6th EGIG-report 1970-2004

GAS PIPELINE INCIDENTS

6th Report of the ***E***uropean ***G***as Pipeline ***I***ncident Data ***G***roup

Comprising:

Danish Gas Technology Centre represented by DONG (Denmark)
ENAGAS, S.A. (Spain)
Fluxys (Belgium)
Gasum (Finland)
N.V. Nederlandse Gasunie (The Netherlands)
GRT Gaz (France)
E.ON Ruhrgas AG (Germany)
SNAM Rete Gas (Italy)
SWISSGAS (Switzerland)
National Grid (UK)
RWE Transgas (Czech Republic)
Transgas (Portugal)

Doc. Number EGIG 05.R.0002
December 2005

The next (7th) EGIG report will be issued in December 2008. An annual update (in 2006 and 2007) can be found on the EGIG website.

Comments or questions to this publication can be directed to the EGIG secretariat:

N.V. Nederlandse Gasunie
mr. D. van den Brand
Project Manager EGIG
P.O. Box 19
NL - 9700 MA GRONINGEN

N.V. Nederlandse Gasunie
mr. R. Kenter
Secretariat EGIG
P.O. Box 19
NL - 9700 MA GRONINGEN

Fax: **+31 50 521 1999**
E-mail: **R.Kenter@gasunie.nl**
Website: **http://www.EGIG.nl**

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.

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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 (**E**uropean **G**as pipeline **I**ncident data **G**roup). Presently, EGIG is a cooperation of twelve 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 the safety performances of Europe's transmission pipeline systems and to improve safety in the gas transmission pipelines systems.

This report demonstrates the safety performance of the major existing pipeline transmission systems in Europe, and it also provides a broad basis for statistical use.

Conclusions from the sixth EGIG report

- EGIG has maintained and expanded the European Gas pipeline incident database. Transmission companies of twelve European countries now collect incident data on more than 122,000 km of pipelines every year. The total exposure, which expresses the length of a pipeline and its period of operation, is 2.77 million km.yr.
- The statistics of incidents collected in the database give reliable failure frequencies. The overall incident frequency is equal to 0.41 incidents per year per 1,000 km over the period 1970 to 2004.
- The 5 year moving average overall failure frequency, which represents the average incident frequency over the past 5 years, equals 0.17 per year per 1,000 km. This frequency is almost 5 times lower than the one reported in the first years of the data base (1970-1974).
- The failure frequencies have been reducing consistently over the years, although they recently tend to stabilize.
- The major cause of incidents remains external interference (50% of all incidents), followed by construction defects/material failures (17%) and corrosion (15%). Over the past five years, 51% of all incidents were due to external interference. The relatively high contribution of external inference emphasises its importance to pipeline operators and authorities.
- External interference incidents are characterised by potentially severe consequences (holes and ruptures), and the incident in Ghislenghien on 30 July 2004 reminds us of this fact.

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 mode of transport in terms of impact on the environment and human health. 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 statistical use, 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. Nowadays, EGIG is a cooperation of twelve major gas transmission system operators in Western Europe and it is the owner of an extensive database of pipeline incident data collected since 1970. In the period between 2001 and 2004, three new major gas transmission companies have become EGIG members. The participating companies are now:

- Danish Gas Technology Centre represented by DONG (Denmark)
- ENAGAS, S.A. (Spain)
- Fluxys (Belgium)
- Gasum (Finland)
- N.V. Nederlandse Gasunie (The Netherlands)
- GRT Gaz (France)
- E.ON Ruhrgas AG (Germany)
- SNAM Rete Gas (Italy)
- SWISSGAS (Switzerland)
- National Grid (UK)*
- RWE Transgas (Czech Republic)
- Transgas (Portugal)

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 are not taken into account so that the results of 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 performances of the existing transmission pipeline system in Europe and also provides a broad basis for statistical use. Nevertheless, particular care must be given to the use and interpretation of 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 23rd edition of the International Gas Union (IGU) World Gas Conference in 2006 in Amsterdam.

This report introduces the EGIG database and presents different analyses and their results. The results of the analyses are commented on and give the most interesting 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.

***** *Was Transco, part of National Grid Transco, at time of data collection.*

2 EGIG DATABASE

2.1 Definition

The EGIG database is a database of pipeline and incident data. 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 loss of gas incidents to present 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 design pressure higher than 15 bar
    - To be located outside the fences of the installations

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 the major European gas transmission pipelines system as well as specific information about the incidents.

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

- Diameter
- Pressure
- Year of construction
- Type of coating
- 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 or unknown)
    - The corrosion type (galvanic, pitting, stress corrosion cracking “SCC” or unknown)
- Construction defect/material failure:
    - The type of defect (construction or material)
    - The defect details (hard spot, lamination, material, field weld or unknown)
    - The pipeline type (straight, field bend, factory bend)
- Ground movement:
    - The type of ground movement (dike break, erosion, flood, landslide, mining, river or unknown).
- Other and unknown:
    - The sub-causes out of category such as design error, lightning, maintenance.

Most of the information mentioned here has been used for the statistics given in this 6th EGIG report.

2.5 Limits

The EGIG database offers a global overview of the safety level of the European gas transmission pipelines system. 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 calculate 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 data or statistical analysis is to interpret the information contained in the data in order 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 pipelines system are based on the calculation of indicators such as failure frequency, (mean or deviation) 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 and is expressed in kilometres-years [km.yr]. Example: company A 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.

The failure frequencies are calculated by dividing the number of incidents by a system exposure.

In order to distinguish safety improvements of the last period a 5-years moving average has been introduced. The 5-years moving average means that the calculations have been performed over the 5 previous years in question.

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 (so 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.

3.2 Trends of the European gas transmission system

This paragraph gives information on the trends of the European gas transmission system. It not only shows the evolution of the exposure but also which design parameters tend to be more or less used in today's construction. This paragraph gives a picture of the European gas transmission system from 1970 up to the present.

3.2.1 Total length

The total length of the European gas transmission pipelines system in EGIG is constantly increasing. In 2004 the annual length was equal to 122,168 km against 110,236 km in 2001. The evolution of the total length of the system is shown in figure 1 and is also given per category (diameter, pressure, etc.) in figures 2 to 8.

