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Risk Factors in a Process of Gas Supply Pipeline Construcion

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Abstract. The paper applies to the risk management in the specialized construction by the example of construction of a high-pressure gas supply pipeline. The specific character of the construction project has an impact on the scope and types of risks which may occur and adversely affect the outcome of the project. The paper aims to indicate the groups of technological tasks which need to be carried out when constructing a gas supply pipeline, the associated factor risks and the quality control method as a tool of mitigating the level of risk.

1 Introduction

Investing in a gas supply infrastructure is a costly, complex and multi-step undertaking. Since such infrastructure is a strategic component of a national energy supply system, which is designed to provide energy supplies for production and service processes, for the needs of collective and individual heat supplies, its reliability and uninterrupted operation must be ensured. Every participant of an investment process (an investor, a designer and a contractor) has to be fully aware of the requirements and bear liability for the tasks they have undertaken to perform. Therefore, appropriate supervision and control become a key element of a construction process with the view to acknowledging and ensuring that a given facility will be built in compliance with the construction law, the conditions specified in a building permit, the applicable regulations and standards as well as the investor's demands.

The character of a gas supply pipeline construction project has an impact on the scope and types of risks which may occur and adversely affect the outcome of the project. The paper aims to indicate the groups of technological tasks which need to be carried out when constructing a gas supply pipeline, the associated risks and any ways in which risks may be mitigated using the right quality control methods. The study is based on the actual historical data (documentation of the gas pipeline constructions in the period of 2012-2017), from the polish STALPROFIL S.A. (joint stock company) group experts' information (employees) and the literature on the subject. The methods of risk analysis in the construction had been based on the theoretical approach described in [1, 2]. The risks in the pipeline construction projects may be of different origin, including: design risk, management risk, construction risk, subcontractor risk, political/governance risk, economical/financial risk, owner generated risk, material risk and equipment generated risk. However, in this paper we concentrate on construction risk. The construction risk remains in relation with the majority of other listed above risks [3].

2 Risk factors and the specific groups of technological tasks in a gas supply pipeline construction process

Construction activities related to linear facilities are exposed to a variety of risks and hazards, the occurrence of which may significantly distort the process and lead to e.g. delays, cost overruns and, in some extreme cases, discontinuation of a project or a failure to complete a given task.

Making a decision on the participation in a tender or on the acceptance of a contract, a party involved should be fully aware of any unfavourable events which may occur and should be able identify these in an effective way. Such unfavourable phenomena or risks of a given project should be carefully and meticulously specified and documented. An analysis of risk factors, the determination of preventive actions, the assignment of personal responsibility and the scheduling of periodic or continuous monitoring of both the formerly identified and the new risks, may help us find the right directions for actions, mitigate these risks and protect our operations from the consequences of such undesirable events. All these efforts, when conducted in a planned manner, will create a system to implement a risk management policy.

The risk analysis for the construction of a gas supply pipeline shows that the process is highly complex and covers many stages, which can also be translated into the scope and extent of risks that may have a negative impact on the outcome – the aim of the project. In the study 16 groups of the technological tasks which are performed when producing a gas supply was taking into

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consideration. The study identifies 116 risks which are specific to the construction of gas supply pipelines (Table 1). The risk factors, which have been established, are ranked according to the weights assigned to them. The weights has been estimated as the normalized (between 0 and 1) result of multiplication of the probability of occurrence (from the historical data) and the cost. This gives an overall picture of what risks may be considered critical, i.e. which risks are expected to have the biggest impact on the construction process failure or success. The risks were divided into three groups: high risks (risk weight 0,200-1,00), moderate risks (risk weight 0,050-0,200) and low risk (risk weight less than 0,050). Then the risk factors were assigned to groups of technological tasks (Table 2). The most vulnerable technological tasks are: welding, connections in trenchless technology technological facilities – gas units. The failure in these groups of technological tasks can be easily detected by standard quality control methods (e.g. x-ray inspection). However the other risk factors can not be neglected as the risk occurrence is usually described as critical in pipeline industry.

