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Explosion of the gas pipeline in Sighet-Romania

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ABSTRACT: This article analyzes the effect of the gas pipeline explosion in Sighetul Marmației, city in maramures County, Romania. Through a numerical modeling and an analysis of the risk in operation.
Two explosions occurred on February 19, 2012, in a nightclub in the city, the first at 1 pm and the next at 10.30, the next day.
21 people were injured, one of whom died.
That is why in the present material it is wanted to present the ways of risk assessment, in order to reduce the environmental and human incidences.
The effects of the explosion and the risk in operation of the gas distribution network are presented.
The causes that led to this catastrophe are also presented.

KEYWORDS: pipeline, natural gas, distribution, risk assessment, explosion.

I. INTRODUCTION

The history of the introduction of gas in Sighetu Marmației began after 1990, when the mayor of Sighet, Mr. Bledea Ioan, wanted to bring gas from Ukraine.
The mayor's plan was to place a pipeline between Tece and provide for the diversion of a Ukrainian pipeline from Tece and then through Rakhiv to Sighetu Marmatiei.
But this project did not respond to Transgaz's policy of offering gas for distribution in the national transmission network (it does not ensure a security of the offer price, the pipes that offer gas from a single source being captive to the price offered by the supplier).
That is why Transgaz decided to build a 20-inch gas pipeline between Medieșu Aurit and Sighet.
The pipeline starts at the Medieșu Aurit measuring point, which is the end point of the Tekovo (UA) – Medieşu Aurit (RO) gas import-export pipeline with a diameter of 700 mm (28 inches) and a transport capacity of 4.0 billion m3 / year and a maximum pressure of 70 bar.
The pipeline was built in the period 2003-2004 on the Medieșu Aurit-Huta-Sighet route.
The gas distribution service in Sighet was won by Berg Sistem Gaz S.A.
The company was established in 2002 and on September 8, 2003, the company concluded with the Ministry of Economy the contract for the concession of natural gas distribution in Sighetu Marmației.
Berg Sistem Gaz S.A. "Has become the only natural gas distribution operator in the municipality of Sighetu Marmației".
The company has had a gas distribution license and license since 2006.
In the period 2003-2004, the activity of designing the gas network started, and at the beginning of 2005, the operation of installing the gas network in the municipality of Sighetu Marmației began.
On February 19, 2012, at 1.00 in a building in the center of the city, an explosion took place in a nightclub.
7 young women who were in the club's toilet were injured.
Even if the building was not connected to the gas network, on February 20, 2012, at 10.30 during the building's expertise, a second explosion took place, 10 people being injured.
Note that the gas was not turned off.
Following the technical expertise, it turned out that the gas network in the area had a defect, when the T-joint between the gas pipeline and the intersection where the building was located, a weld crack was discovered.
Surprisingly, the network was new and this accident should not have occurred, or even if it did, the section should be isolatedimmediately.

The building in Sighet where the explosion took place [1]

The building in Sighet where the explosion took place [1]

Chemical composition of natural gas [3]

Zăcământul de gaze	% volum						
	CH_4	C_2H_6	C_3H_8	C_4H_{10}	CO_2	N_2	He
Sărmăşel (Rom)	99,2	-	-	-	0,1	0,6	-
Arkansas (USA)	96,7	-	-	-	1,0	2,3	0,01
Alberta (Canada)	97,8	0,3	-	-	0,4	-	-
Groznâi (Russia)	57,6	16,8	15,0	10,5	0,4	-	-
Baku (Azerbaidjan)	77,5	2,0	1,3	-	18,2	0,8	-
Kansas (USA)	10,5	1,6	-	-	-	87,7	2,1
Băile Odorhei (Rom)	21,9	-	-	-	1,6	76,2	-
Colorado (USA)	-	-	-	-	14,7	74,7	8,6

II. RISK ASSESSMENT IN THE OPERATION OF GAS NETWORKS

The gas network in Sighet has a working pressure between 5 kPa and 400 Kpa, ie 0.05 and 0.4 atm.

Risk identification, assessment and control methodology

The methodology for identifying, assessing and controlling the risks in the gas distribution pipeline includes the following steps:

a. Identification of the system subject to risk analysis,
b. Establishing the level of risk acceptability,
c. Choice of working method and tools,
d. Hazards identification:
- the integrity of the system and its components,
-gas accumulations and exceeding the explosion limit,
-explosion, fire and release of a large amount of natural gas into the environment,
- ignition sources that can lead to the formation of the self-ignition temperature of the air / gas mixture released from the pipe,

e. Identifying the causes that can lead to the failure of the system:
- defects caused by time-dependent factors,
-defects due to stable factors,
-defects due to time-independent factors.