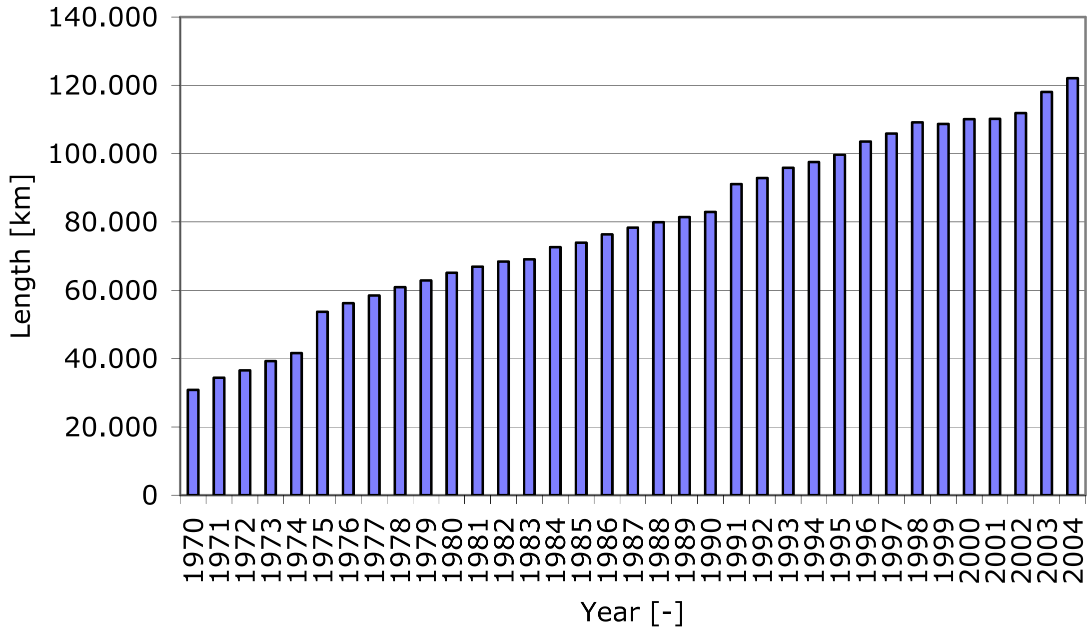

Figure 1: Total length of the European gas transmission system in EGIG

Figure 1 shows a linear increase in the length of the European gas transmission system in EGIG, which has significant step changes in the years 1975, 1991, 1998 and 2003. These changes correspond to new members joining the EGIG.

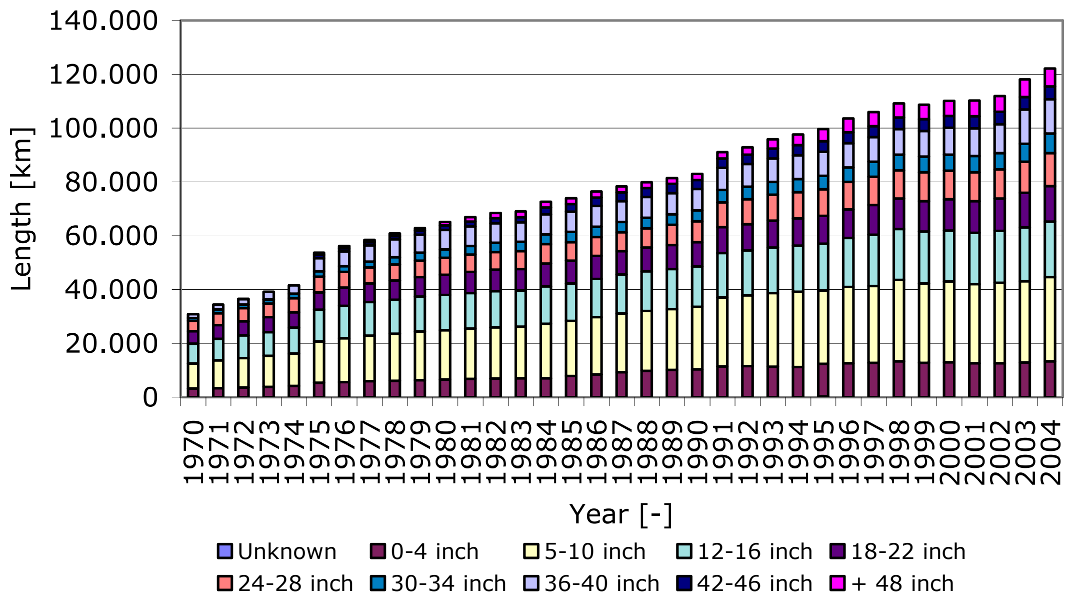

Figure 2: Total length per diameter class

Figure 2 demonstrates that the 5-10 inch and 12-16 inch classes are still the most commonly used. However, the trend is to use more and more pipelines with a diameter larger than 18 inch. Indeed, thirty years ago only one third of the pipelines had a diameter larger than 18 inch compared to half now.

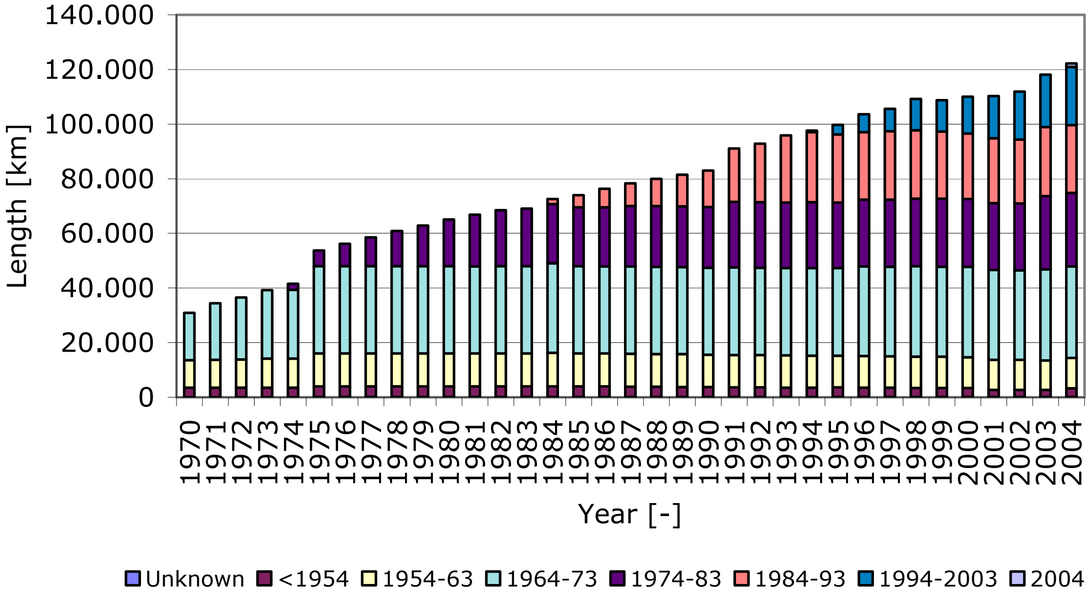

Figure 3: Total length per year of construction class

Figure 3 shows that more pipelines were built in the period 1964-1973 than any other period. No significant drop can be observed, which means that these pipelines are still in operation.

