any construction works. If a buried electrical cable or other services are required to cross the pipeline route, then the pipeline operator should specify the minimum clearance distance above or below the pipeline.

5.1.2. DC interference

Stray currents originating from direct current (DC) power line systems can also increase the risk for pipelines.
Bipolar High Voltage Direct Current (HVDC) systems should be given preference to avoid stray current interference. The earthing of HVDC systems should be designed in such a way as to avoid current flowing through the earth during normal operation and to minimize earth current during faulty or unbalanced load conditions. NEN-EN 50162:2004 "Protection against corrosion by stray current from direct current systems", should be respected. The DC interference is also addressed in SP0169-2013-SG, "Control of External Corrosion on Underground or Submerged Metallic Piping Systems"

5.2. Railways (DC and AC)

5.2.1. DC

In a DC electrified traction system, the rails are one of the main sources of electromagnetic disturbance to buried pipelines cathodic protection system. The main electrical role of the rails is to form the current return circuit. However, due to the imperfect insulation of the return circuit versus earth, the currents flowing in the running rails can "leak" to the ground and affect the cathodic protection system of the pipeline, which offers a low electrical resistance path for the current. Due to this, the cathodic protection system of the pipeline should be adapted with specific measures mitigate corrosion risk.

5.2.2. AC

The induced voltage by AC railways overhead lines is similar to the influence caused by AC HV lines. In addition to this influence, the return circuit for the current is intended to flow in earthing systems along the tracks. Any metallic infrastructure in the vicinity of such railway might experience influences that could lead to corrosion risks.

5.3. Motorways

5.3.1. Crossing under pavement

When a new road is constructed which crosses a pipeline, the pipeline will experience extra loads from the road material itself and from the traffic. It should be calculated if the pipeline can carry these additional loads.
Special attention should be given to the safety of the pipeline during the construction phase of the road, when heavy traffic and soil moving equipment crosses the pipeline frequently. It is good practice to inspect, and repair if necessary, the coating of the pipeline before the pavement is applied.

5.4. Waterways

When crossing a waterway, the pipeline shall have adequate depth of cover beneath the bottom of the waterway to protect the pipeline from dropped/dragged anchors, spud poles, sinking ships and other threats. The depth of cover requirement depends on soil type, pipeline diameter, waterway type, morphological situation, maximum anchor size, etc.

In many countries, specified requirements are applicable and shall be respected.

In fast flowing rivers, a (partially) free span of the pipeline can be particularly hazardous for pipeline failure due to oscillations induced by the water flow. The depth of cover should be monitored regularly.

In case of reducing of depth of cover a risk assessment can be carried on to evaluate all potentials risks. Local legislation comprising generally accepted calculation methods might be applicable for the additional failure frequencies of the pipeline as a result the failure of the water crossing.

Local legislation comprising generally accepted calculation methods might be applicable for the additional failure frequencies of the pipeline as a result the failure of the water crossing.

5.5. Dykes

The dyke can be subject to setting of the soil and consequently, then the pipeline, crossing the dyke, may be a subject to setting as well. This increases the stress in the pipeline wall which, in time, may exceed the stress limits.
For buried pipelines, the soil investigation shall be performed during the design and the expected settlements shall be investigated and calculated. The setting of the dyke and the pipeline should be regularly monitored.

5.6. Other pipelines with dangerous content (fuels, chemicals)

5.6.1. Pipelines with dangerous content (fuels, chemicals)

The dangerous contents of another pipeline can, when leaking, affect the quality of the coating of the nearby gas pipeline. Some substances may even be corrosive for steel.
Leakage from a high-pressure pipeline or from a pipeline with a large liquid outflow may cause an erosion crater around the pipeline and, subsequently, around a crossing or parallel gas

pipeline. The dimensions of erosion crater can be calculated according to NEN-3651:2012 “Additional requirements for pipelines in or nearby important public works”

When the combustible liquid spillage is ignited, the gas pipeline may be surrounded by flames from the burning pool. When the spillage is a combustible gas, the gas pipeline may be affected by heat radiation from the burning pipeline. In both cases, it is the consensus to keep the flow going in the unbroken gas pipeline, so that the pipe is cooled from inside by the flow.
Therefore, vertical and horizontal clearance requirements are necessary to protect the underground gas pipeline against possible leaks from the other pipeline.

5.6.2. Sewer/water pipelines

A leaking sewer/water pipe bursting water jet in the soil will create erosion crater which may finally cause failure of the natural gas pipeline. The dimensions of erosion crater can be calculated according to NEN-3651:2012 “Additional requirements for pipelines in or nearby important public works”.

Vertical and horizontal clearance requirements normally can be found in the local regulations.

6. Soil pollution

Leakage of stored substances or other sources might cause penetration of soil with aggressive substances causing the coating of the pipeline to be harmed and stimulate corrosion. Regular monitoring the pipeline by the pipeline operator will typically be necessary to detect such threats within a reasonable timeframe.

7. Conclusion

MARCOGAZ recognizes the unavoidability of neighboring infrastructures relatively close to gas infrastructure due to space limitations. Provided that some minimum distances and proper precautions are respected, risks for the gas infrastructure remains low and acceptable.

The approach described in this paper provides a high-level insight into the operator’s management of the risks related to wind turbines, solar installations, high voltage systems and other infrastructure near the gas pipeline and the way these risks can be managed. This will contribute to the enhancement of the already high safety level of transmission of gas by pipelines.

It is recommended to assure the protection of (underground) infrastructures like high pressure gas pipelines against third party structures by national legislation or law.

* * * * *