Table 1. Risk factors and their weights

No.	Risk factor	Risk weight
1	Incorrect placement of pipes for ramming and borings	0.560
2	Incorrect installation of a supply pipe in a protective pipe	0.560
3	Failure to achieve the required resistance of a connection or jacking pipe after drawing	0.560
4	Incorrect production of a weld – no acceptance	0.400
5	Failure to meet insulation parameters of joints	0.400
6	Leaving blocks, debris, stones, roots etc. in a trench	0.400
7	Incorrect insulation of protective pipe terminals in a pipeline	0.400
8	HDD boring – diversion from a planned route	0.400
9	Incorrect testing of an insulation layer for leakage, failure to find the location of a defect using DCVG survey	0.400
10	Incompliant quality documentation (for acceptance tests)	0.400
11	Failure to restore the land to its original condition (when handing the land over to the owner)	0.280
12	Defective joints, exceeding the limit specified in the tender	0.240
13	Welders and/or welding equipment operators without required authorisations	0.240
14	Welding conducted by the Ordering Party's unauthorised welders and operators	0.240
15	No required authorization held by a Non-destructive Testing Laboratory	0.240
16	No non-destructive testing of joints (RT, UT, MT, PT)	0.240
17	Failure to meet insulation requirements for fittings	0.240
18	Failure to perform (or incorrect performance) of insulation testing for joints using a defectoscope	0.240
19	Failure to perform (or incorrect performance) of pipe tightness tests with a defectoscope before placement of a pipeline in a trench	0.240
20	Failure to perform (or incorrect performance) of an insulation tightness test for fixtures with a defectoscope	0.240
21	Failure to repair damaged insulation	0.240
22	Failure to perform (or incorrect performance) of insulation testing on separated (zero defect) sections	0.240
23	No correct protection of trenches	0.240
24	Incorrect placement of a gas supply pipeline in a trench (axis and cover)	0.240
25	Filling trenches with blocks, debris, stones, roots etc.	0.240
26	HDD boring – a supply pipeline stuck under the ground	0.240
27	Inaccurate tightening of screws on a flange	0.240
28	Pressure drop in tightness or fatigue testing	0.240
29	Failure to introduce changes to design documents	0.240

30	Changes not accepted by a designer or a construction site inspector	0.240
31	Lack of pipeline tightness e.g. in fixtures or flange connections	0.240
32	Unreliability of devices used during commissioning	0.240
33	Incorrect accounting for investor supplied pipes and fixtures	0.240
34	Failure to obtain an operating permit	0.240
35	Failure to obtain a decision from the Office of Technical Inspection (UDT) with an operating permit	0.240
36	Incorrect assembly and placement of sinkers	0.200
37	No sinkers placed on geotextile	0.200
38	Incorrect placement of a pipeline at intersection with another infrastructure (vertical distance)	0.200
39	Failure to perform (or incorrect performance) of soil compaction	0.200
40	Incorrect repair or patency of drains and melioration systems (ditches)	0.200
41	HDD boring – hydraulic breakthrough of drilling fluids	0.200
42	Collision of a boring with an underground infrastructure	0.200
43	Leaks in insulation layers of fittings	0.200
44	Dirt inside the pipeline	0.200
45	Incorrect gas pipeline manual – no approval from UDT and/or the Ordering Party	0.200
46	No Welding Procedure Specification (WPS) for a given type of connection	0.120
47	Failure to submit results to WRB in a timely manner	0.120
48	No monitoring of welding parameters for joints	0.120
49	Too shallow/deep trench	0.120
50	Uneven shaping of a trench bottom	0.120
51	No sand bedding	0.120
52	No sand shading	0.120
53	No sand backfill	0.120
54	Incorrect filling of space between pipes with insulation mass (if required)	0.120
55	Planned pressure testing not agreed on by UDT and the Ordering Party	0.120
56	Inability to dry a pipeline to the required dew point	0.120
57	Incorrect production of cathodic protection connections	0.120
58	Failure to perform periodic measurements of pipeline resistance between P and S points	0.120
59	Correctness of an anode ground bed	0.120
60	Correctness of stationary reference electrodes	0.120
61	Placement of cables in a trench incompliant with the design	0.120
62	Insufficient separation of electric devices from pipelines	0.120
63	No control over welding of fixtures with a pipe (e.g. measurement of welding temperature)	0.120
64	Planned pressure tests not agreed on with UDT and the Ordering Party	0.120
65	Failure to perform (or incorrect performance) of soil compaction	0.120
66	Incorrect Quality Assurance Scheme (if required)	0.100
67	Incorrect Control and Testing Plan (if required)	0.100
68	Incorrect Health and Safety Scheme	0.100
69	Incorrect Environmental Protection Scheme	0.100
70	Incorrect procedure specifications for performance of selected tasks	0.100
71	A construction site inspector's refusal to approve the material to be built into	0.080

