7th EGIG-report 1970-2007

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GAS PIPELINE INCIDENTS

7th Report of the *E*uropean *G*as Pipeline *I*ncident Data *G*roup

Comprising:

DGC (Denmark)
ENAGAS, S.A. (Spain)
Fluxys (Belgium)
Gasum Oy (Finland)
N.V. Nederlandse Gasunie (The Netherlands)
GRT Gaz (France)
E.ON Ruhrgas A.G. (Germany)
SNAM Rete Gas (Italy)
SWISSGAS (Switzerland)
National Grid (UK)
RWE Transgas Net (Czech Republic)
Ren Gasodutos S.A. (Portugal)
Swedegas A.B. (Sweden)
Bord Gais Eireann (Ireland)
OMV Gas GmbH (Austria)

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An annual update of key information can be found on the EGIG website.

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The EGIG encourages the reader, who would like specific information not available in the report, to make direct contact with the companies involved. Company addresses are available on the EGIG website.

CONTENT

FIGURES

TABLES

SUMMARY

In 1982 six European gas transmission system operators took the initiative to gather data on the unintentional releases of gas in their transmission pipeline systems. This cooperation was formalised by the setting up of EGIG (**E**uropean **G**as pipeline **I**ncident data **G**roup). Presently, EGIG is a cooperation of fifteen major gas transmission system operators in Europe and it is the owner of an extensive database of pipeline incident data collected since 1970.

The EGIG database is a valuable and reliable source of information that is used to help pipeline operators to demonstrate and improve the safety performance of Europe's gas transmission pipeline systems. It also provides a broad basis for statistical use.

Conclusions from the 7th EGIG report

- EGIG has maintained and expanded the European Gas pipeline incident database. Transmission companies of fifteen European countries now collect incident data on almost 130,000 km of pipelines every year. The total exposure, which expresses the length of a pipeline and its period of operation, is 3.15 million km.yr.
- The statistics of incidents collected in the database give reliable failure frequencies. The overall incident frequency is equal to 0.37 incidents per year per 1,000 km over the period 1970 to 2007.
- The 5 year moving average failure frequency, which represents the average incident frequency over the past 5 years, equals 0.14 incidents per year per 1,000 km. This frequency is almost 6 times lower than the one reported in the first years of the database (1970-1974).
- The failure frequencies have been reducing over the years, although the rate of reduction has slowed in recent years.
- The major cause of incidents remains external interference (50% of all incidents), followed by construction defects/material failures (16%) and corrosion (15%). Over the past five years, 48% of all incidents were due to external interference. The relatively high contribution of external interference emphasises its importance to pipeline operators and authorities.
- External interference incidents are characterised by potentially severe consequences (holes and ruptures).
- Early constructed pipelines had a higher failure frequency due to corrosion, in their early years, than recently constructed pipelines. In recent years, due to improved maintenance, pipeline age is no longer a major influence on the occurrence of corrosion failures.

1 INTRODUCTION

The use of pipelines for the transport of large quantities of natural gas to industry and to commercial and domestic consumers represents a safe and environmentally friendly mode of transport. The safety and the protection of the environment are constant objectives in the policies about construction, operation and maintenance of pipeline systems of the European natural gas industry.

In 1982 six European gas transmission system operators took the initiative to gather data on the unintentional releases of gas in their transmission pipelines systems. This cooperation was formalised by the setting up of EGIG (European Gas pipeline Incident data Group). The objective of this initiative was to provide a broad basis for the calculation of safety performances of pipeline systems in Europe, thus providing a more realistic picture of the frequencies and probabilities of incidents than would have been possible with the independent data of each company considered separately. EGIG is a cooperation of fifteen major gas transmission system operators in Europe and it is the owner of an extensive database of pipeline incident data collected since 1970. In the period between 2004 and 2007, three new major gas transmission companies have become EGIG members. The participating companies are now:

- DGC (Denmark)
- ENAGAS, S.A. (Spain)
- Fluxys (Belgium)
- Gasum Oy (Finland)
- N.V. Nederlandse Gasunie (The Netherlands)
- GRT Gaz (France)
- E.ON Ruhrgas A.G. (Germany)
- SNAM Rete Gas (Italy)
- SWISSGAS (Switzerland)
- National Grid (UK)[*]
- RWE Transgas Net (Czech Republic)
- Ren Gasodutos S.A. (Portugal)
- Swedegas A.B. (Sweden)
- Bord Gais Eireann (Ireland)
- OMV Gas GmbH (Austria)

Considering the number of participants, the extent of the pipeline systems and the exposure period involved (from 1970 onwards for most of the companies), the EGIG database is a valuable and reliable source of information. The regional differences, such as population density and geological conditions, are not taken into account, so that the results from the database present an average of all participating companies.

Uniform definitions have been used consistently over the entire period. Consequently, on condition that the data is correctly used and interpreted, the EGIG database gives useful information about trends which have developed over the years. Indeed, the EGIG report demonstrates the safety performance of the existing gas transmission pipeline systems in Europe and also provides a broad basis for statistical use. Nevertheless, particular care must be given to the use and interpretation of

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[*] Representing National Grid, Scotia Gas Networks, Wales and the West Utilities and Northern Gas Networks

the statistical data. The EGIG report gives, for example, the incident frequency per design parameter (diameter, pressure, wall thickness) but not per combination of design parameters.

This report will be presented during the 24th edition of the International Gas Union (IGU) World Gas Conference in 2009 in Argentina.

This report introduces the EGIG database and presents different analyses and their results. The results of the analyses are commented on and gives useful information that can be extracted from the database. Linking of results of different analyses takes place when possible. However, the reader who would like to combine different results should be careful before drawing conclusions.

International developments for pipeline databases

The International Gas Union (IGU) performed an investigation in which regional databases were compared with the aim to develop a world wide database. Many of these databases are collecting information on incidents but not on (detailed) pipeline system information. Also the definitions of incidents are different. To develop a world wide database from the individual databases more work has to be done in collecting system information and using a common incident definition.

2 EGIG DATABASE

2.1 Definition

The EGIG database contains information on pipelines and incidents. Pipeline data and incident data of natural gas transmission pipelines are in the database from 1970.

2.2 Objective

The objective of the EGIG database is to collect and present data on unintentional loss of gas incidents so as to report on the safety performance of the European gas transmission pipelines and to provide a broad basis for statistical use.

2.3 Criteria

The required criteria for an incident to be recorded in the EGIG database are the following:

- The incident must lead to an unintentional gas release,

- The pipeline must fulfil the following conditions:

    - To be made of steel
    - To be onshore
    - To have a maximum operating pressure higher than 15 bar
    - To be located outside the fences of the gas installations

Note that in his report, the term maximum operating pressure is being used rather than design pressure to reflect current terminology.

Incidents on production lines or involving equipment or components (e.g. valve, compressor) are not recorded in the EGIG database.

2.4 Contents

The EGIG database contains general information about major European gas transmission pipeline systems as well as specific information about the incidents.

General pipeline system information is given per year on pipeline length categorised according to:

- Diameter
- Pressure
- Year of construction
- Type of coating
- Depth of cover
- Grade of material
- Wall thickness

Specific information about incidents comprises:

- The characteristics of the pipeline on which the incident happened, namely the general information listed above.
- The leak size:
    - Pinhole/crack: the diameter of the hole is smaller than or equal to 2 cm
    - Hole: the diameter of the hole is larger than 2 cm and smaller than or equal to the diameter of the pipe
    - Rupture: the diameter of the hole is larger than the pipeline diameter.
- The initial cause of the incident
    - External interference
    - Corrosion
    - Construction defect/material failure
    - Hot tap made by error
    - Ground movement
    - Other and unknown
- The occurrence (or non-occurrence) of ignition
- The consequences
- Information on the way the incident has been detected (e.g. contractor, landowner, patrol)
- A free text for extra information

Additional information is also given for the individual cause:

- External interference:
    - The activity having caused the incident (e.g. digging, piling, ground works)
    - The equipment involved in the incident (e.g. anchor, bulldozer, excavator, plough)
    - The installed protective measures (e.g. casing, sleeves)
- Corrosion:
    - The location (external, internal)
    - The corrosion type (galvanic, pitting, stress corrosion cracking "SCC")
- Construction defect/material failure:
    - The type of defect (construction or material)
    - The defect details (hard spot, lamination, material, field weld)
    - The pipeline type (straight, field bend, factory bend)
- Ground movement:
    - The type of ground movement (dike break, erosion, flood, landslide, mining, river).
- Other and unknown:
    - The sub-causes out of category such as design error, lightning, maintenance.

2.5 Limits

The EGIG database gives an overview of the average safety level of European gas transmission pipeline systems. It gives information on the distribution of incidents per pipeline design parameter (e.g. diameter, pressure, wall thickness) but does in general not offer the possibility of making correlation analyses. In other words, with the EGIG database it is possible to know the incident frequency of 42-inch pipelines or to know the incident frequency of pipelines with a wall thickness of 15 mm, but it is not possible to extract the incident frequency of the 42-inch pipelines with a wall thickness of 15 mm.

3 ANALYSES AND RESULTS

3.1 Definitions

The objective of statistical analysis is to interpret the information to draw conclusions from the sample or the population from which the sample is taken.

The statistical analyses about the safety level of the gas transmission pipeline systems are based on indicators, such as failure frequency and ignition probability.

The failure frequency is calculated by dividing the number of incidents by the exposure. The EGIG report presents two kinds of failure frequencies, the primary and the secondary. They refer to the notions of total and partial exposure respectively. These notions are defined below.

- Exposure is the length of a pipeline and its exposed duration covered in the database and is expressed in kilometres-years [km.yr]. Example: company A in the database has a constant length of transmission pipelines over 5 years of 1,000 km. Its exposure is then 5 times 1,000 km, so 5,000 km.yr.

- The total system exposure is the exposure as defined above, calculated for the complete system.

- The partial system exposures are the exposures calculated per design parameter, e.g. per diameter class or per depth of cover class.

In order to report safety performance over recent years, a 5-year moving average has been introduced. The 5-year moving average means that the calculations have been performed over the 5 previous years for the year being considered.

Two statistical terms are also used in this report, confidence interval and ageing analysis:

- A confidence interval gives an estimated range of values which is likely to include an unknown population parameter, the estimated range being calculated from a given set of sample data. In our case, the unknown population parameter is the overall failure frequency. Confidence intervals are usually calculated so that this confidence level is 95%. In other words, a confidence interval at 95% means that there is 95% probability that the real value (not the estimated one) of the failure frequency lies in this interval.
- Ageing is the process of growing old and showing the effects of increasing age. For EGIG purposes, an ageing analysis has been carried out in order to study the impact of the age of the pipelines on their failure frequencies. This analysis was made by comparing the failure frequencies of different pipeline age categories. In particular, the effect of age on corrosion is discussed more intensively in this report.

3.2 Trends of the European gas transmission system

Information presented on the trends of the European gas transmission system not only shows the evolution of the exposure but also key design parameters. This gives a picture of European gas transmission systems from 1970 up to the present.

3.2.1 Total length

The total length of European gas transmission pipeline systems in EGIG is constantly increasing. In 2007 the total length was 129,719 km against 122,168 km in 2004. The evolution of the total length of the system is shown in Figure 1 and is also given per category (diameter, pressure, etc.) in Figure 2 to 8.

