

SZÁLLÍTÓ CSŐVEZETÉKEK TÖNKREMENTETELI MÓDJAI ÉS ANNAK KÖVETKEZMÉNYEI

FAILURE STATISTICS OF TRANSPORTING PIPELINES AND THEIR CONSEQUENCES

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ABSTRACT

The findings of the study of long-distance oil and gas pipeline failures are essential for the industry. They can be the basis for pipeline operators' risk analysis, integrity evaluation, and management improvement. Analysis and evaluation of Europe's statistical findings on pipeline failure rates, causes, effects, similarities, and discrepancies in pipeline management were used to define management's focal points and effectiveness. Suggestions on technologies and management for long-distance pipeline protection are proposed.

1. INTRODUCTION

When we talk about the transporting pipelines, it is essential to maintain high-pressure oil and gas pipeline systems safety because the products are dangerous. Perhaps, it will cause fire, explosion or poisoning and lead to substantial economic losses, casualties and environmental pollution. Pipeline operators collect and review the failure data and recognize the critical detection of pipeline risk, integrity evaluation, risk reduction and accident avoidance [1]-[3]. During this paper, the statistical results of European pipeline failures, causes, and consequences will be analysed. The similarity and the differences of pipeline managements will be studied, too.

2. EXAMPLES OF OCCURRED FAILURES

2.1. Pipeline Accident in California [4]

A pipeline owned and run by the Pacific Gas and Electric Company (PG&E) broke down in a residential area in California on September 9, 2010 (Figure 1). The ruptured section was installed with a 30-inch (0.762 m) diameter. A crater about 21.9456 m long by 7.9248 m wide was formed by the rupture. The ruptured pipe part, about 8.5344 m long and weighing about 3,000 pounds

(1360.777 kg), was located 30.48 m to the south of the crater.

PG&E has projected the release of 47.6 million standard cubic feet (1347881.8978 m³) of natural gas. The natural gas released ignited, leading to a fire that destroyed 38 homes and damaged 70. Eight people died, and dozens were wounded.



Figure 1. Pipeline Accident in California [4]

2.2. Pipeline Accident in West Virginia [5]

The 11th of December, 2012 a buried 20-inch-diameter (0.508 m) interstate pipeline, owned and operated by Columbia Gas Transmission Corporation (Columbia Gas), ruptured in West Virginia, a sparsely populated region (Figure 2). Just before the rupture, the pipeline was running at around 929 pounds per square inch (6.405e+6 pascal). The pipe was expelled from the underground pipeline by about 6.096 m and landed more than 12.192 m away.

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Figure 2. Pipeline Accident in West Virginia [5]

2.3. Pipeline Accident in New Mexico [6]

A 30-inch-diameter natural gas transmission pipeline owned by the El Paso Natural Gas Corporation broke down in New Mexico on Saturday, August 19, 2000 (Figure 3). It released the inflamed gas and burned it for 55 minutes. Twelve people who were camping under a concrete-decked steel bridge supporting the river pipeline were killed and their three vehicles were burned.



Figure 3. Pipeline Accident in New Mexico [6]

3. ANALYZING AND CONTRASTING

Failure statistical results of European Gas pipeline Incident data Group (EGIG) in Europe on long-distance pipeline failure frequencies, causes, and consequences are comparatively analysed the pipeline types that the analysis involves in our case Natural Gas [7].

The overall length of the EGIG gas pipeline will be 144,000 km until 2016. In order to show the safety performance of the European gas transmission network

to the general public and authorities, the goal of EGIG is to collect and present data on gas loss incidents.

The conditions required to be reported in the EGIG database for an incident are the following:

- An event could result in an accidental release of gas.
- The pipeline must meet the conditions set out below:
 - a. to be built of steel
 - b. being onshore,
 - c. have an operating maximum pressure greater than 15 bar,
 - d. to be placed outside the fences of the gas stations.