Operation risk assessment based on the analysis of accidents over a previous period of time - Accident rate

The accident rate is a component of the pipeline operation safety analysis.

The methodology used for the pipeline system is taken from the analysis of damage in nuclear installations (NUCLEAR REGULATORY COMISSION NUREG 0492).

In essence, the methodology anticipates the accident rate of a system based on the analysis of accidents over a previous period of time.

The probability of an accident is:

$$F = 1 - e^{-rt} \quad (1)$$

where:
- r-accident rate,
- t-exposure time,
- the natural e-logarithm.

The probability of an accident has a Poisson distribution, depending on the exposure period.
The accident rate is:

$$r = \frac{total\ accidents\ in\ time\ (years)}{100\ km\ x\ time\ (years)} \quad (2)$$

For a pipe of length L, the accident rate will be:

$$r' = r \cdot (\frac{L}{100}) \quad (3)$$

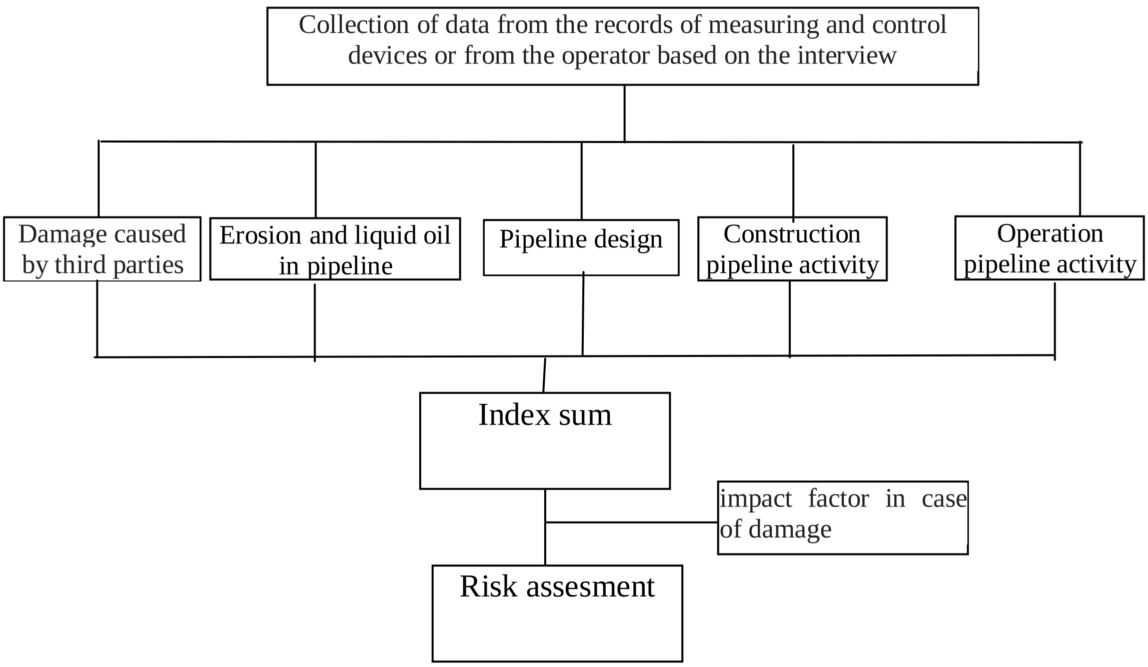
This method of analysis of accidents over a previous period of time cannot be used due to the fact that there were no damage to the pipeline before the accident.

Operational risk assessment based on the priority scheme

A risk assessment methodology was developed in 1987 by Dow Chemical [3].
This methodology starts from the premise of establishing a scheme of priorities regarding the preventive maintenance of the 14 locations that the company operates in different geographical areas. There are a finite number of ways in which a pipe can be damaged.
These "modes" of damage must be identified and classified.
The questions "what could go wrong" and "how likely the damage is" are answered by analyzing the system.

In this risk model, the causes of pipeline accidents can be grouped into four categories:
- damages of the third party.
-corrosion.
-design.
-incorrect operations.

Within each of these categories any possible element of risk is quantified.
That is why each element in the risk index is “a risk element” which is either an existing condition or an activity that is tangent to the risk.
The classifications are based on the amplitude of the contribution of the elements, either positive or negative to the risk picture.
Items that have a high risk tangent are classified as having a high risk factor.
For example, performing a hydrostatic test on a route segment has a higher risk factor than performing normal maintenance.
Of course, there are unforeseen events, for example where a low-risk activity prevents an accident that a high-risk activity did not take into account.
Classifications are somewhat subjective and can be improved if certain data become available.
However, even in the absence of this data, good results can be obtained based on the experience of the operators.