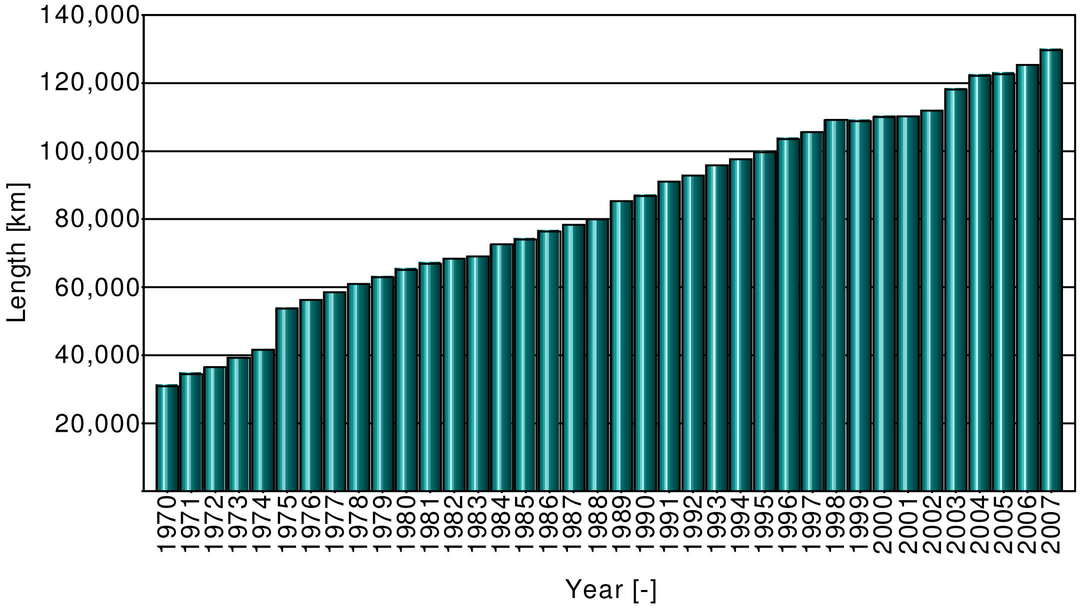

Figure 1: Total length of gas transmission pipeline systems in EGIG

Figure 1 shows the increase in length of gas transmission pipeline systems in EGIG, which has significant step changes in the years 1975, 1991, 1998, 2003 and 2007. These changes correspond to new members joining the EGIG. In fact the EGIG is now covering more than 50% of all natural gas transmission pipelines in Europe.

Figure 2 demonstrates that the 5-10 inch and 11-17 inch classes are still the most commonly used. However, the trend is to use more pipelines with a diameter larger than 17 inch.

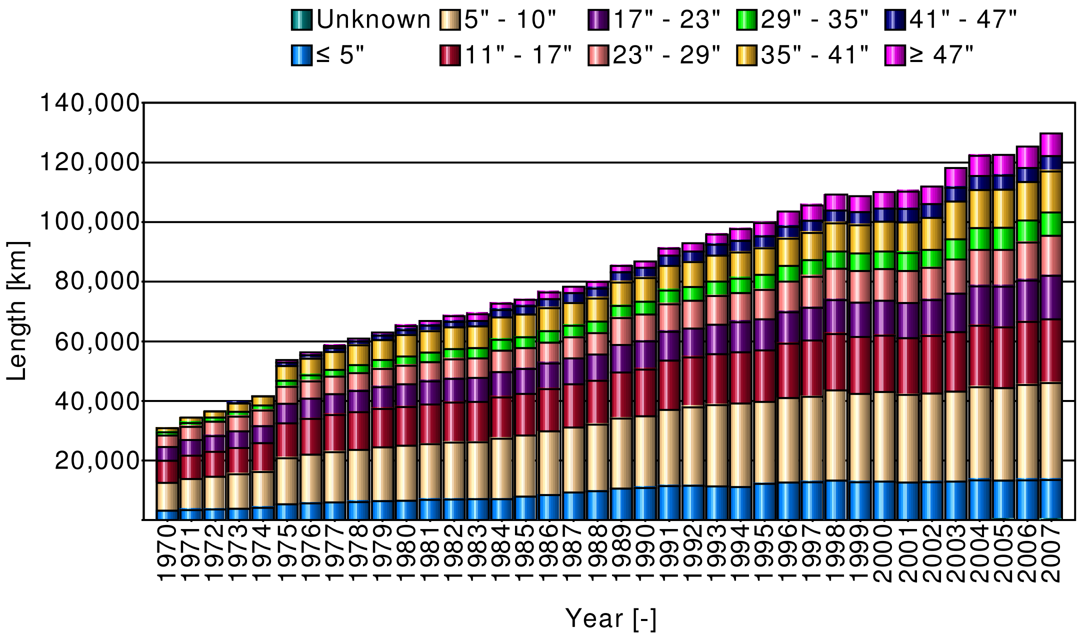

Figure 2: Total length per diameter class

Figure 3 shows that more pipelines were built in the period 1964-1973 than any other construction period class. No significant drop can be observed, which means that these pipelines are still in operation.
Small steps as can be seen in the line 1974 – 1983 in the year 1991, which are mostly caused by the introduction of new EGIG members.

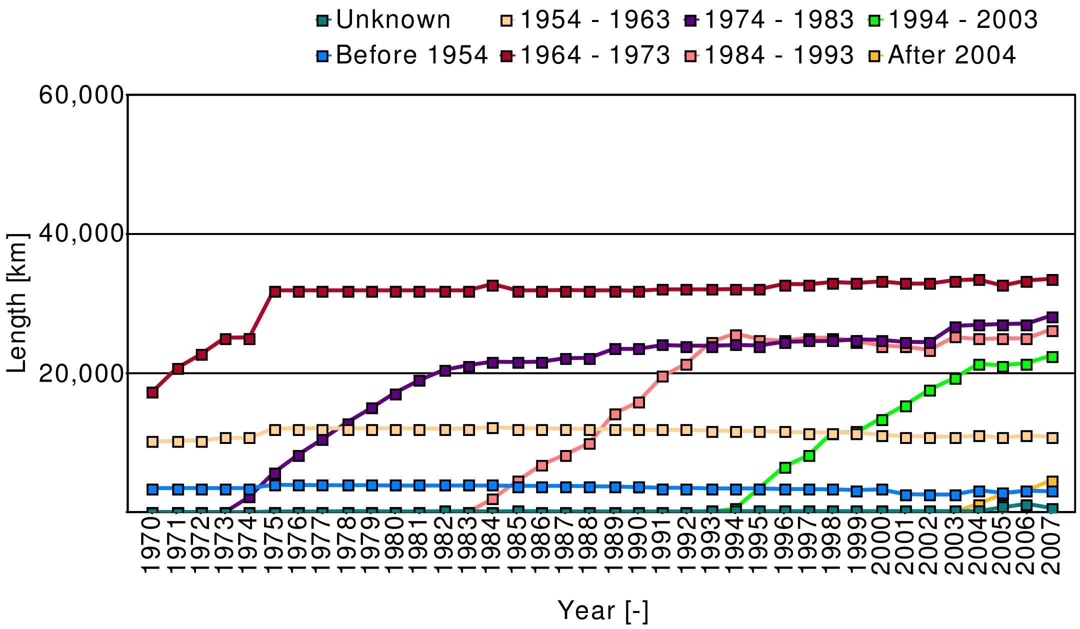

Figure 3: Total length per year of construction class

Figure 4 shows that coal tar, bitumen and polyethylene are nowadays the most commonly used coatings with a clear preference for the latter. From 2004 a drop of the pipeline systems with an unknown coating type can be observed. The reason for this is that pipeline operators are improving their data recording systems due to new technologies.

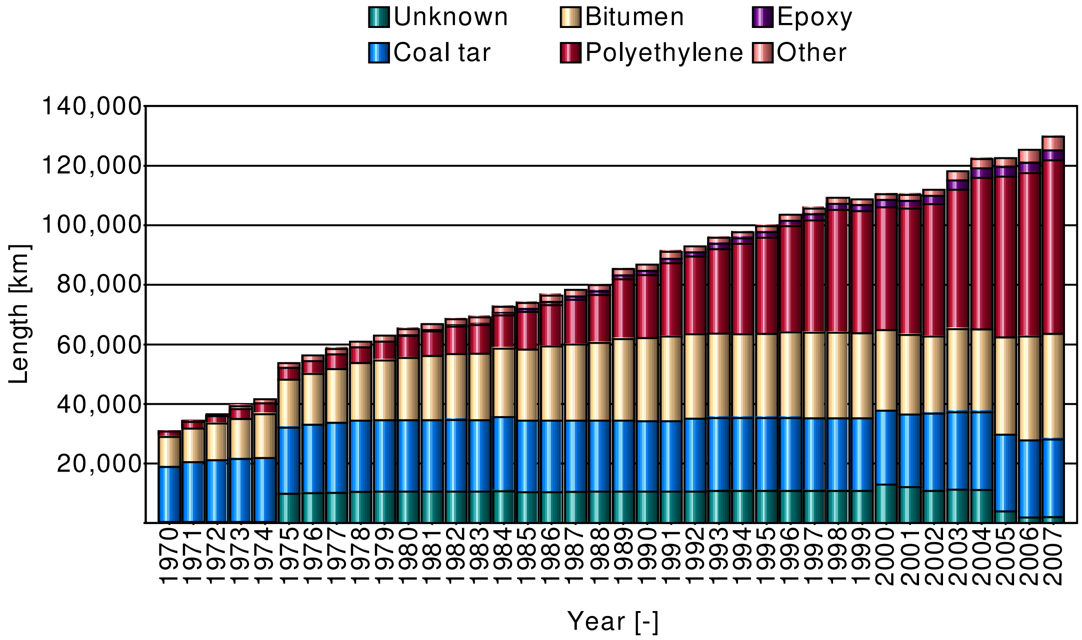

Figure 4: Total length per type of coating class

Figure 5 shows that generally older pipelines have a depth of cover less than 80 cm and that most of the new pipelines have a depth of cover greater than 80 cm. The trend is clear that most companies see depth of cover as an important line of defence against external interference. This can be seen from the increase of the pipeline length with a depth of cover larger than 1 meter.

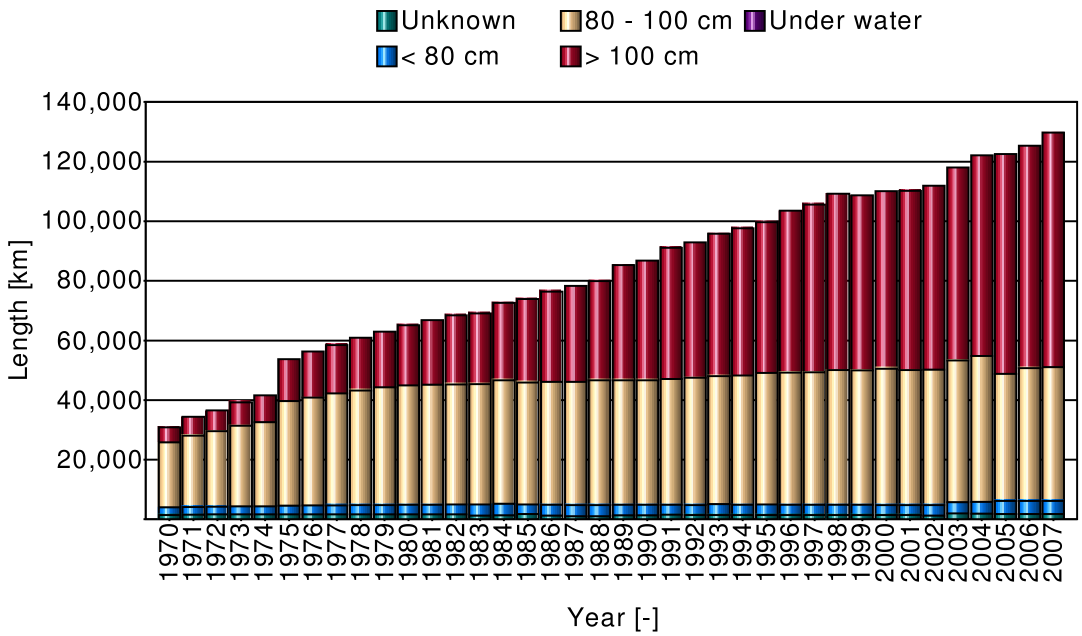

Figure 5: Total length per depth of cover class

Figure 6 shows that the most commonly used wall thicknesses are 5 to 10 mm. The Figure also shows an almost linear increase, with a proportional distribution of the wall thickness classes, except for the ≤ 5 mm class.

