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Statistical Criteria and Methodologies Used for Assessing the Technical Condition of Urban Gas Distribution Networks

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Abstract: ***This paper lists a number of ways of assessing the urban gas distribution networks, the main purpose of evaluating the networks being that the licensed distribution operator would have a clearer understanding of the weak points in the system.***

Keywords: network, defects, corrosion, natural gas, assessment

1. Introduction

The paper analyzes the way of assessing the urban gas distribution networks. In general, the purpose of network assessment is that the licensed distribution operator should be aware of the weaknesses of the system, thus being able to take the necessary measures for the proper management and exploitation of the gas sectors.

2. Measures to Improve System Performance

As main measures for the improvement of the distribution systems, we mention two major categories of works:

- System remediation/maintenance;
- Upgrading/replacement of gas networks.

Taking into consideration these two categories, it is very important that the operator can decide which of the two directions to focus on; the transition from one category to the other is very subtle and we can describe it as follows:

If the amount of the modernization costs over a defined depreciation period (Cm), plus the maintenance of the newly accomplished system (Msn) and the obtained distribution rate (Td) is lower than the amount of the remediation costs (Cr) plus the maintenance required on an old network (Msv), the technological gas loss (Cpt), an almost exceeded lifespan (n), plus the costs generated by the eventual gas leakage events (Ce); then it is conclusive that it is profitable to go with the first option. [5]

$$Cm+Msn+Td<Cr+Msv+Cpt+n+Ce$$
$$\Rightarrow \text{upgrading /replacement of gas networks} \quad (1)$$

3. Analysis of the Condition of the Urban Gas Distribution Networks

Starting from these two possibilities, we further developed the first variant. Considering the premise that the distribution operator does not have all the details necessary for a proper analysis, we have defined the structure of a database that can provide him with the basic information. [1]

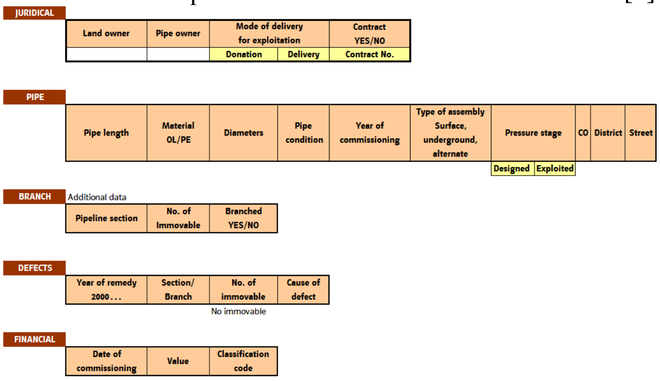

Figure 1: Data fields required for the statistics of a natural gas distribution network

We have called "statistics" the database obtained with this information. The information can be obtained in different ways:

- by importing it from multiple computer sources;
- by field measurements;
- by analyzing the documents provided by the operator.

However, this database is not sufficient without information on the operation of the respective networks; that is why we designed a model for the permanent collection and maintenance of data on gas sector interventions.

The purpose of these data is to highlight the type of defects and the cause of their occurrence and the technological gas losses generated by them.

Figure 2 shows the main data needed to support and update the information useful for the assessment of natural gas networks.

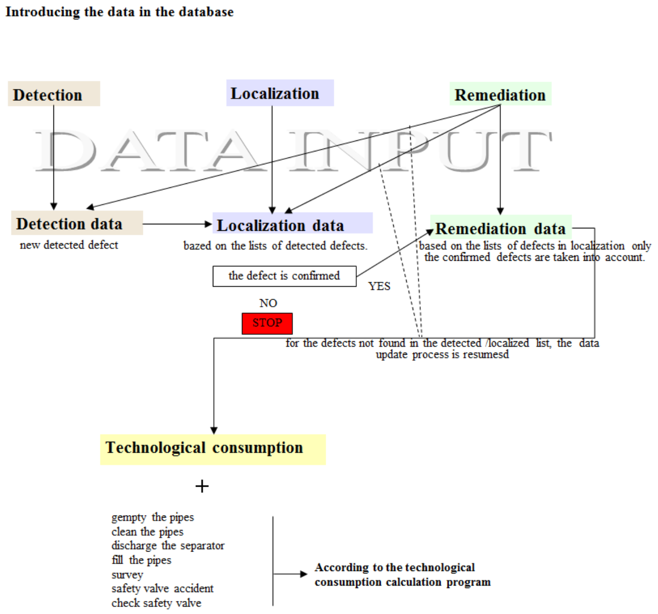

Figure 2: Entering data on interventions in the distribution system

Describing Figure 2, the flow of data input is as follows: when a defect is detected, its identification data are entered into the program, generating a new task for the locator; after locating the defect, operating the data in the system generates a new task for those who have defect correction responsibilities.