Assessment of the risk of a pipeline due to the effects of "Third party damage",

Nr.	*Name of elements analysis*	*Score*	*%*
1.	Depht of burial of pipelines	0-15	15
2.	Activity level of area	0-15	15
3.	Facility in area of pipelines	0-10	10
4.	Advertising regarding the location of the pipeline	0-10	10
5.	Educating the public on the tasks involved in the event of a breakdown	0-10	10
6.	Compliance with the installation conditions imposed by the standards in force	0-5	5
7.	Patrol frequency on the pipeline route	0-10	10
8.	Announcing the works of third companies in the pipeline area	0-10	10
9.	Informing the authorities of the presence of pipes in the area	0-5	5
10.	Granting excavation and location permits and verifying their observance	0-10	10

Assessment of the risk of a pipeline due to the effects of Erosion and liquid oil in pipeline

Nr.	*Name of elements analysis*	*Score*	*%*
1.	External erosion a.incorrect assembly operations b. incorect activity operation	 0-10 0-10	20
2.	Internal erosion a.the presence of contingent elements in natural gas b. quality control of natural gas	 0-10 0-10	20
3.	Oil liquids in natural gas	0-60	60

Assessment of the risk of a pipeline due to the effects pipeline design

Nr.	*Name of elements analysis*	*Score*	*%*
1.	Choosing the safety coefficient in operation of the pipeline	0-25	25
2.	Choosing the safety coefficient in operation of the pipeline equipment	0-25	25
3.	Providing for the possibility of a pipe failure	0-25	25
4.	Providing for the possibility of accidents of the nature of the site	0-25	25

Assessment of the risk of a pipeline due to the effects of construction pipeline activity

Nr.	*Name of elements analysis*	*Score*	*%*
1.	Inspection of activity	0-25	25
2.	Pipeline and pipeline equipment using in installation	0-25	25
3.	Used assembly equipment and machinery	0-25	25
4.	Training of employees and chefs of jobs	0-25	25

Assessment of the risk of a pipeline due to the effects of operation pipeline activity

Nr.	*Name of elements analysis*	*Score*	*%*
1.	Inspection of activity	0-25	25
2.	Pipeline and pipeline equipment inspection	0-25	25
3.	Used automation leak detection	0-25	25
4.	Training of employees and chefs of jobs	0-25	25

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Assessment of the risk of a pipeline in Sighet area

The nature of loads on the pipeline	The nature of accidents	The type of consequence of the accident	Probability	Gravity	Score	Risk residual
Accidental	Gas leaks from the pipe during its repair	The possibility of an explosion	Possible if the technological procedure is not followed	extremely serious because it can catch fire	0,40	The repair will be done following the working procedures
Strictly human	Failure to comply with the operating conditions of valves and compressors	The possibility of an explosion	Probably if the working procedures are not followed	Total disaster	0,60	The operation of the pipeline will be done only in compliance with the provisions of gas distribution
Naturals	The appearance of an earthquake leading to cracks in the pipe	The possibility of an explosion	unlikely	Total disaster	0,2	The repair will be done following the working procedures
Technology	Increased pressure above the allowable limit in natural gas distribution	Breaking the pipe	Possible if the measuring and control devices are not checked and the protection systems are not maintained	extremely serious because it can catch fire	0,40	Permanent verification of protection systems

E. Impact factor in case of damage:
a. Accidents caused by fluid in the pipe.
-acute 0-20 points,
-chronic 0-10 points.
b. Fluid dispersion in the populated area:
-loss or gaseous product losses 0-10,
-population density in the area 0-5.
As you can see, risk management does not necessarily mean cost management.
Smart spending is needed to reduce operational risk.
The final risk classification can have values between 150 (the case of a propylene pipe in a metropolis) or 1 points (the case of a low pressure gas pipe located in the area of a village).

This method of determining the risk based on the priority scheme is useful but has a high degree of subjectivity. for Sighet I got a score of 20 points.

Operational risk assessment based on the effects of accidents

For the accident in Sighet, it was taken into account that methane (99% percent) circulates through the pipeline.
Technical characteristics of the objective:
-Operating pressure 0.5 atm,
-Length 30 km,
-Diameter 20 inches,
Wall thickness 2 mm,

Specific local conditions:

-wind speed 10 km/h,

-ambient temperature 15°C,

-humidity 50%.

The effect of gas dispersion was analyzed by a fault with a diameter equal to the diameter of the pipe (pipe rupture).