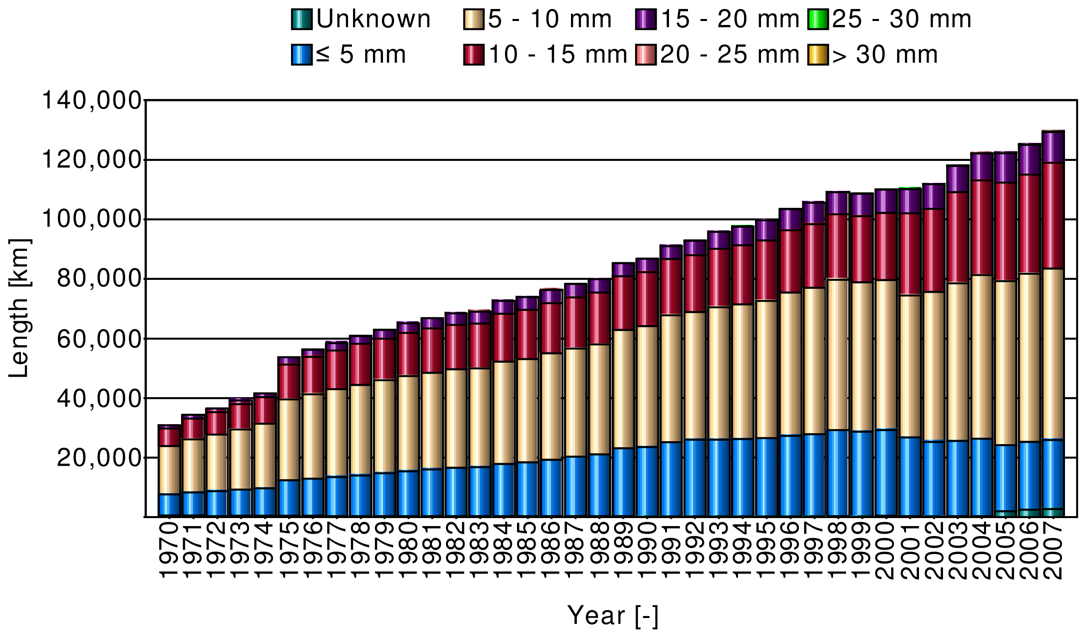

Figure 6: Total length per wall thickness class

Figure 7 demonstrates that three grades of material are predominant, namely grades B, X52 and X60. Together they represent approximately 65% of the total. There is a tendency to use higher grades of materials.

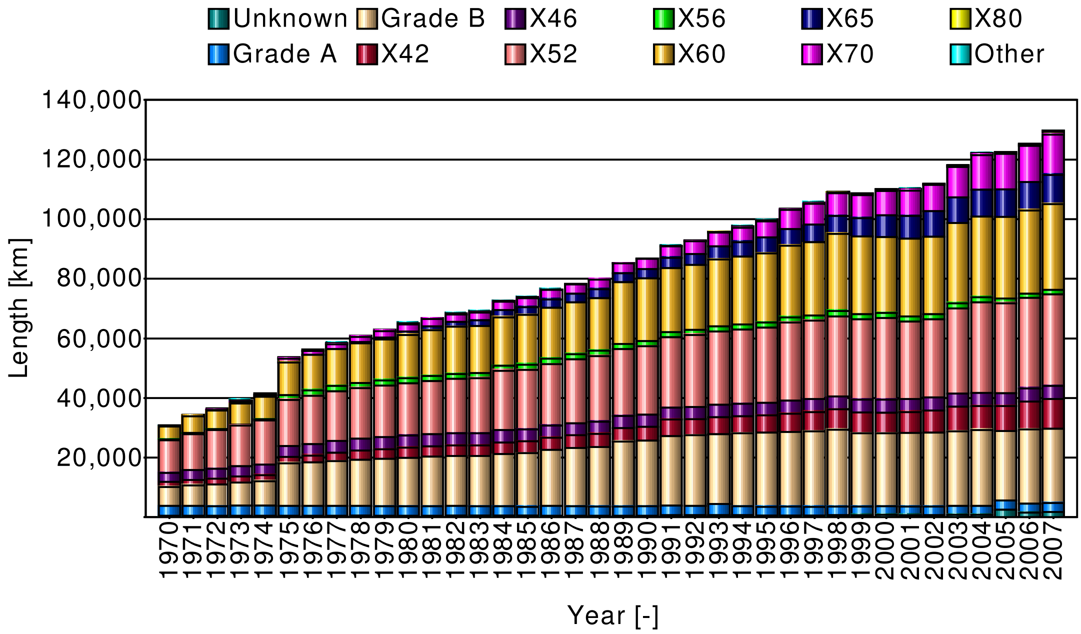

Figure 7: Total length per grade of material class

Figure 8 clearly shows a predominance of high pressure pipelines, with a trend to design pipelines at 66 bar and above.

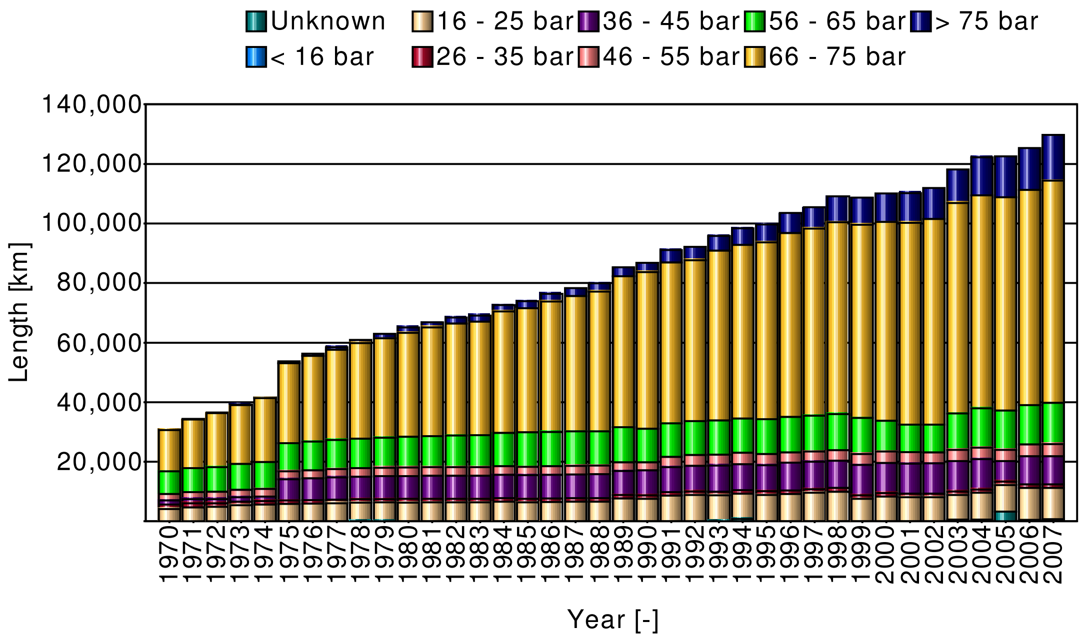

Figure 8: Total length per maximum operating pressure class

3.2.2 Exposure

Figure 9 shows the increase of the total system exposure expressed in kilometres-years [km.yr]. For the period 1970-2007, the total system exposure was 3.15 million km.yr. The increase is due to the year-to-year experience built up, the construction of new pipelines and the EGIG participation of new operators.

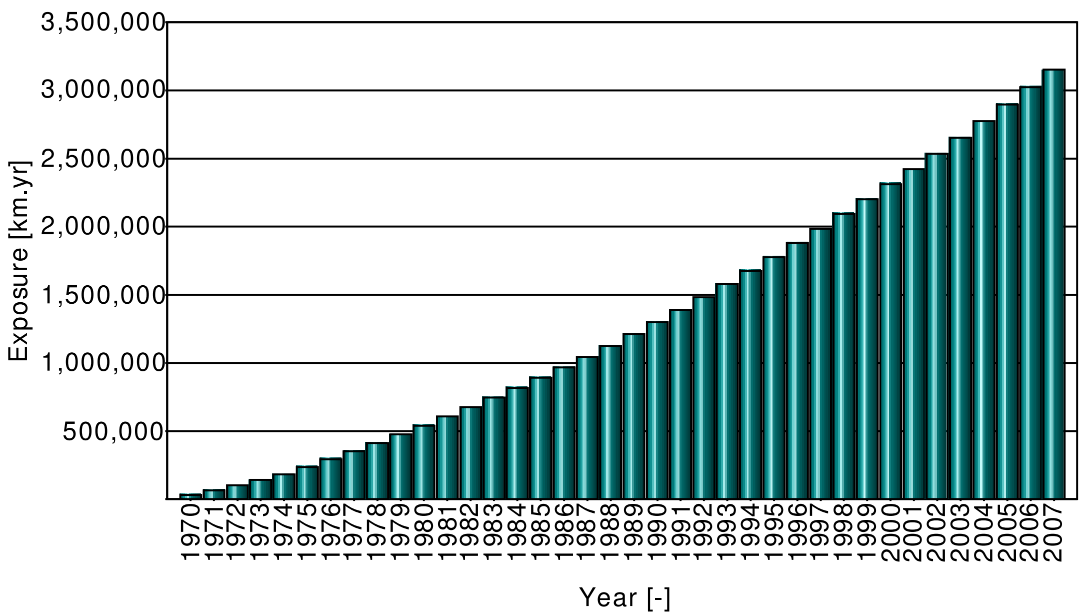

Figure 9: Evolution of the exposure

3.3 Failure frequencies analyses

The calculation of safety indicators, namely the primary and secondary failure frequencies refer to three notions: the total system exposure, the partial system exposure and the number of incidents.

3.3.1 Number of incidents

In the 6th EGIG report, which covers the period 1970-2004, a total of 1,123 incidents were recorded. In the last three years, 49 incidents were reported by the EGIG members, which brings the total number of incidents to 1,172 for the period 1970-2007. Figure 10 shows the number of incidents per year and Figure 11 the cumulative number of incidents.
Although more European companies are becoming EGIG members, it seems that the number of incidents is generally decreasing, although the pipeline system length is increasing.