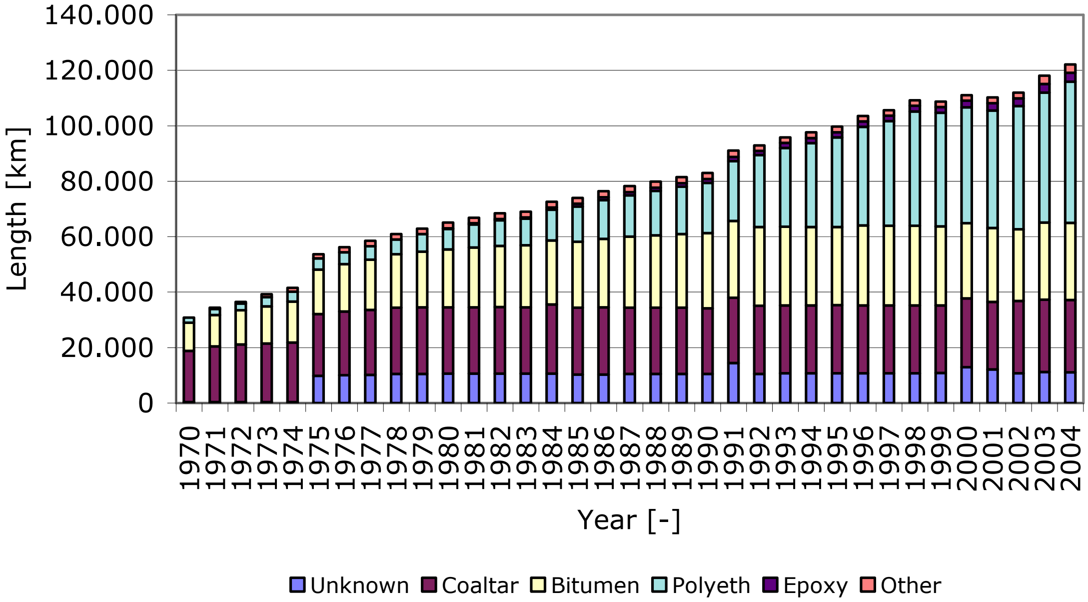

Figure 4: Total length per type of coating

Figure 4 shows that coal tar, bitumen and polyethylene are nowadays the most commonly used coatings with a clear predominance of the last one.

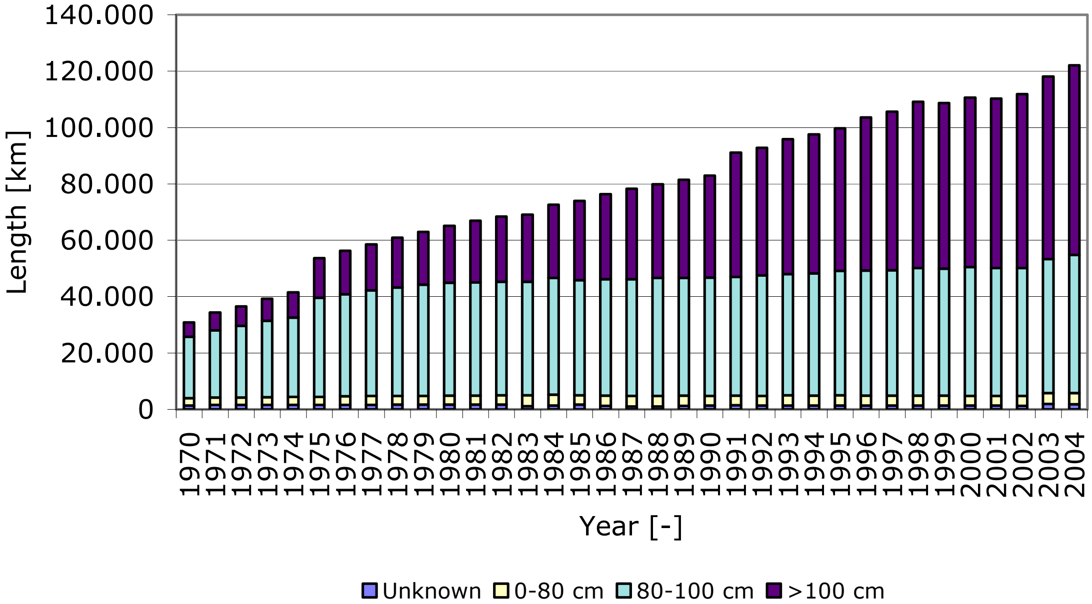

Figure 5: Total length per depth of cover

Figure 5 shows that only old pipelines have a depth of cover smaller than 80 cm and that most of the new pipelines have a depth of cover greater than 80 cm.