Based on the data on detecting, locating and repairing the defect, the technological consumption caused by gas leakages is calculated, depending on the operations carried out, the defect type and the remediation method.

By compiling this information, the overview of the state of the natural gas distribution networks is much more complex, and thus the information needed to maintain or modernize the network is more easily obtained.

Figure 3 thoroughly describes the way to interpret and introduce data into the system. [2]

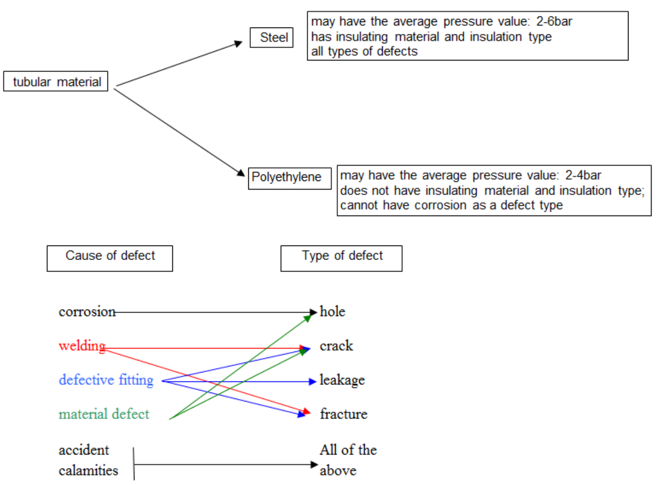

Figure 3: Interpreting the defects according to the type of the tubular material

- The cause of a hole type defect may be corrosion or a material defect;
- The cause of a crack may be improper welding, a faulty reinforcement or a material defect;
- A leakage defect can be generated by a defect in the fitting;
- The cause of a fracture may be an inadequate weld or a faulty fitting;
- In case of accidents or calamities, all types of defects can occur.

The classification of these criteria must also take into account the tubular material of the network where the defects occur, in the sense that, for example, corrosion defects can not occur on a polyethylene pipe.

By gathering all this information, we get information that lacks a single selection criterion that will result in the prioritization of the networks that need to be upgraded and the identification of those that can be further exploited; at the same time, this criterion is the separation by scoring the streets which pose the biggest problems in exploitation. Thus by pointing out the main factors that influence the exploitation of the network, we can get a hierarchy of what we are using and this is defined as evaluating a network.

Based on the results, the survey of a distribution network can be generated and initiated in addition to the direct decisions that can be made by the distribution system operator. [3]

Table 1: Criteria for determining and prioritizing defective networks

Criterion/Score		1		2		3		4		5		6
Ownership	EGR	1	OTHER	0								
Designed pressure	low pressure	2	reduced pressure	0	average pressure	1	high pressure	3				
Exploted pressure	low pressure	2	reduced pressure	0	average pressure	1	high pressure	3				
Material tubular	OL	1	PE	0								
Type of insulation	regular	2	reinforced	1	over reinforced	0						
Insulation condition	very good	4	good	3	relatively good	2	unsatisfactory	1	deteriorated	0		
Insulating material	asphalt board	3	bitumen	1	extruded polyethylene	0	paint	2	other	4		
Diameter	undersized network	1										
Type of pipe laying	U - underground	0	S - surface	1	US - alternate	2						
Improper laying	YES	1	NO	0								
Tubular material	OL	1	PE	0								
Type of soil	clayey (heavy)	1	sandy	0	rocky	2	petroliferous	5	saline	3	marshy	4
DC and AC currents existent in the area	DC-industrial area	1	DC -tram	2	AC -surface electrical networks	0	AC -electrified railway	3	cathodic protection for other networks	4	other negative influences	5
Cathodic protection	YES	0	NO	1								
Type of cathodic protection	current injection	0	sacrificial anodes	1	current injection through suction	2						
Corroboration of local authorities investment programs	YES	1	NO	0								
Type of defect detected on the network	corrosion	6	welding	4	defective fitting	3	material defect	5	accident	1	calamities	2

Taking these issues into account, generating such databases and constantly updating the information on the distribution systems that we manage, in addition to a much clearer picture and realistic statistics, we can think and process investment strategies that would provide beneficial programs that will bring an economic and technical boost to all utilities not only natural gas companies.