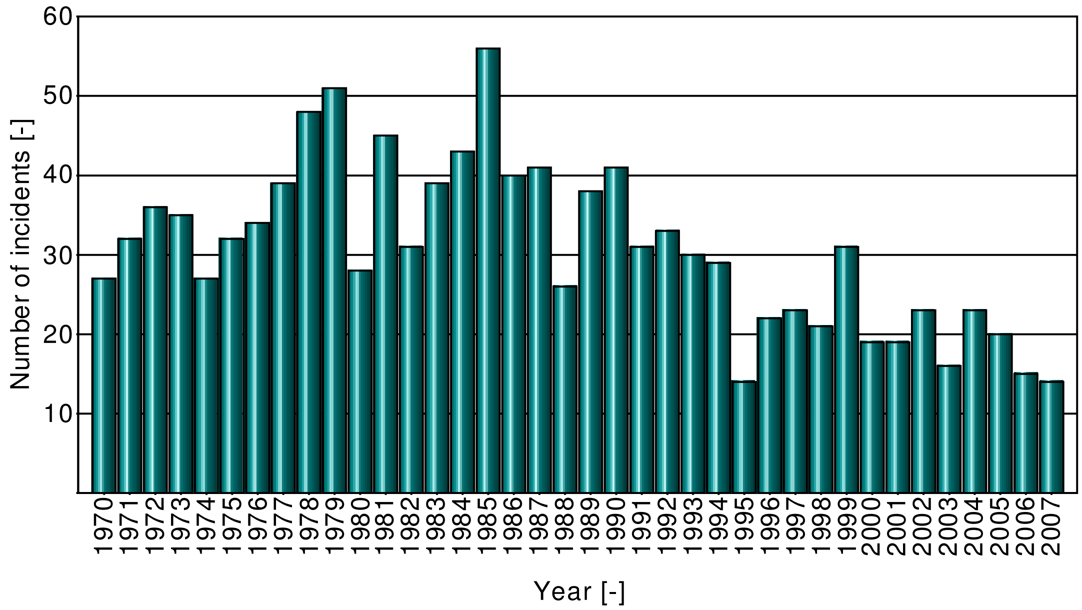

Figure 10: Annual number of incidents

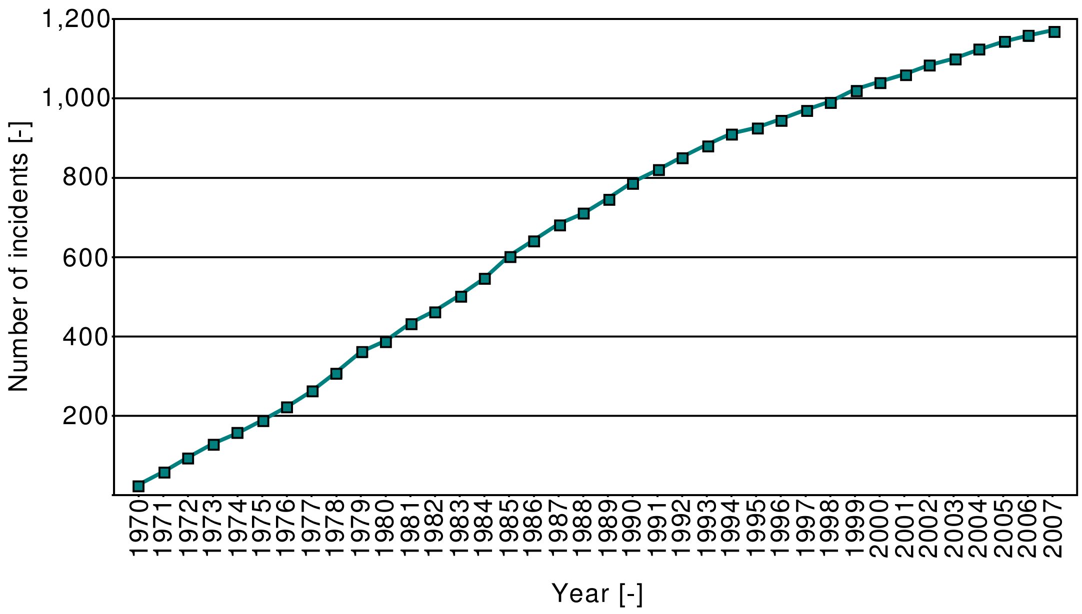

Figure 11: Cumulative number of incidents

3.3.2 Primary failure frequencies

The primary failure frequency is the result of the number of incidents (Figure 11) within a period divided by the corresponding total system exposure (Figure 9). Depending on the period studied, the number of incidents varies and so does the total system exposure.

EGIG has compared the primary failure frequencies of different periods, namely the total period (1970-2007), the period corresponding to the 6th EGIG report (1970-2004), the period of the last 5 years (2003-2007) and the final year.

The primary failure frequencies of these periods are given in Table 1.

Period	Number of incidents [-]	Total system exposure [km.yr]	Primary failure frequency [1000 km.yr]
1970-2007	1,172	$3.15.10^6$	0.37
1970-2004	1,123	$2.77.10^6$	0.40
2003-2007	88	$0.62.10^6$	0.14
2007	14	$0.13.10^6$	0.11

Table 1: Primary failure frequencies

An observation is that the primary failure frequency (0.37) over the entire period (1970-2007) is slightly lower than the failure frequency of 0.40 reported in the period of 1970-2004 (6th EGIG report).

The failure frequency over the past five years (0.14 for 2003-2007) is nearly one third of the primary failure frequency over the entire period showing the improved safety performance over recent years. Also, the primary failure frequency over the last year (0.11 for 2007) is slightly lower than the failure frequency of 0.14 calculated over the last 5 years (2003-2007).

Figure 12 and Figure 13 show the evolution of the primary failure frequencies over the entire period and for the last five years, as well as the confidence intervals at 95%.

Figure 12 illustrates the steady reduction of the overall average primary failure frequency and the 5 year moving average failure frequency. The primary failure frequency over the entire period declined from 0.87 incidents per 1,000 km.yr in 1970 to 0.37 incidents per 1,000 km.yr in 2007. The 5 year moving average primary failure frequency decreased by a factor of 6 (0.86 for the period 1970-1974 to 0.14 for the period 2003 - 2007).

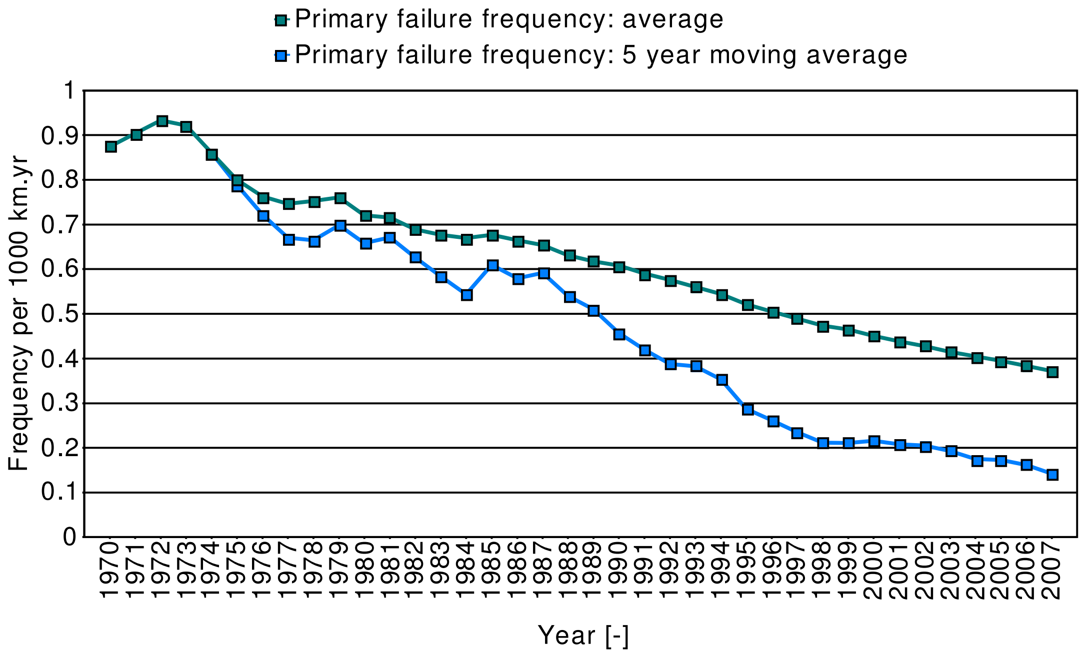

Figure 12: Evolution of the primary failure frequencies

Figure 13 shows the confidence intervals for the primary failure frequency.

Note

A confidence interval takes uncertainty into account. We see that the greater the exposure, the smaller the confidence interval - this means that the uncertainty decreases if the quantity of information increases. To calculate a confidence interval, the population is assumed to have a known distribution. The assumption is made that the distribution of the failure frequency follows Poisson's law.

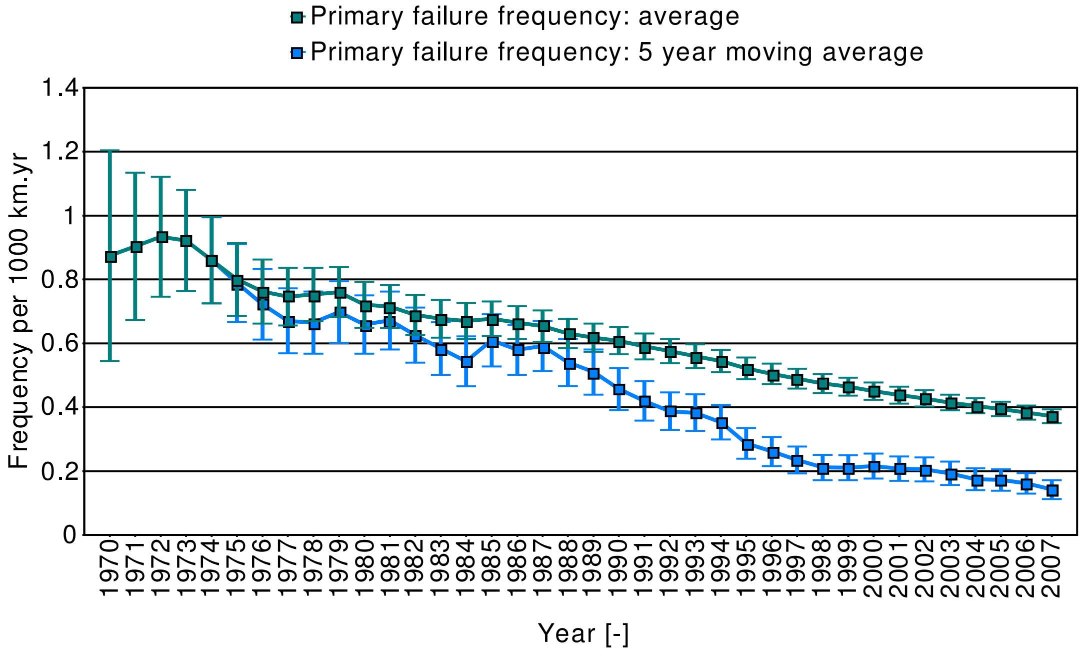

Figure 13: Primary failure frequencies and confidence intervals at 95%

In 2007, the primary failure frequency over the entire period was 0.37 incidents per 1,000 km.yr with a 95% confidence interval of ± 0.02. The primary failure frequency over the last five years, in 2007, was 0.14 incidents per 1,000 km.yr with a 95% confidence interval of ± 0.03.

Analysis of incident causes gives an insight to which causes effort should be focused. Incidents have been categorised into six different causes and are presented in Table 2.

Cause	Overall Percentage [%]
External interference	49.6
Construction defect / Material failure	16.5
Corrosion	15.4
Ground movement	7.3
Hot-tap made by error	4.6
Other and unknown	6.7

Table 2: Incident causes by percentage

External interference is still the major cause of all incidents on pipelines.