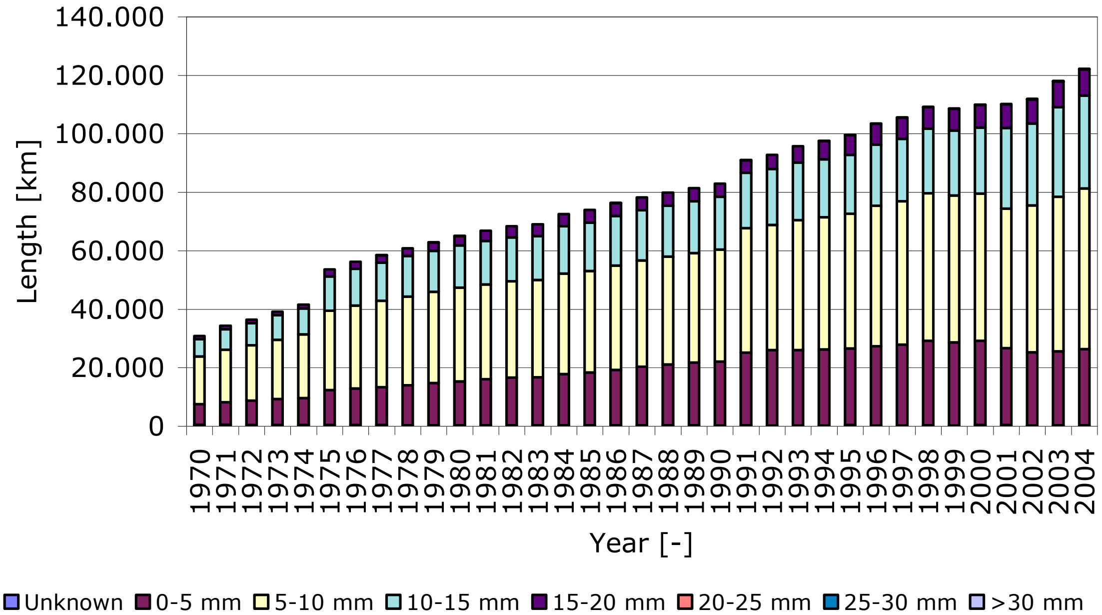

Figure 6: Total length per wall thickness

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 0-5 mm class, which has remained constant since 2001.

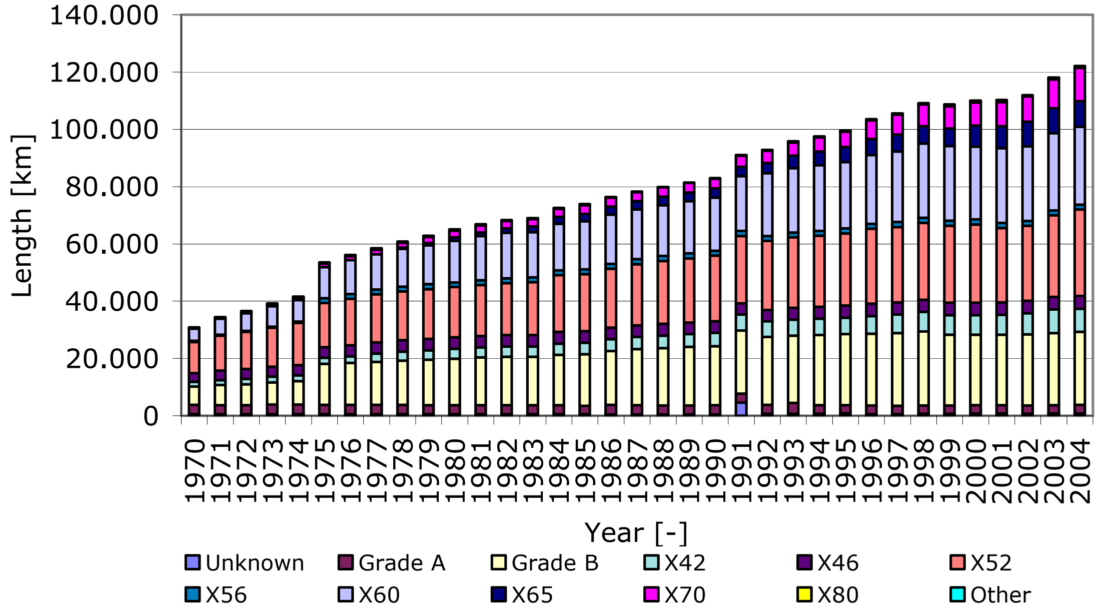

Figure 7: Total length per grade of material

Figure 7 demonstrates that three grades of material are predominant, namely: Grade B, X52 and X60. Together they represent more than 70% of the total.

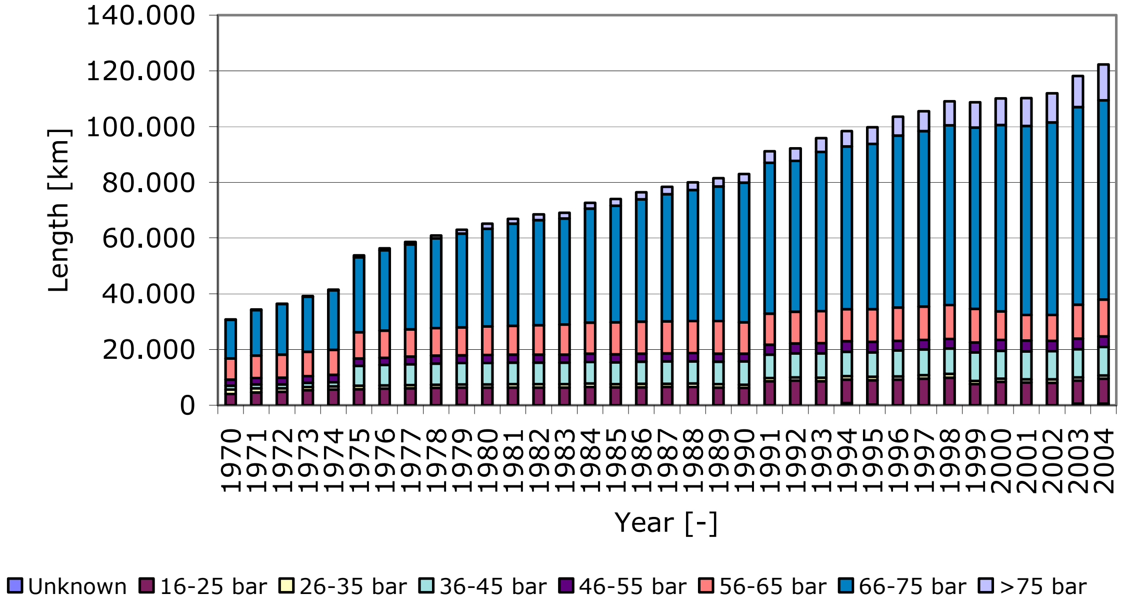

Figure 8: Total length per design pressure class

Figure 8 clearly shows a predominance of the high design pressure pipelines. The trend is clearly to design the pipelines at 66 bar and above.

3.2.2 Exposure

Figure 9 shows the increase of the exposure over the years. For the period 1970-2004, the total system exposure was equal to 2.77 million km.yr. The increase is due to the year-to-year experience built up and the EGIG participation of new operators in Europe.