By putting together all this information, combined with geographic programs of the distribution networks, we can say that we have set up a system for managing the integrity of the natural gas distribution systems, based on an assessment of the technical analysis of the natural gas distribution networks. [2]

4. Expertise of Urban Gas Distribution Networks

Taking into account that the analysis of an urban gas distribution network is an action that is taken before a technical expertise in the context of the current paper, and that this action is the most complete and conclusive solution for assessing the condition of a distribution network, we will present a number of basic criteria necessary for conducting a technical expertise.

Supplementary to the information obtained from the technical analysis of the networks and from consulting the technical documentation, the network expertise involves two important steps in collecting the data specific to the networks subjected to the expertise:

a) Field measurements, following surveys on the network:
- The material and the condition of the pipe insulation;
- The assessment of the adhesion of the insulation to the pipe;
- The examination of the corrosion condition after removing the insulation on a length of approx. 500 mm, measuring the depth, the size, the relative position of the corrosion points;
- The examination of the welded joint, the assessment of the welding method, the measurement of the super-elevation and the width of the cord;
- The examination of the branch tee;
- The examination of the end of the protective tube;
- The examination of the vent hole;
- The examination of other metal structures in the control pit;
- The granulometric characterization of the sand or earth covering the pipe;
- The presence of stones and other rough bodies in contact with the pipe and the examination of the traces left on the insulation;

b) Measurements and determinations related to the technical and installation characteristics of the network:
- The measurement of the depth of pipe laying;
- The measurement of the insulation thickness in multiple points on the circumference;
- The identification of the insulation defects;
- The measurement of the outer diameter of the pipe;
- The ultrasonic measurement in 6 points of the thickness of the pipe wall;
- The measurement of the natural potential of the pipeline;
- The measurement of the on and off potentials noting the depolarization values for at least 3 minutes after stopping the cathodic protection station, where appropriate;
- Highlighting the dispersion streams received by the pipeline;
- The measurement of the electrical conductivity of the soil covering the pipe;
- The measurement of the resistivity of the soil around the pipeline.

As it can be observed, these are important determinations with a great contribution to the decision making on the actions to be undertaken, that is why we consider the assessment of the natural gas distribution networks to be the most important and significant decision making factor regarding the modernization and/or the exploitation of the distribution systems.

As presented at the beginning of this chapter, the analysis and/or the assessment of the networks are basic elements that can lead to the following actions:
- The modernization of the networks through the application of the anti-corrosion protection;
- The replacement of the pipes with others of superior quality or different tubular material to ensure greater operational safety and longer life of the system;
- The preventive maintenance, a process that requires actions to be taken to ensure the proper exploitation and the elimination of the risk factors;
- The increased actions to detect the technical defects that can cause problems in exploitation and negative events;
- Safety programs that include and provide for additional measures to ensure that risks of a technical nature are eliminated; these may include the measures listed above. [6]

5. Observations and Conclusions

The paper presents a model of a database structure that can lead to and determine the modeling and the definition of an integrity management system for the natural gas distribution networks, aiming to support the exploitation of natural gas distribution networks and to generate strategies to upgrade them.

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Author Profile

Stefan Mihai Filip has had an extensive and important training in the natural gas field, studying at the Petroleum-Gas University of Ploieşti and "Lucian Blaga" University in Sibiu, being awarded the title of Bachelor of Science in Engineering in the Petroleum and Gas Engineering Department. He has a rich practical experience in the natural gas distribution systems, occupying the position of project manager within the Eon Romania Distribuţie SA company, coordinating important works in the field, which allowed him to gain important knowledge and to detect certain problems the company has been dealing with, and, by performing such works, to try to find solutions for them.