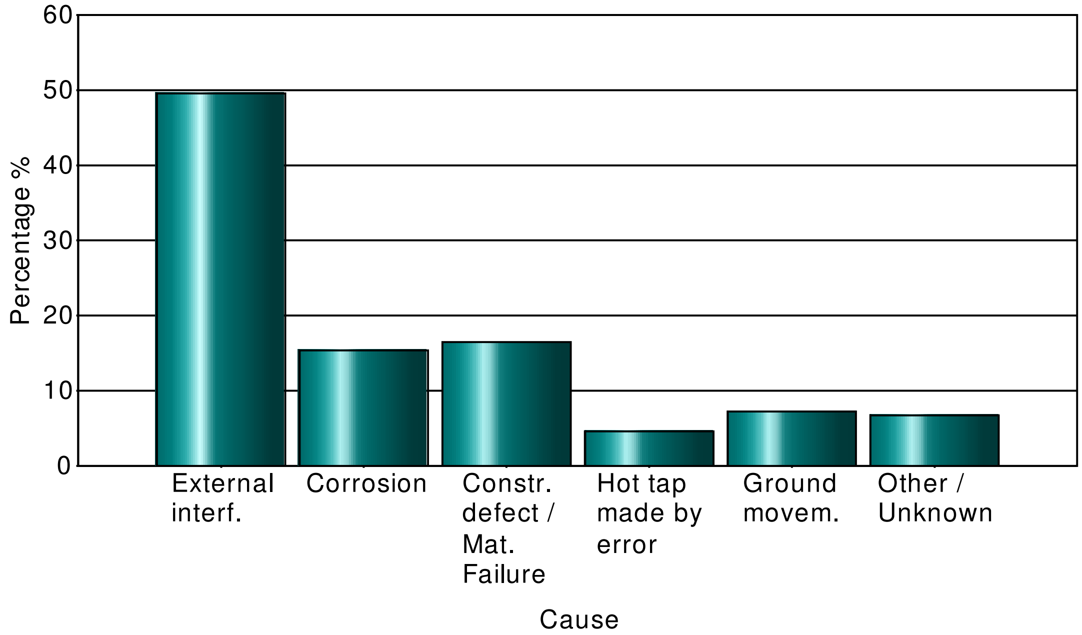

Figure 14: Distribution of incidents per cause

Figure 15 shows the primary failure frequencies per cause for the entire period.

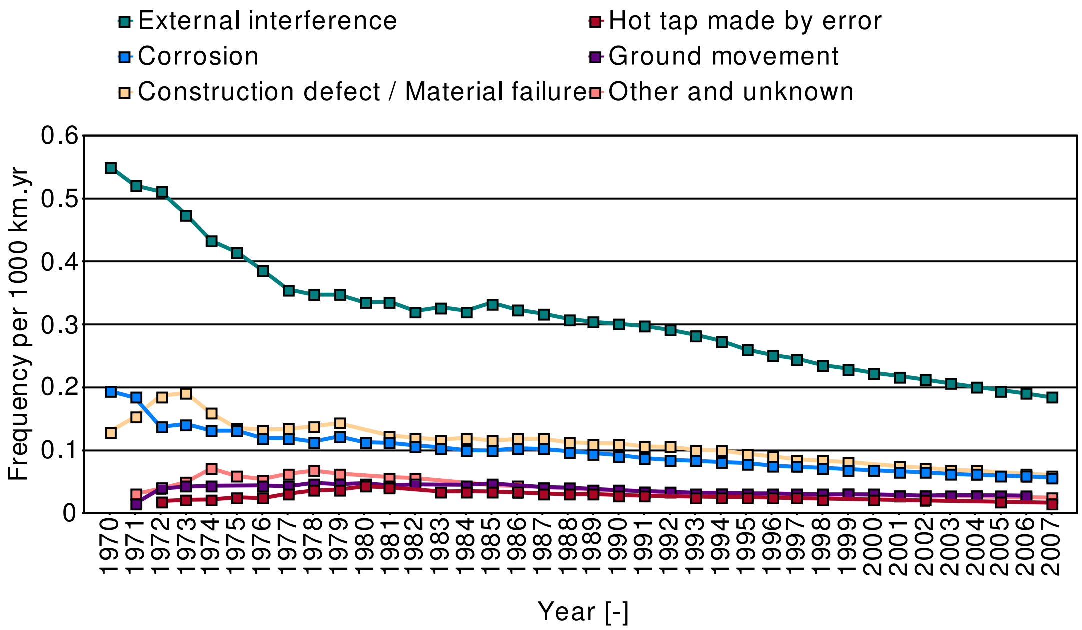

Figure 15: Primary failure frequencies per cause (up to the year)

Figure 16 shows the primary failure frequencies per cause for the 5 year moving average for each year.

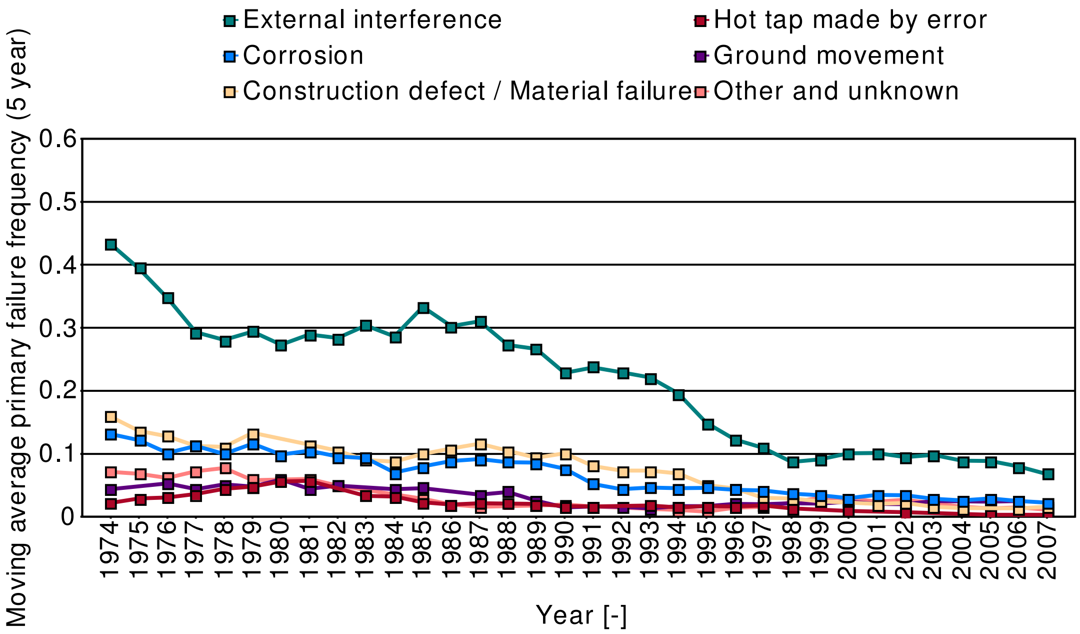

Figure 16: Primary failure frequencies per cause (5-year moving average)

Figure 15 and Figure 16 illustrate the reducing failure frequencies over the years. This has been due to technological developments, such as welding, inspection, condition monitoring using in-line inspection and improved procedures for damage prevention and detection.

As far as the cause of external interference is concerned, its associated primary failure frequency over the period 1970-2007 decreased to 0.18 incidents per 1,000 km.yr, while the 5-year moving average has generally levelled off at around 0.10 incidents per 1,000 km.yr since 1997. In recent years, external interference is only decreasing slowly. External interference remains the main cause of incidents, with 48% of incidents measured over the past 5 years.

Further improvements in the prevention of external interference could be obtained through a more stringent enforcement of land use planning, the application of one-call systems for the digging activities of external parties, safe working practices and information/education campaigns with landowners and contractors to raise awareness of the threat of external interference.

EGIG has analysed the relationship between the causes and the damage size. Figure 17 illustrates the link between the causes and the type of incident in terms of size of leak.

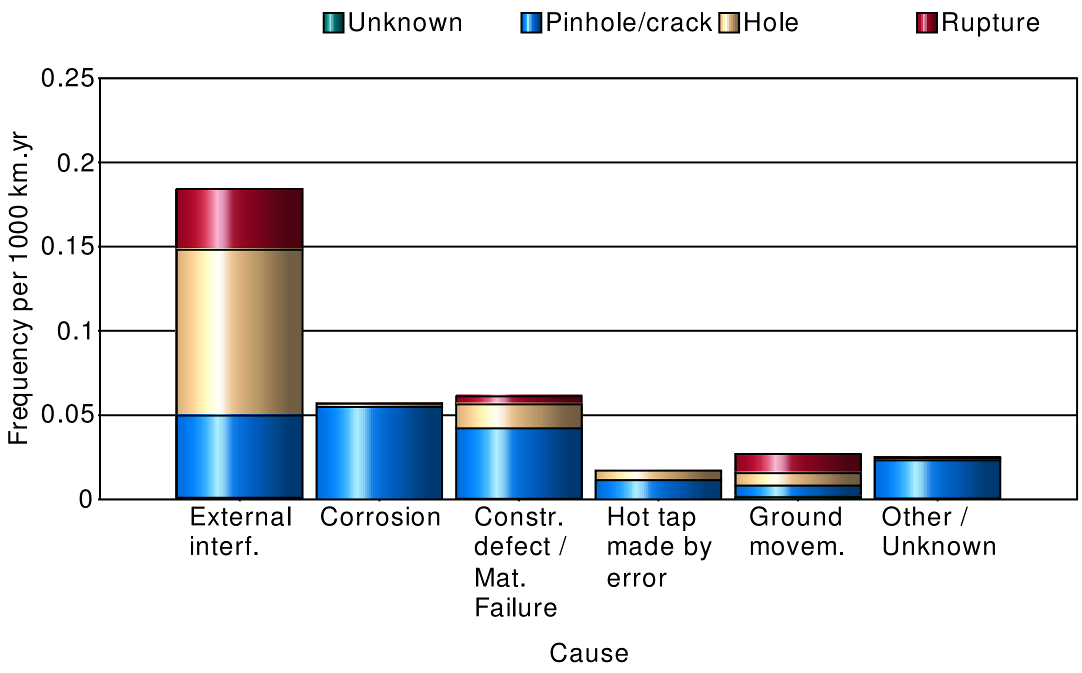

Figure 17: Relationship between cause and size of leak

Figure 17 shows external interference and ground movement are the causes most likely to cause ruptures.

In Table 3 an overview is given of the major activities causing incidents which are assigned to external interference incidents.

Activity	Percentage [%]
Digging	38
Ground works	9
Public works	9
Agriculture	9
Drainage works	8

Table 3: Activities causing external interference by percentage

3.3.3 Secondary failure frequencies

The secondary failure frequencies are calculated by dividing the number of incidents by a partial system exposure. Partial system exposure means, for example, the exposure related to one diameter class or one year of construction class.

The calculation of secondary failure frequencies are intended to demonstrate the influence of 'design parameters' (pressure, diameter, depth of cover, etc.) on the causes and consequences of the incidents.

The maintenance operational parameters (like in-line inspection, pipeline patrolling etc) will also influence the failure frequency. The data about these parameters are not collected in the database and thus their influence can not be estimated in this report.

For the six damage causes, the secondary failure frequencies have been calculated according to the following design parameters:

- External interference: the diameter of the pipeline, the depth of cover and the wall thickness.
- Corrosion: the year of construction, the type of coating and the wall thickness.
- Construction defect/material failure: the year of construction.
- Hot tap made by error: the diameter of the pipeline.
- Ground movement: the diameter of the pipeline.
- Other and unknown: main causes.

For ground movement and other or unknown causes, other more relevant considerations are reported.

3.3.3.1 Relationship between external interference, size of leak and design parameter

Figures 18 to 20 show the relationship between the consequences of the incidents caused by external interference and the diameter of the pipeline, the depth of cover and the wall thickness. Although the graphs are presented separately, it must be noticed that the design parameters are correlated, although no quantitative correlations between parameters have been studied.