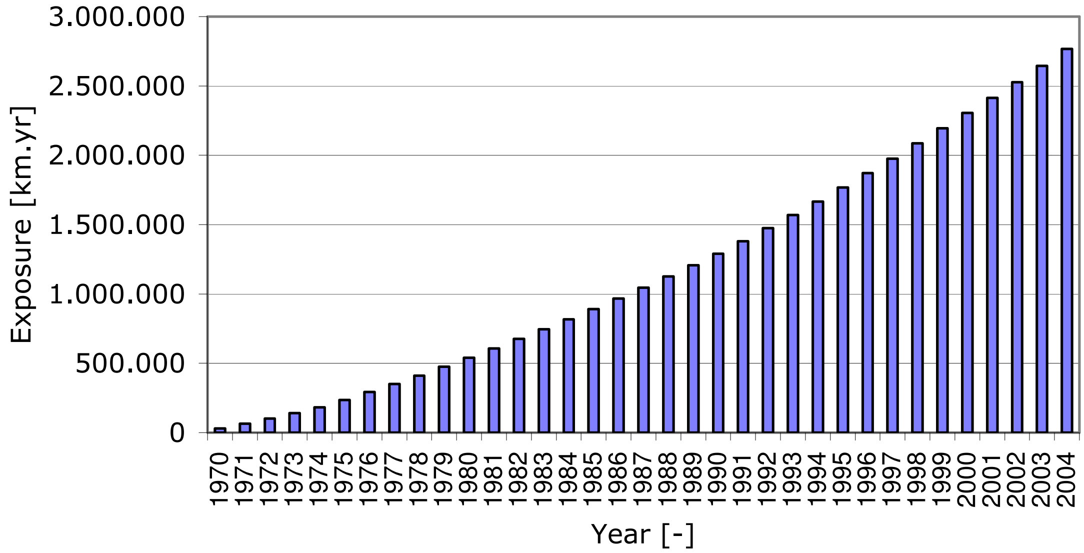

Figure 9: Evolution of the exposure

3.3 Failure frequencies analyses

This paragraph deals with the calculation of safety indicators, namely the primary and secondary failure frequencies. These calculations 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 fifth EGIG report, which covers the period 1970-2001, a total of 1,061 incidents were recorded. In the last three years 62 incidents were reported by the EGIG members, which brings the total number of incidents to 1,123 for the period 1970-2004. Figure 10 shows the number of incidents per year and Figure 11 the cumulative number of incidents.

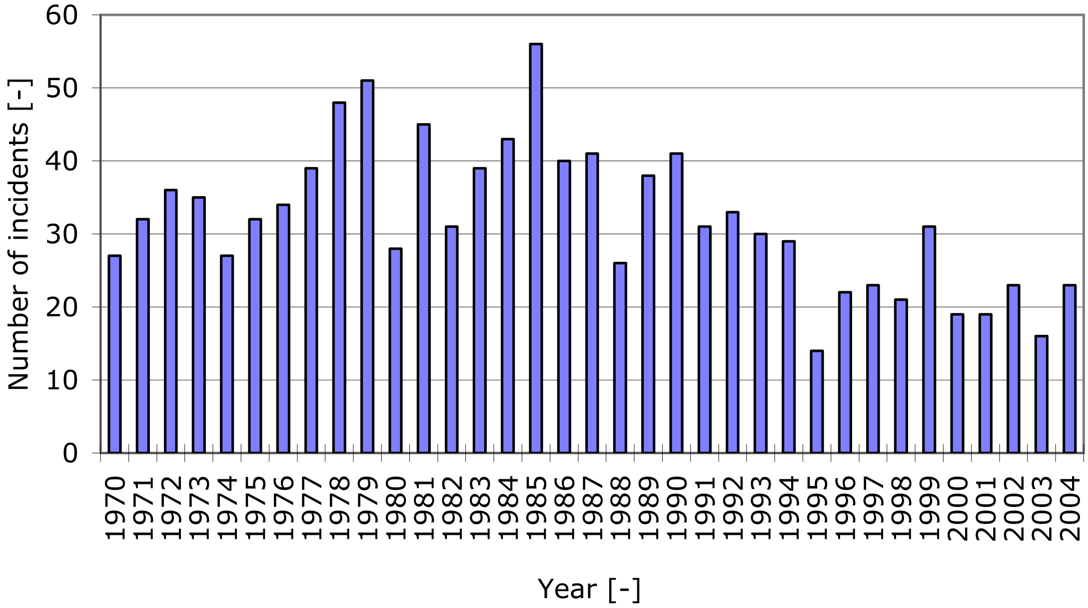

Figure 10: Annual number of incidents

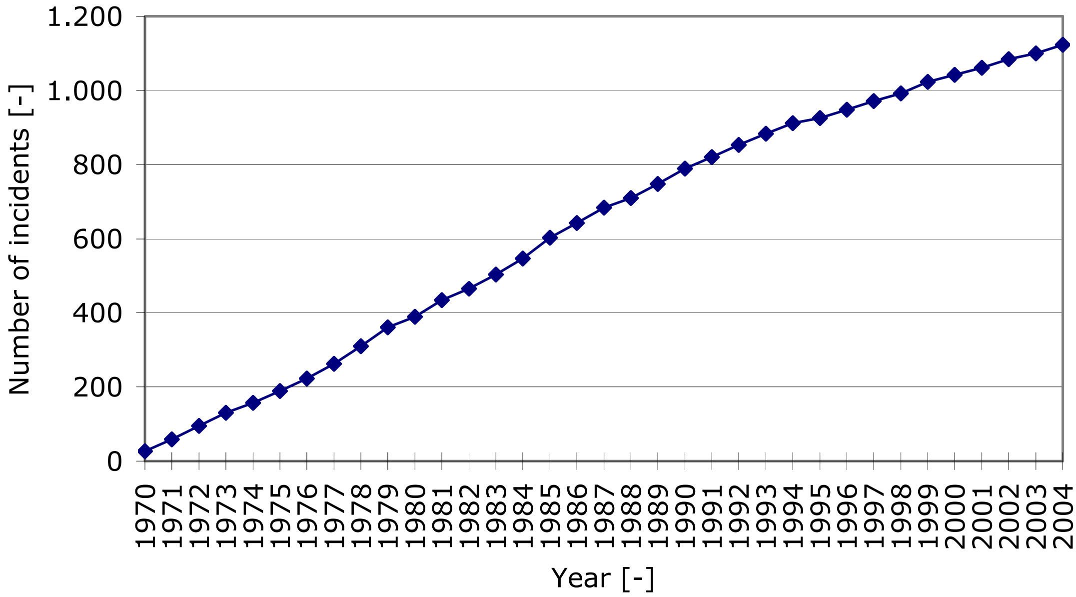

Figure 11: Cumulative number of incidents

3.3.2 Primary failure frequencies

As explained in paragraph 3.1, 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.