72	Building in of the materials which has not been approved by a construction site inspector	0.080
73	No required and approved welding technologies	0.080
74	No authorisations held by people who perform non-destructive testing in a given method	0.080
75	No visual testing of joints – VT (required 100%)	0.080
76	Failure to perform (or incorrect performance) of insulation testing after the pipeline is placed and backfilled	0.080
77	Incorrect use of placement technology (layout of girders, deflection, straps, equipment)	0.080
78	Pressure drop in tightness or fatigue testing of a pipeline	0.080
79	No required and approved technologies for cathodic protection connections with a pipeline	0.080
80	Incorrect configuration of telemetric and facility control data	0.060
81	Incorrect readings of pressure transmitters	0.060
82	No mechanical response to start-up and verification of valve and bolt automation	0.060
83	Incorrect placement of fixtures on foundations	0.060
84	Careless placement of paint layer on steel above ground components	0.060
85	Imprecise laying of foundations (trench control)	0.060
86	Delays in supplies of materials (e.g. pipes, steel fittings, additional materials for welding, insulation materials)	0.040
87	Materials incompliant with an order	0.040
88	Incorrect dimensions of components, poor condition of insulation or incorrect operation of devices/fixtures from own purchases	0.040
89	Failure to provide quality documents together with a consignment	0.040
90	Incomplete material documentations	0.040
91	No welding supervision with authorisations, as per PN-EN 14731	0.040
92	Incorrectly prepared joints for welding	0.040
93	Incorrect lamination of pipes or welds	0.040
94	Failure to perform the right number (1 per 300 welds) of adherence tests for insulation on pipes and welds	0.030
95	Unreliable assembly and stability of fencing	0.030
96	Failure to perform (or incorrect performance) of marking on welds	0.025
97	The area not checked by explosives engineers	0.020
98	No archeologic survey in the earth work area	0.020
99	Incorrect welding plan for a pipeline	0.020
100	No testing of cut pipe terminals for delayering	0.020
101	Insufficient capacity of pumps - difficulties in filling a pipeline with water and getting the right pressure	0.020
102	No or poor GSM signal	0.020
103	Inability to dry a pipeline to the required dew point	0.020
104	No inspection log books (for pressure devices in facilities) obtained	0.020
105	No notification to the owner about the entry to their land (construction site)	0.010
106	Incorrect operation of fixtures after testing	0.010
107	Use of concrete mixture with is incompliant with a specification	0.010

108	Waste processing areas incompliant with a specification (e.g. subbase thickness, curbs)	0.010
109	Access roads incompliant with a specification	0.010
110	Failure to meet final acceptance requirements for a pipeline	0.010
111	Incorrect pre-project environmental assessment report	0.005
112	Incorrect angle of an arc	0.005
113	Incorrect roundness of a pile at a bending point	0.005
114	Incorrect thickness of a wall and condition of insulation after bending	0.005
115	Incomplete testing of welds	0.005
116	Incorrect marking of a pipeline route with posts	0.005

Table 2. Risks in specific groups of technological tasks.