3.1. Failure Frequency

Figure 4 illustrates the decreasing failure frequencies per cause over the years, between 1974 and 2016. The decrease may be explained by technological developments, such as welding, inspection, condition monitoring using in-line inspection and improved procedures for damage prevention and detection. Improvements in the prevention of external interference incidents may be explained by more stringent enforcement of land use planning and the application of one-call systems for the digging activities of external parties. (Figure 4) In several countries, there is now a legal requirement to report digging activities. Companies have adopted appropriate actions, like supervision or marking of the pipeline in the direct neighbourhood of the digging activities.



Figure 4. Failure frequencies of different causes by EGIG [7]

To demonstrate failure frequencies over a more recent period (Table 1) in addition to the frequencies for the whole period, frequencies over a time span of the last 5, 10 and 20 years. As far as the cause external interference is concerned, its associated primary failure frequency over the five-year moving average has levelled off at around 0.03 per 1,000 km*yr.

Table 1. Primary failure frequencies of different causes by EGIG [7]

Cause	Primary failure frequency			
	1970-2016 per 1,000 km-yr	1997-2016 per 1,000 km-yr	2007-2016 per 1,000 km-yr	2012-2016 per 1,000 km-yr
External interference	0.144	0.064	0.043	0.032
Corrosion	0.052	0.034	0.037	0.027
Construction defect / Material failure	0.051	0.022	0.027	0.021
Hot tap made by error	0.014	0.006	0.006	0.003
Ground movement	0.026	0.023	0.022	0.031

Figure 5 and Figure 6 show the failure frequency per leak size and per-incident cause for period 1970-2016 and 2007-2016, respectively.

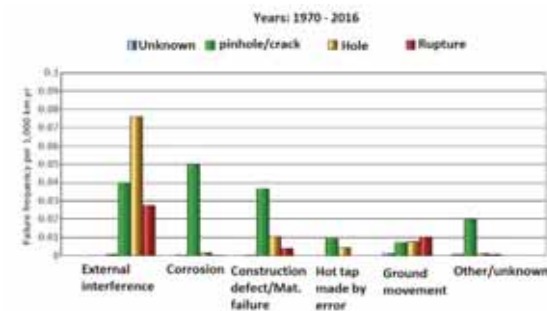


Figure 5. Relationship primary failure frequency, cause, and size of leak (1970-2016) [7]

Table 2. Failure frequency, cause and size of leak (2007-2016)

Leak size	Failure frequency per 1,000 km-year					
	External interference	Corrosion	Construction defect / Mat. Failure	Hot tap made by error	Ground movement	Other and unknown
Rupture	0.0058	0.0000	0.0022	0.0000	0.0065	0.0007
Hole	0.0195	0.0007	0.0014	0.0014	0.0079	0.0014
Pinhole/crack	0.0166	0.0353	0.0224	0.0043	0.0065	0.0123
Unknown	0.0007	0.0014	0.0007	0.0000	0.0014	0.0007

3.2. Failure Causes

External interference, corrosion, and design defects/material failure are the leading three causes of gas pipeline failures in EGIG.

In Figure 7 the incident distribution per cause over the last 10 years is given. Corrosion and external interference incidents occurred in about the same rate. However, corrosion incidents tend to have smaller leak sizes.

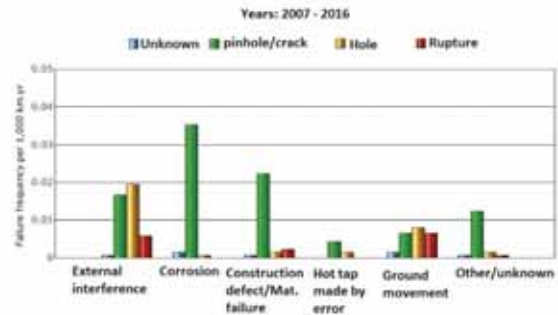


Figure 6. Relationship primary failure frequency, cause and size of leak (2007-2016) [7]

The data for the period 2007-2016 were summarized in Table 2. Although the failure frequency decreased over the years, the general trend in the distribution of the leak sizes remain the same: holes and ruptures were mainly caused by external interference. For pinhole/crack leak sizes, corrosion remains the main cause.