The EGIG has compared the primary failure frequencies of different periods, namely the total period (1970-2004), the period corresponding to the fifth EGIG report (1970-2001), the period of the last 5 years (2000-2004) 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]
1970-2004	1123	$2.77.10^{6}$	0.41
2000-2004	100	$0.57.10^{6}$	0.17
2004	23	$0.12.10^{6}$	0.19

Table 1: Primary failure frequencies

An observation is that the primary failure frequency (0.41) over the entire period (1970-2004) is slightly lower than the failure frequency of 0.44 reported in the 5th EGIG (1970-2001).

The failure frequency over the past five years (0.17 for 2000-2004) is equal to less than half of the primary failure frequency over the entire period showing the improved performance over recent years. Another observation is that the primary failure frequency over the last year (0.19 for 2004) is slightly, but not significantly, higher than the failure frequency of 0.17 calculated over the last 5 years (2000-2004).

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%.

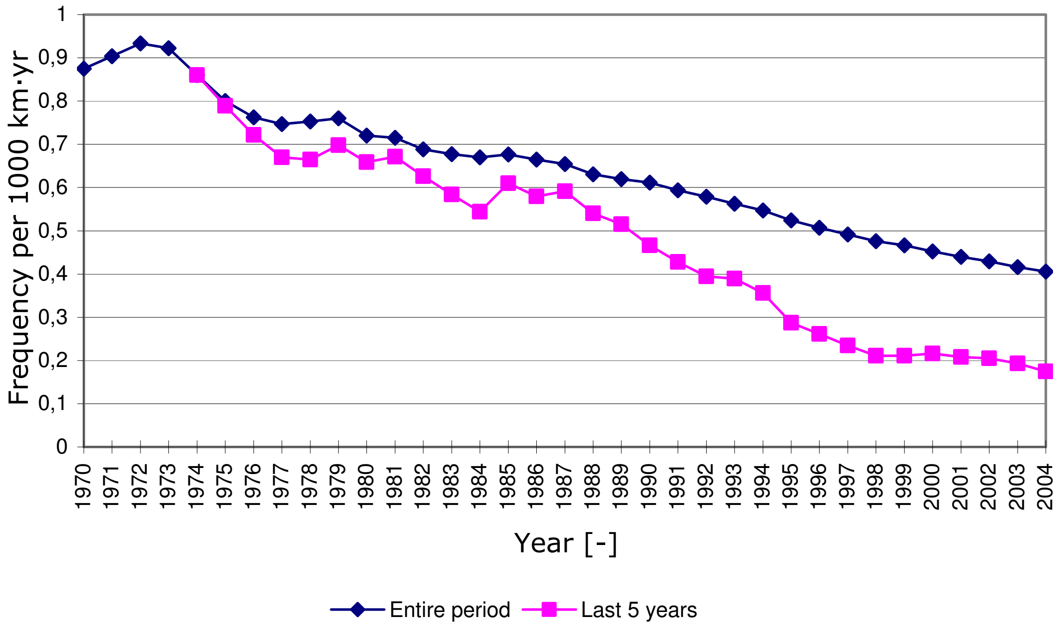

Figure 12: Evolution of the primary failure frequencies

Figure 12 illustrates the steady drop of the primary failure frequencies and the failure frequencies of the 5 years moving average. The primary failure frequency over the entire period declined from 0.87 per 1,000 km.yr in 1970 to 0.41 per 1,000 km.yr in 2004. The moving average primary failure frequency over five years decreased by a factor 5 (0.86 to 0.17 per 1,000 km.yr).

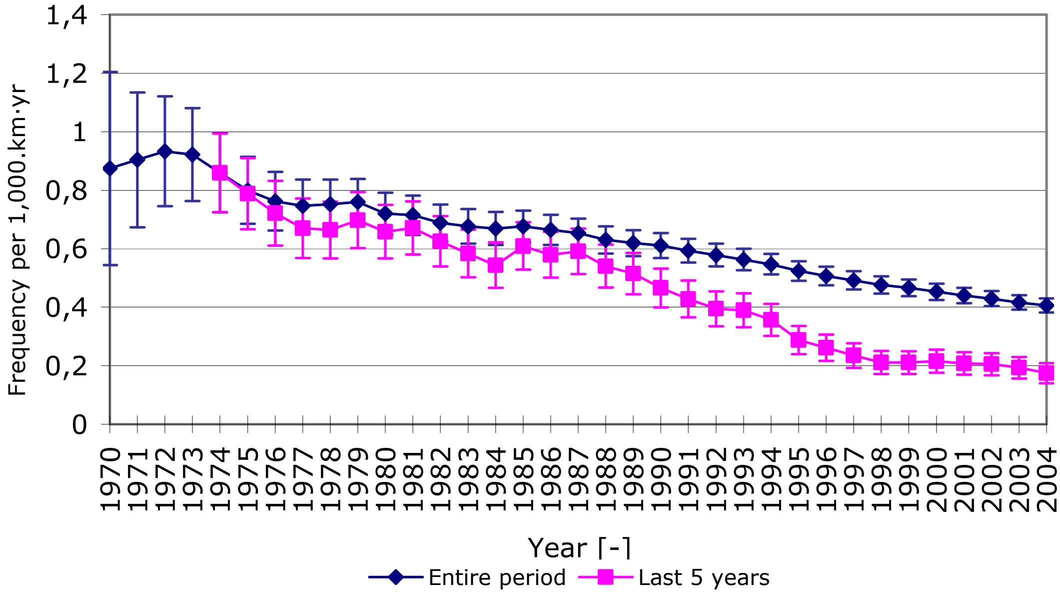

Figure 13: Primary failure frequencies and confidence intervals at 95%

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

Remark

A confidence interval is made to take uncertainty into account. We see that the greater the exposure, the smaller the interval, which, logically, 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. Most used and common distributions are: Gauss law (normal distribution), Poisson's law, the binomial distribution or the exponential one. The number of incidents, being a whole number (discrete), is small in comparison to the exposure. The assumption is made that the number of incidents follows Poisson's law, also called law of rare events.

In 2004 the primary failure frequency over the entire period was equal to 0.41 per 1,000 km.yr with a 95% confidence interval of ± 0.02. The primary failure frequency over the last five years was, in 2004, equal to 0.17 per 1,000 km.yr with a 95% confidence interval of ± 0.03.