No	Group of technological tasks	No. of low risks	No. of moderate risks	No. of high risks	No. of risks per a technological activity	Percentage share in total
1	Preparing quality documentation	0	5	0	5	4.31%
2	Commencement of work	4	0	0	4	3.45%
3	Purchase of materials	5	2	0	7	6.03%
4	Cold bending of steel tubes	3	0	0	3	2.59%
5	Welding	6	6	6	18	15.52%
6	Insulation	1	1	7	9	7.76%
7	Digging of trenches	0	3	2	5	4.31%
8	Placing of a pipeline	0	2	4	6	5.17%
9	Burying of the pipeline and land reconstruction	1	1	4	6	5.17%
10	Connections in trenchless technology	1	1	8	10	8.62%
11	Pressure tests	1	3	0	4	3.45%
12	Installation of cathode protection	0	5	1	6	5.17%
13	Technological facilities – gas units	7	11	4	22	18.97%
14	Technical acceptance	0	0	3	3	2.59%
15	Filing with gas and start-up	0	0	2	2	1.72%
16	Final acceptance and handover for operation	2	0	4	6	5.17%
Total		**31**	**40**	**45**	**116**	**100%**
Percentage share in the risk group		**26.72%**	**34.49%**	**38.79%**	**100%**	

3 Conclusion

The failure of the high-pressure gas pipeline would be extremely dangerous for both people, civil engineering constructions (including buildings), and environment. Therefore the use of any method which will diminish the probability of occurrence of such an event is necessary. The process of the construction of the gas pipeline is very complicated and many risk factors can occur. The critical factors can materialise at different stages of the construction process. Therefore the in-process risk management is a proper tool in these cases. Additionally, such an approach is used widely in infrastructural construction projects [e.g. 4]. Having identified the main risk factors in the pipeline construction process (as stated above) one can try to manage it. The main tool of risk management in the industry is quality control (eg. [5]).

The purpose of quality control is to check and assess, in an independent manner, the compliance and the progress of a construction process in order to ensure that the planned work quality is met. A contractor which builds the given gas supply pipeline is responsible for the correct application of technologies and for the quality of materials to be built in at every stage throughout a project delivery process, assuming the risk of any potential failure to perform or duly perform. That is why it is so vital to have well-qualified staff, whose members are well-organised and will carry out control activities, as set out in the project and tender documents, resulting from the legal status and required by the investor. In case of a highly complex construction project, the contractor may draw on their subcontractor's expertise and experience from conducting similar assignments, also in the area of quality control. Quality control staff should act within an established system of control, be provided with the necessary documents, equipment and measuring devices to enable them to evaluate the quality of work. The contractor, in the course of the construction process, should carry out all tests, examinations and checks needed to verify the compliance of the work performed with the requirements specified in the technical design, the technical terms and conditions of delivery and acceptance, all the applicable standards and the investor's guidelines [6].

When it comes to highly complex projects, in particular the ones in which the occurring risks may negatively affect human health, lives, the natural environment or result in substantial financial losses, it would definitely be advisable to implement in-process control as a tool for monitoring and mitigating risks. Such procedures are commonly applied in the pharmaceutical industry [7, 8]. They assume that the next stage of a project may not be started until the previous one has been reviewed in terms of its compliance with the quality targets established for this phase. Owing to in-process quality control the planned quality of project deliverables can be ensured and the entire process can be controlled. To be sure that such tasks are performed in a reliable manner Quality Assurance staff and production workers need to be given autonomy (independence). Such an approach tends to be adopted in the construction business [9]. It is part of a total quality control system and it is used especially in cases when no faulty component may be allowed to appear throughout the process. Although it is impossible to expect any construction process to run without any possible faults, quality may be significantly boosted and potential risks can be considerably limited and prevented from occurrence [10, 11].

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