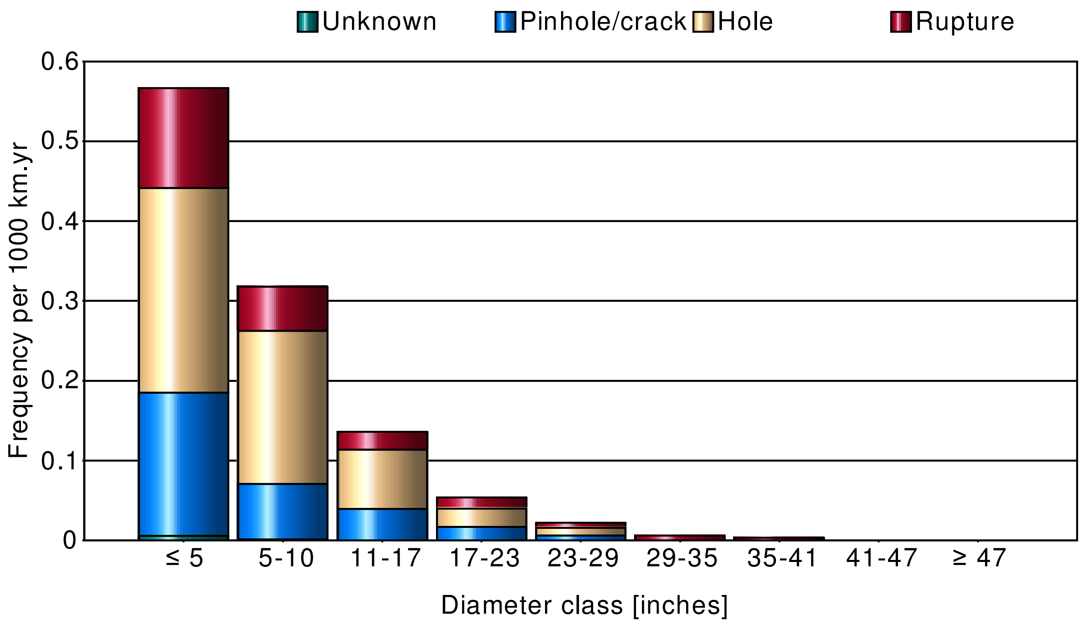

Figure 18: Relationship between external interference, size of leak and diameter class

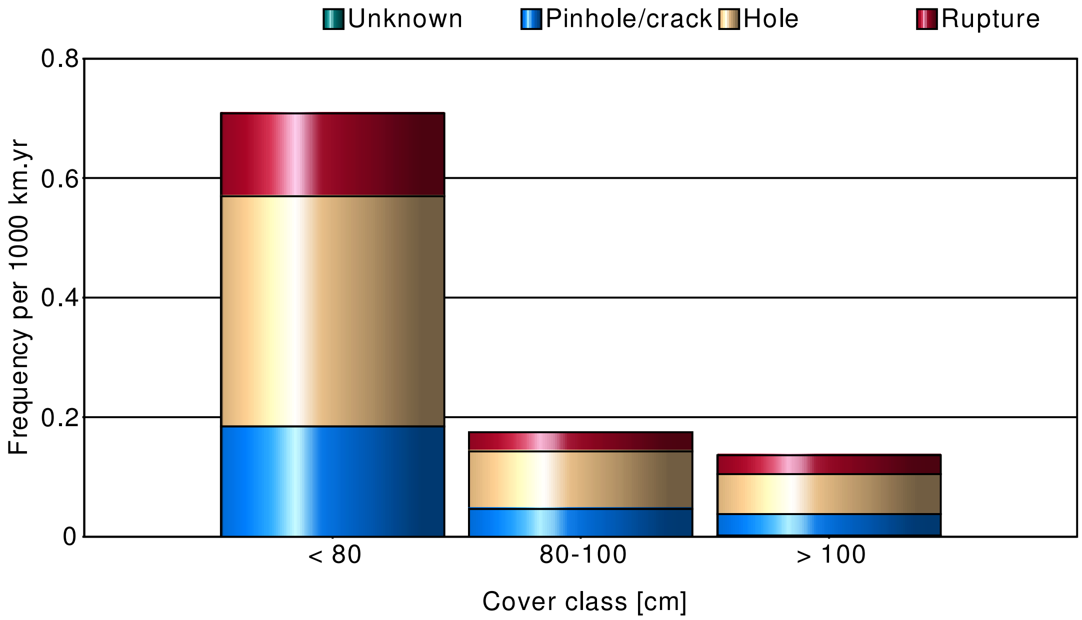

Figure 19: Relationship between external interference, size of leak and depth of cover class

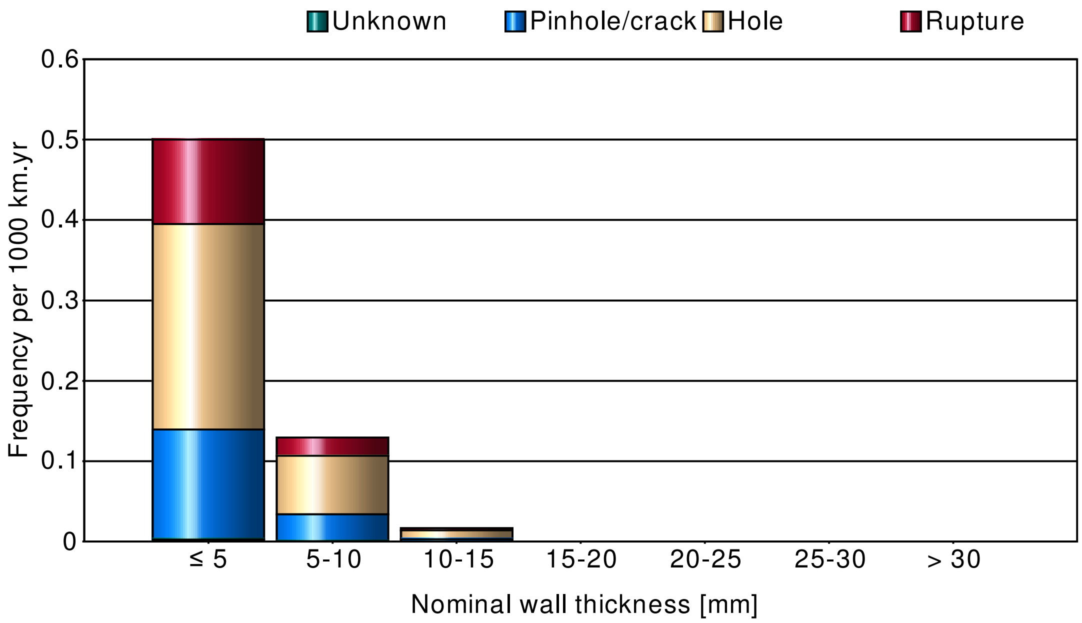

Figure 20: Relationship between external interference, size of leak and wall thickness class

From these figures, some general conclusions can be drawn. The first conclusion is that small diameter pipelines are more vulnerable to external interferences than larger diameter pipelines. This can be explained by the fact that small diameter pipelines can be more easily hooked up during ground works than larger pipelines. The second reason is that their resistance is often lower due to thinner wall thickness.

Figure 20 combined with Figure 6 confirms that the wall thickness classes of 0-5 mm and 5-10 mm are the most commonly used. It can also be seen that the exposure of the 5-10 mm wall thickness class is larger than the one of the 0-5 mm class. Nevertheless, the failure frequency of the 0-5 mm class is much higher than that of the 5-10 mm class, which demonstrates that a larger wall thickness is an effective protective measure against external interferences.

3.3.3.2 Relationship between corrosion, size of leak and design parameter

Figure 21 shows the relationship between the leak sizes of the incidents caused by corrosion, the year of construction of the pipeline, the type of coating and the wall thickness.