Other interesting information is the distribution of the incidents per cause. Six different causes have been identified and are given below in association with the percentage of incidents they represent:

External interference	: 49.7%
Construction defect / Material failure	: 16.7%
Corrosion	: 15.1%
Ground movement	: 7.1%
Hot-tap made by error	: 4.6%
Other and unknown	: 6.7%

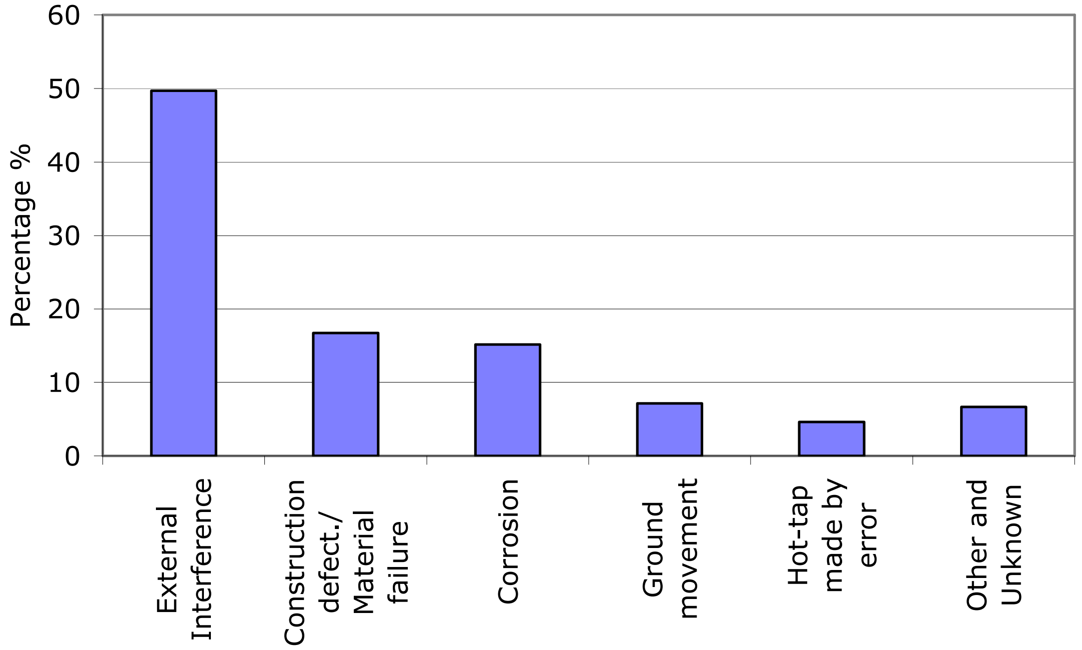

Figure 14: Distribution of incidents per cause

Figure 15 and Figure 16 give respectively the primary failure frequencies for the entire period (up to the year) and for the last five years moving average per cause.

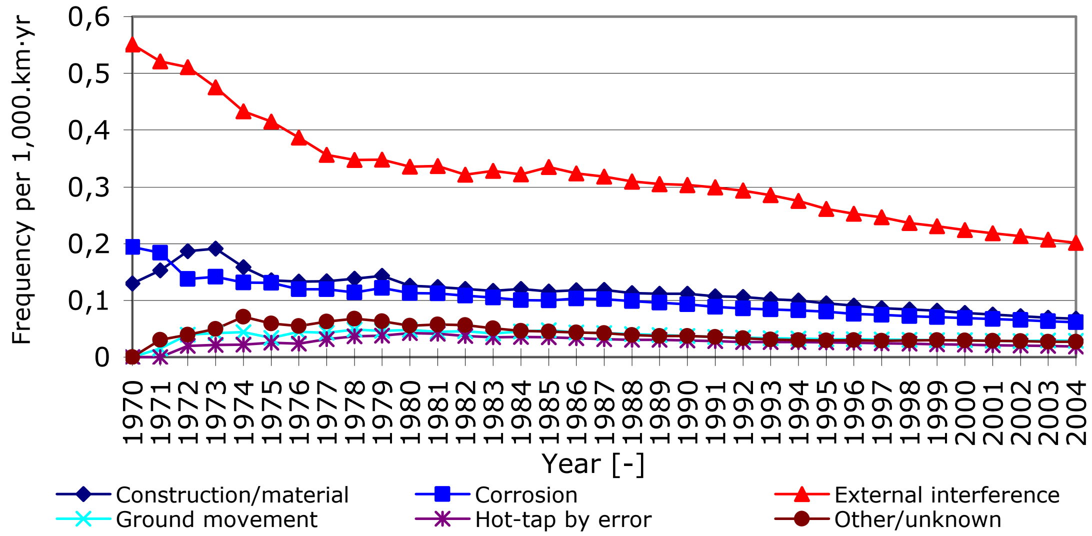

Figure 15: Primary failure frequencies per cause (up to the year)

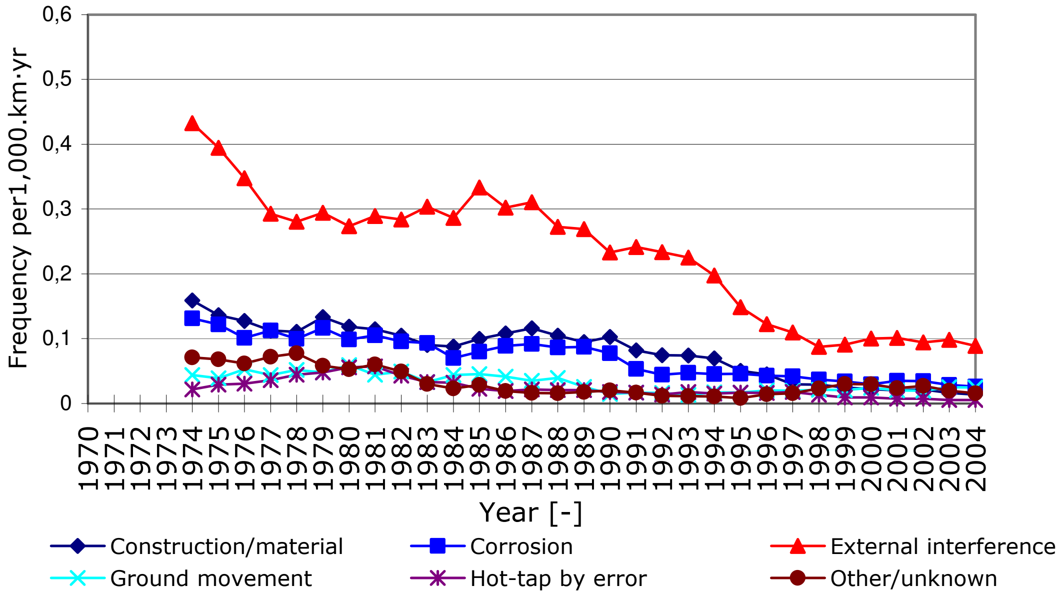

Figure 16: Primary failure frequencies per cause (5-years moving average)

Figure 15 and Figure 16 illustrate the reducing failure frequency 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 1970-2004 decreased to 0.20 per 1,000 km.yr while the 5-years moving average has levelled off at around 0.10 per 1,000 km.yr since 2000. However external interference remains the main cause of incidents.