Chemical methane number

-CAS Number: 74-82-8

-Molecular weight: 16.04 g/mol

-PAC(minor accident concentration)

-1: 65000 ppm

PAC (concentration of a major accident)

-2: 230000 ppm

PAC (fatal accident concentration)

-3: 400000 ppm

Burning point: -161.9 ° C

Vapor pressure to produce an explosion: less than 1 atm

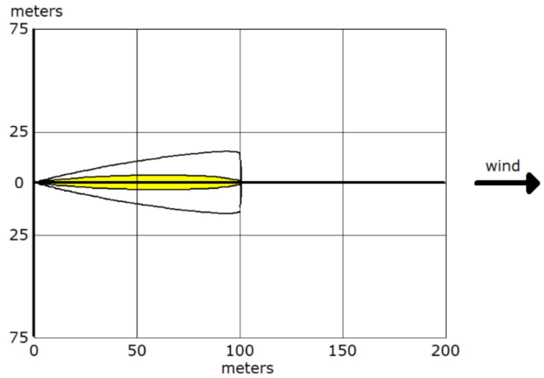
Methane discharge rate from the pipeline: 371 kilograms / min

The amount of gas emitted in an hour: 11,340 kilograms

Exhaust area:

red: 41 meters --- (30,000 ppm) -explosion zone

yellow: 101 meters --- (5000 ppm) dangerous area.



As can be seen, the explosion occurred due to the presence of the amount of gas in the area of the pipeline breaking less than 41 meters.

Risk assessment in operation by qualitative method

The basic formula for risk assessment is as follows:

$$RISK = SEVERITY \times PROBABILITY \quad (4)$$

For a municipal gas network we proposed about 8-10 conventional levels, both for gravity and for probability, located in value between 0 and 1:

For probability:

• safe event: 1

• impossible event: 0

Intermediate levels for probability:

•almost sure; 0.90

• very possible; 0.75

• probably; 0.60

• possible; 0.45

•plausible; 0.30

• unlikely. 0.15

For gravity:

• total disaster: 1

• imperceptible event: 0

Intermediate levels for severity:

• extremely serious; 0.90

•very bad; 0.75

• moderate; 0.60

• easy; 0.45

• weak; 0.30

• insignificant. 0.15

The causes that can cause accidents are:

a. natural, due to the external conditions of the environment:

• blows or pressure from deposited soil and stones or blows and erosion caused by winds and rains;

• stresses caused by variations in the external temperature of the air and water (expansions, contractions);

• tectonic (seismic) movements.

b. Accidental, due in large part to inappropriate activities:

-collision with equipment that made a wrong maneuver;

- serious damage to the pipeline (fire, explosion),

- accidentally placing a self-erecting platform with the feet on the pipe;

- carrying out unauthorized activities in the prohibited area.

c.technological causes, occurring both during installation and in subsequent operation:

• vibrations and pressure shocks;

• increased pressure above the safety limit;

• fatigue of the material at repeated demands, accumulated over time;

• failure or improper operation of the signaling, safety and protection systems of the pipeline;

• hidden defects that have escaped the non-destructive control made during installation;

• blows and deformations suffered by the installation during installation;

d. strictly human, involuntary or not, related to the actions of individuals or groups, starting from the design stage of the pipelines and going to the operating stage:

• informational and methodological limitations of design (eg the use of outdated standards),

construction and operation, given the complexity of the problems to be solved;
• human operating errors (lack or ignorance of operating instructions, incorrect maneuvers and procedures, inattention and / or negligence of service personnel, insufficient preparation for reporting and resolving emergencies, etc.)
• insufficient surveillance in space and time;
• knowingly violating certain rules and regulations, alcohol and drug use, stress, fatigue, etc.

III. CONCLUSION

The accident in Sighet was due to the violation of working procedures.
The first explosion was due to the lack of measuring devices to detect gas leaks.
The second explosion was also due to the desire of emergency services employees to quickly resolve the case and remove the effects of the damage.

The methodology for identifying, assessing and controlling the risks in the gas distribution pipeline includes the following steps:
a. Identification of the system subject to risk analysis,
b. Establishing the level of risk acceptability,
c. Choice of working method and tools,
d. Hazards identification,
e. Identifying the causes that can lead to the failure of the system.

Any gas distribution also has a risk in operation.
In the article we analyzed all the methods that exist on the market in risk assessment.

The method of analysis of accidents over a previous period of time cannot be used due to the fact that there were no damage to the pipeline before the accident.

The method of determining the risk based on the priority scheme is useful but has a high degree of subjectivity. for Sighet I got a score of 20 points.

The best assessment is given by determining the operational risk based on the effects of accidents.
in this case we have a risk of 0.4

Also the simulation of the gas leak for the accident in Sighet shows that the distance at which the explosion could have occurred was 41 m, so the damaged buildings (even if they did not have gas supply), were within range of the explosion.

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