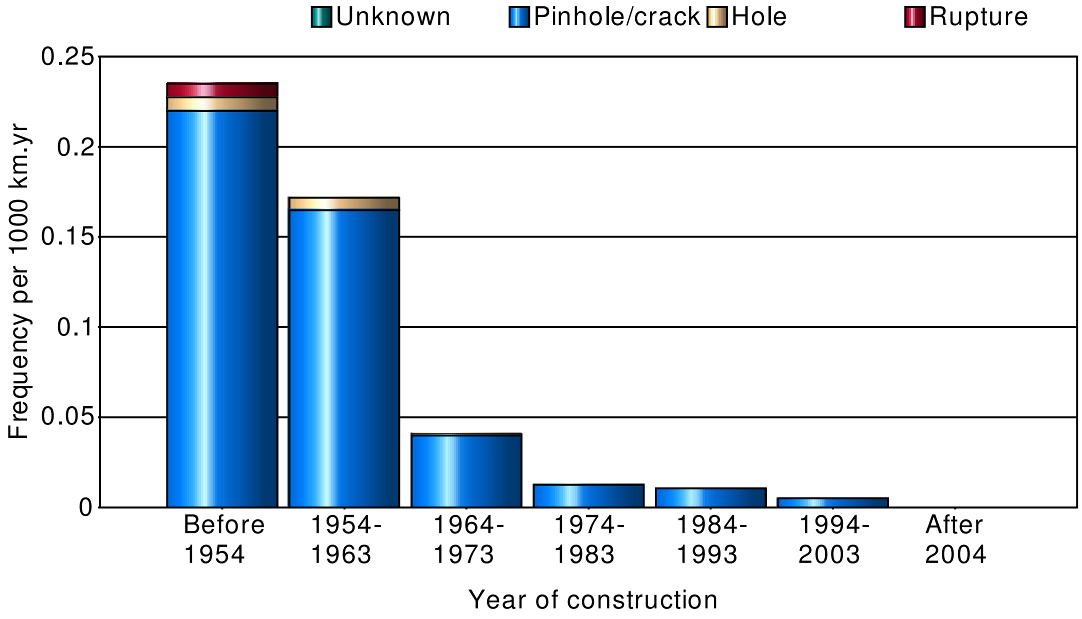

Figure 21: Relationship between corrosion, size of leak and year of construction

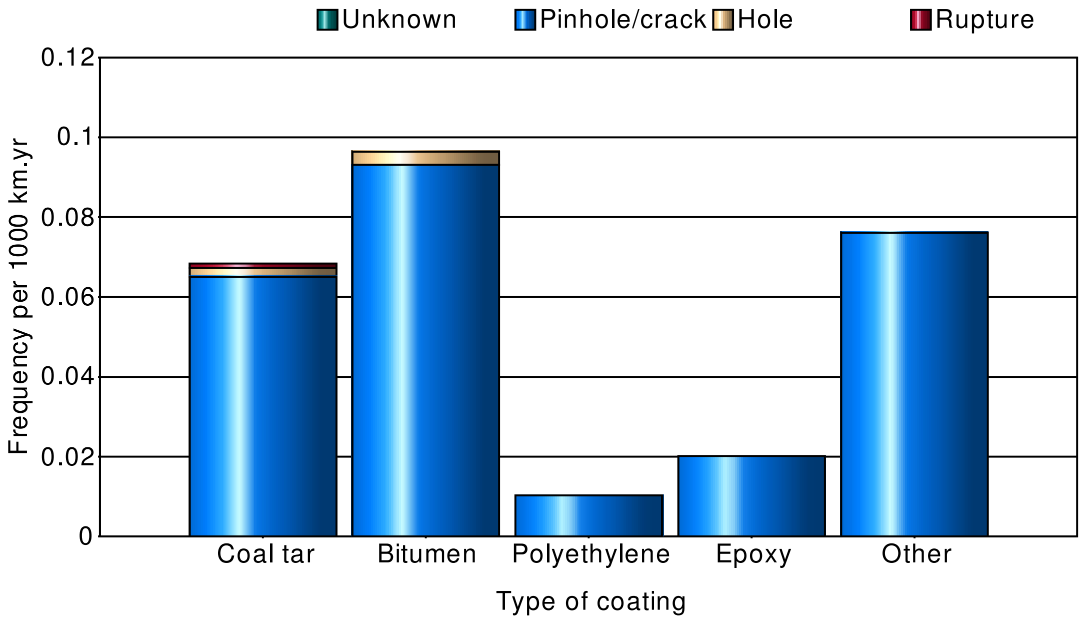

Figure 22: Relationship between corrosion, size of leak and type of coating

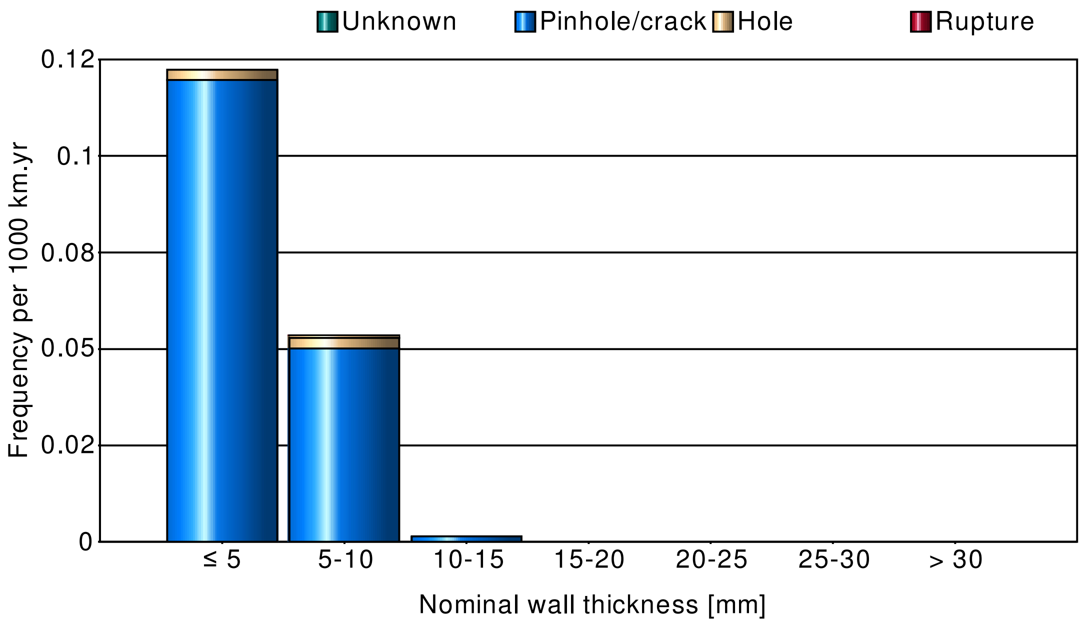

Figure 23: Relationship between corrosion, size of leak and wall thickness class

Corrosion has been identified as the third most common cause of incidents (15%). Study of Figure 21 to 23 show that corrosion often results in smaller leak sizes (pinholes and cracks), whereas very few holes were observed and only one rupture occurred on a pipeline, which was constructed before 1954. This rupture was caused by internal corrosion of a pipeline used for the transportation of coke oven gas.

Figure 21 illustrates the link between the year of construction of the pipelines and the failure frequencies, whereas Figure 22 shows the relation between the type of coating and the failure frequencies. From these figures, it can be concluded that the older pipelines and pipelines with bitumen and coal tar coatings have higher failure frequencies over the whole period covered by the database. The effect of ageing pipelines is covered in paragraph 3.4.

Corrosion is a phenomenon of deterioration of the pipelines. Corrosion takes place independently of the wall thickness, but the thinner the corroded pipeline wall, the sooner the pipeline fails, as Figure 23 illustrates. The failure point of a thinner pipeline is reached more quickly. Corrosion on thicker pipelines takes longer before causing an incident and therefore has more chance to be detected before failure. Protective measures are undertaken by pipeline owners to overcome the problem of corrosion, such as cathodic protection and pipeline coating. In line inspection enables corrosion to be detected at an early stage.

Three categories of corrosion have been considered by EGIG: external corrosion, internal corrosion and corrosion with an unknown cause. Up to 2007, they represented 81%, 15% and 4% respectively of all incidents due to corrosion.

68% of the cases of external corrosion are due to pitting. Galvanic corrosion and unknown causes represents respectively 12% and 15% of the external corrosion incidents, whereas stress corrosion cracking was responsible for only 5%.

3.3.3.3 Relationship between construction defect/material failure, size of leak and year of construction class

Figure 24 shows that the older pipelines have higher failure frequencies (due to construction defect/material failures). Technological improvements are thought to have resulted in reduced construction defect/material failures.

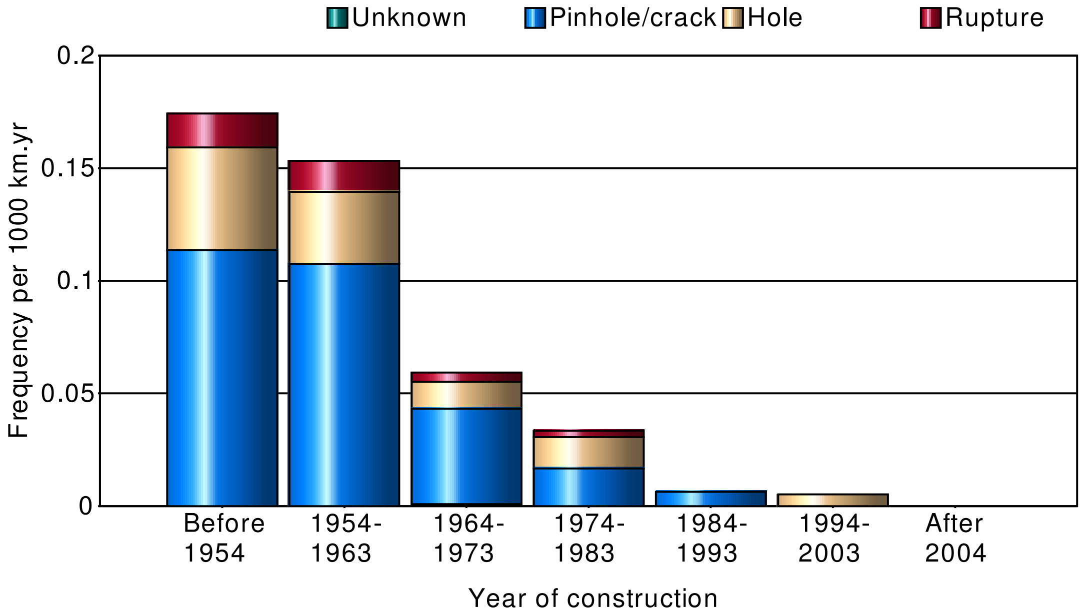

Figure 24: Relationship between construction defect/material failure, size of leak and year of construction class

3.3.3.4 Relationship between hot tap made by error, size of leak and diameter class

The term "hot tap made by error" means that a connection has been made by error to a high pressure gas transmission pipeline, which has been incorrectly identified as another pipeline. Figure 25 presents the failure frequencies, which shows that this kind of error can lead not only to small sizes of leak (pinholes), but also to large sizes of leak (holes), especially with very small diameter pipelines.

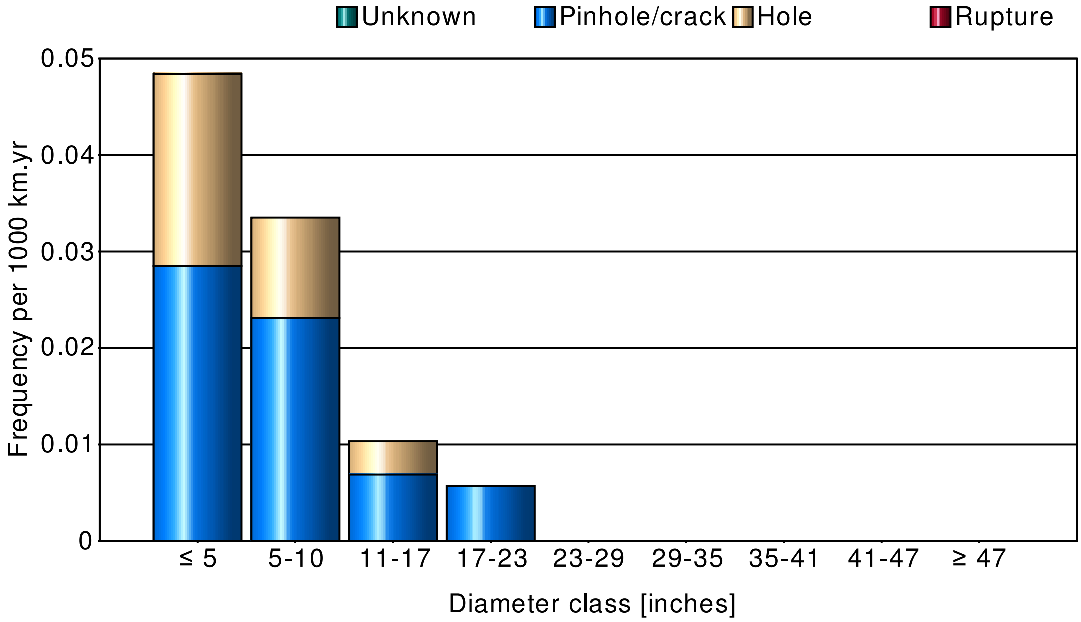

Figure 25: Relationship between hot tap made by error, size of leak and diameter class

3.3.3.5 Ground movement

Ground movement is responsible for 7% of the total incidents in the database.
Figure 26 shows the relationship between ground movement, size of leak and diameter class. Ground movement incidents causes the larger leak sizes, and also shows that smaller diameters are more vulnerable for ground movement than larger diameters. Ground movement related incidents are mainly due to the specific geotechnical conditions in Europe.

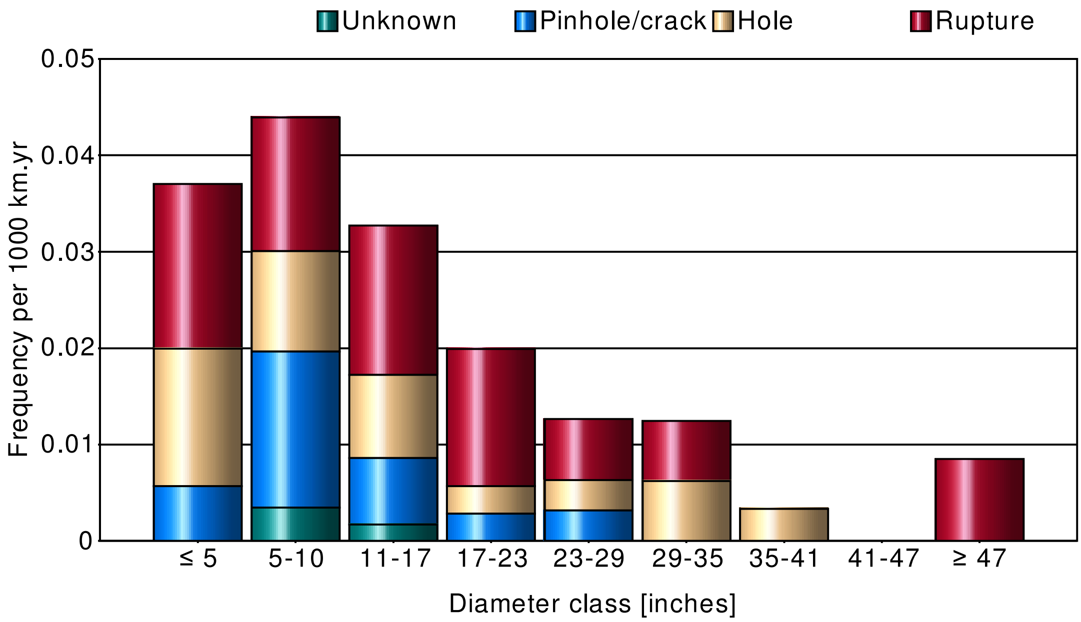

Figure 26: Relationship between ground movement, size of leak and diameter class

Analysing the information recorded about this incident category, it is possible to point out some important elements considering the sub-causes of "Ground Movement".
Eight different sub-causes of ground movement have been identified and are shown in Figure 27.