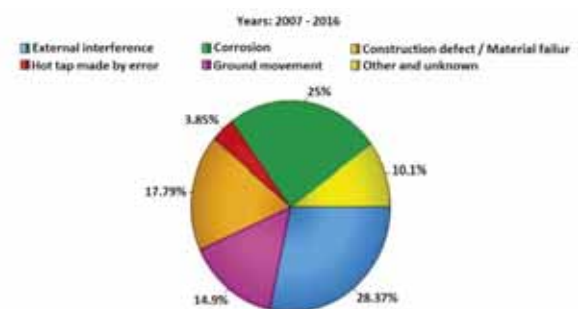


Figure 7. Failure causes by EGIG [7]

3.3. Failure Consequences

Figure 8 shows that gas releases from large diameter pipeline ruptures at high pressure have ignited more frequently than smaller diameter pipeline ruptures at lower pressure. This data is based on only a few ruptures. Care should be taken when using it as an ignition probability, as the uncertainty is high.

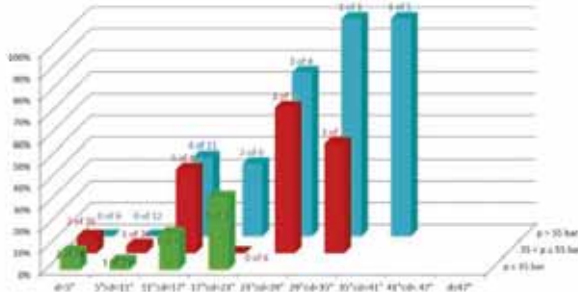


Figure 8. Percentages of ruptures that ignited subdivided in diameter and pressure (1970-2016) [7]

In the paper [8] an analysis is made of ignition probabilities. This paper shows that even ruptures of large diameter pipelines and high pressure not always ignite.

EGIG database also registers qualitative information about the consequences of incidents, amongst other injuries and fatalities that, unfortunately, occurred in some of them (Figure 9).

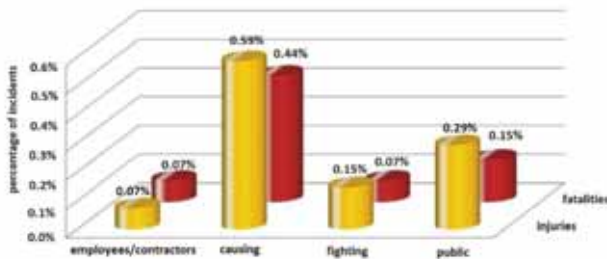


Figure 9. Percentage of accidents of groups involved in pipeline incidents (1970-2016) [7]

EGIG studied the injuries and fatalities among different groups involved in pipeline incidents. These groups are:

- employees or contractors of the transmission system operator.
- third party directly involved in causing the incidents (for example digger drivers in the case of external interference incidents);

- emergency services (firefighters, medical assistance);
- the general public.

4. CONCLUSIONS

This paper made based on information from the European Gas pipeline Incident data Group (EGIG) database, which is a valuable source of information on European gas pipelines and incidents.

In the EGIG database 1,366 pipeline incidents are recorded in the period from 1970-2016.

Reliable failure frequencies are provided by the history of incidents collected in the database. The average level of failures over the period 1970-2016 is equivalent to 0.31 accidents per 1,000 km per year.

External interference, corrosion, construction defects and ground movement have accounted for 28%, 25%, 18% and 15% of the pipeline incidents reported over the past ten years, respectively.

Failure data analysis is an important step for the failure prevention, and the improving of the pipeline integrity is a complex task.

5. REFERENCES

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