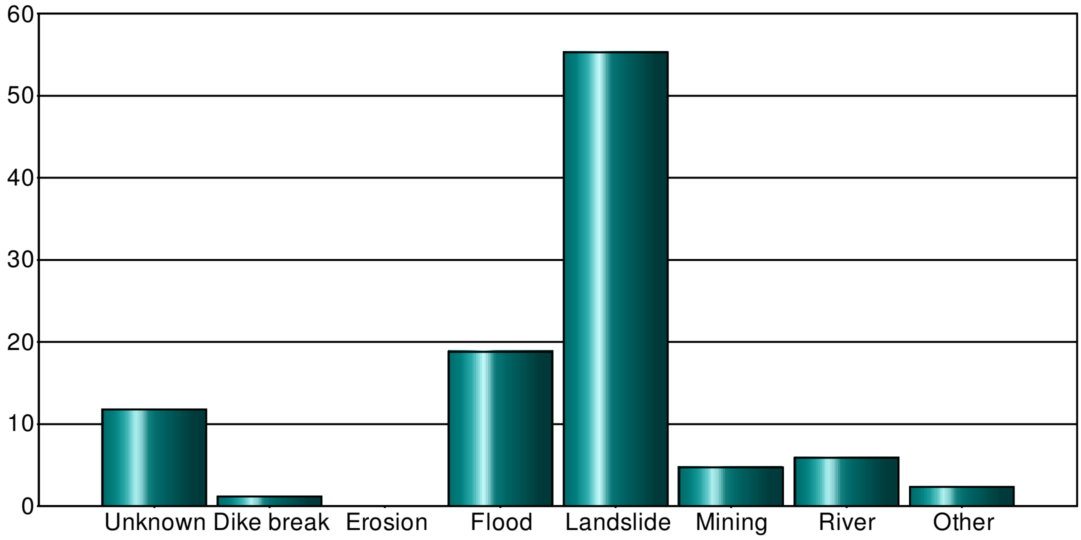

Figure 27: Distribution of the sub-causes of ground movement.

3.3.3.6 Other and unknown causes

The main cause for the category "Other and unknown" is lightning.
The sub-cause lightning represents almost 25% of the incidents within this category.

Within the period 1970-2007, 20 incidents due to lightning have been recorded in the EGIG database, which represents a failure frequency due to lightning equal to 0.0064 incidents per 1,000 km.yr.

Out of 20 incidents caused by lightning, 19 were small leaks (pinholes and cracks) and only 1 resulted in a large leak (hole). As lightning is a huge source of energy, ignition is very likely (see section 3.4.3).

3.4 Other analyses

3.4.1 Ageing analysis

EGIG has investigated the relationship between the age of the pipelines and their failure frequencies to determine whether older pipelines fail, due to corrosion, more often than more recently constructed pipelines. The influence of the age of the pipelines on their failure frequencies has been studied in the ageing analysis presented in Figure 28.

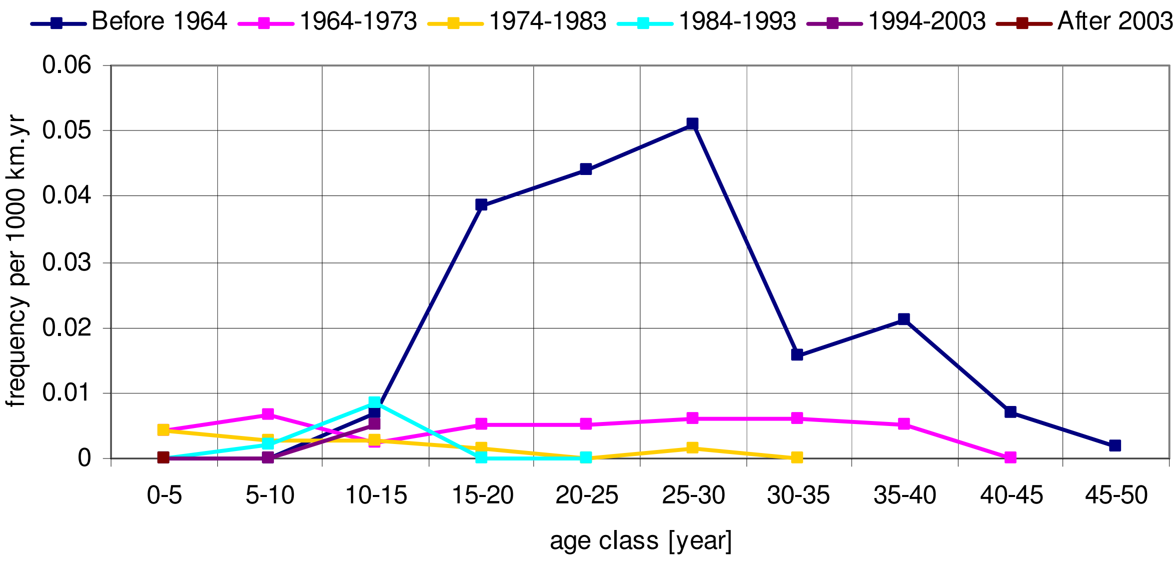

Figure 28: Ageing analysis (corrosion) relationship between age and construction year class

Explanation

Taking for instance a pipeline constructed before 1964, the failure frequency after 25 to 30 years after the construction year is 0.05 whereas it is 0.02 after 35-40 years.

Early constructed pipelines had a higher failure frequency due to corrosion, in their early years, than recently constructed pipelines. In recent years, due to improved maintenance, pipeline age is no longer a major influence on the occurrence of corrosion failures.

3.4.2 Detection of incidents

Figure 29 shows the distribution of the type of detection. Most incidents are detected by the public, with almost 38% of all incidents detected.

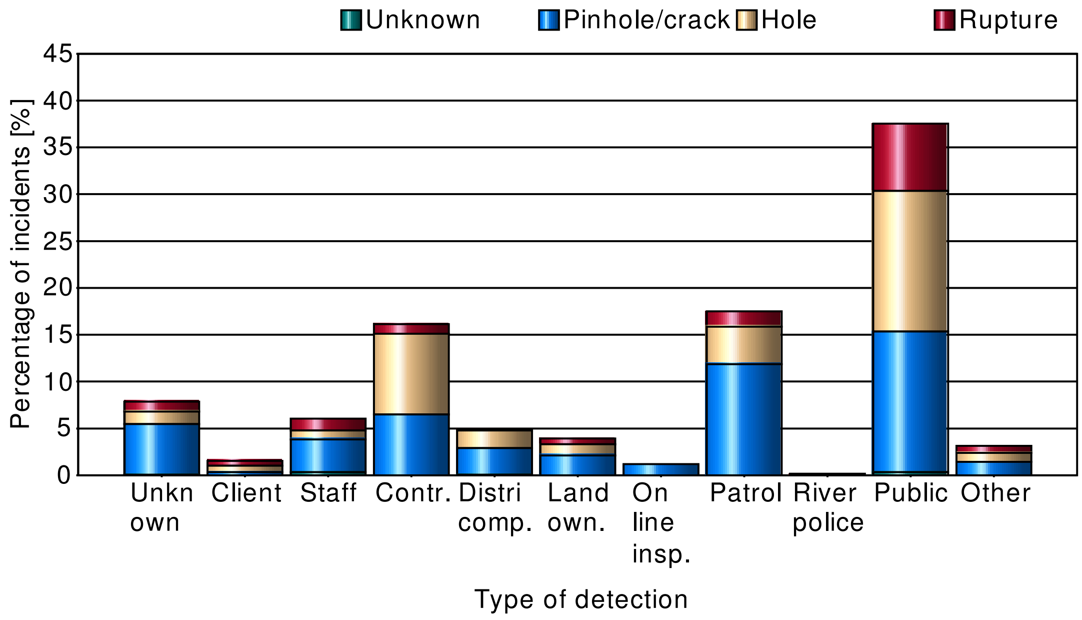

Figure 29: Detection of incidents

3.4.3 Ignition probability

Fortunately not every gas release ignites, which seriously limits the consequences of the incidents. In the period 1970-2007, only 4.4% of the gas releases recorded as incidents in the EGIG database ignited.
Ignition depends on the existence of random ignition sources. The EGIG database gives the opportunity to evaluate the link between ignition and leak size. Table 4 presents the ignition probabilities per leak type.

Size of leak	Ignition probabilities [%]
Pinhole-crack	4
Hole	2
Rupture	13

Table 4: Ignition probabilities per leak type

Table 5 shows, that in case of a rupture, gas releases from larger diameter pipelines are more likely to ignite than releases from smaller diameter pipelines. Larger diameter pipelines are also more likely to be higher in pressure.

Size of leak (Rupture)	Ignition probabilities [%]
Rupture <= 16 inches	10
Rupture > 16 inches	33

Table 5: Ignition probabilities for ruptures

EGIG specifically looked at the ignition probabilities of gas releases caused by lightning. Out of 20 gas releases in the period 1970-2007 caused by lightning, 11 ignited, which brings the ignition probability of gas releases due to lightning up to 55%.

3.4.4 *Injuries and fatalities*

EGIG gives only statistical information about failure frequencies and causes of incidents. Some of the registered incidents unfortunately caused injuries and even fatalities. In the EGIG database, there are 1172 incidents, of which 11 caused either injuries or fatalities.

External interference is the cause of the majority of incidents. This demonstrates the importance of the surveillance of third party works near pipelines and a good quality record system in the gas companies to avoid mistakes in the identification and location of pipelines.

4 CONCLUSIONS

- EGIG has maintained and expanded the European Gas pipeline incident database. Transmission companies of fifteen European countries now collect incident data on almost 130,000 km of pipelines every year. The total exposure, which expresses the length of a pipeline and its period of operation, is 3.15 million km.yr.
- The statistics of incidents collected in the database give reliable failure frequencies. The overall incident frequency is equal to 0.37 incidents per year per 1,000 km over the period 1970 to 2007.
- The 5 year moving average failure frequency, which represents the average incident frequency over the past 5 years, equals 0.14 incidents per year per 1,000 km. This frequency is almost 6 times lower than the one reported in the first years of the database (1970-1974).
- The failure frequencies have been reducing over the years, although the rate of reduction has slowed in recent years.
- The major cause of incidents remains external interference (50% of all incidents), followed by construction defects/material failures (16%) and corrosion (15%). Over the past five years, 48% of all incidents were due to external interference. The relatively high contribution of external interference emphasises its importance to pipeline operators and authorities.
- External interference incidents are characterised by potentially severe consequences (holes and ruptures).
- Early constructed pipelines had a higher failure frequency due to corrosion**,** in their early years, than recently constructed pipelines. In recent years, due to improved maintenance, pipeline age is no longer a major influence on the occurrence of corrosion failures.

5 REFERENCE

6th Report of the **E**uropean **G**as Pipeline **I**ncident Data **G**roup, 1970-2004, December 2005.