A further improvement in the prevention of external interference could be obtained through a more stringent enforcement of land use planning and the application of one-call systems for the digging activities of external parties.

The EGIG was interested in the relation between the age of the pipelines and their failure frequencies. In other words, the EGIG wanted to know if old pipelines fail more often than younger ones. The influence of the age of the pipelines on their failure frequencies has been studied in the ageing analysis presented in Figure 17.

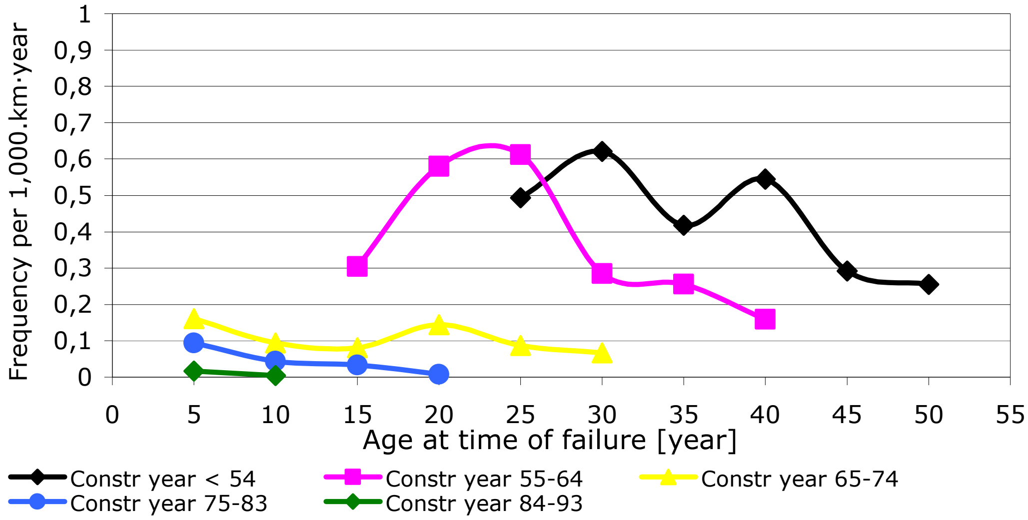

Figure 17: Ageing analysis (corrosion and construction defects)

Explanation Figure 17.

Taking for instance a pipeline constructed in 1970 (Construction year 65-74), the failure frequency after 5 years (1975) will equal 0.15 whereas it will equal 0.08 after 30 years (2000).

The first conclusion of Figure 17 is that early constructed pipelines have indeed a higher failure frequency than recently constructed pipelines. The second very important conclusion is that all failure frequencies irrespective of the age category are slightly decreasing in time.

The EGIG has been interested in the relation between the causes and the damage size. Figure 18 illustrates the link between the causes and the type of incident in terms of size of leak.

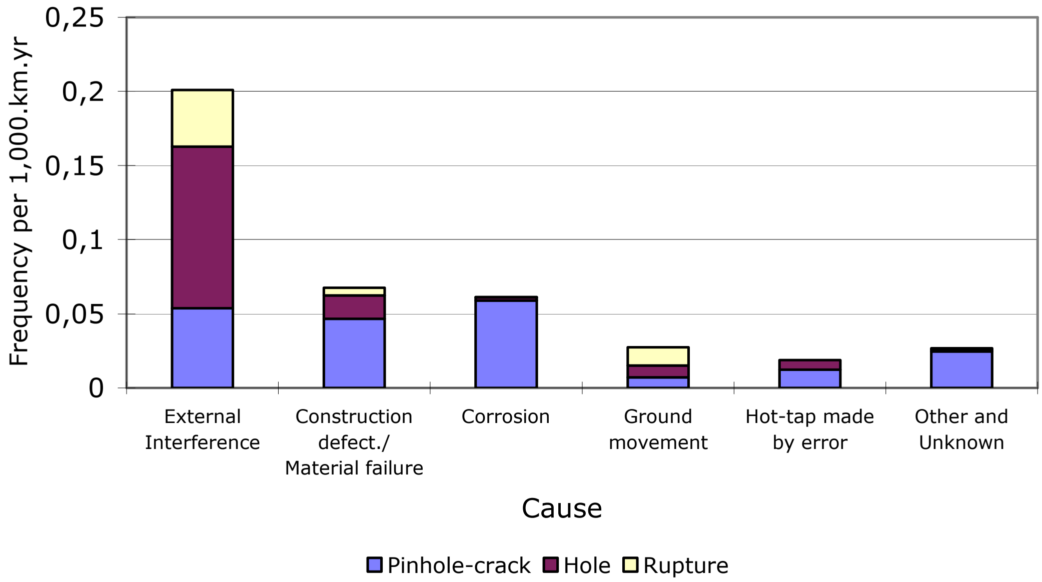

Figure 18: Relation cause, size of leak

Figure 18 shows that the bigger leak sizes (holes and ruptures) are especially caused by external interference, which is also the most common cause (50% of the incidents).

The external interference activities causing most incidents are those which involve excavators for digging (39%), drainage works (8%), public works (8%), and the activities related to agriculture (8%).

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.

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

The maintenance operational parameters (like pig inspection, pipeline patrolling and so on) also strongly influence the failure frequency, but the data about these parameters are not collected in the database and thus their influence can not be directly estimated in this report.

For six damage causes relevant for the EGIG database the secondary failure frequency 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 also other more relevant considerations are reported.

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

Figures 19 to 21 show the relation between the consequences of the incidents caused by external interferences 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.

No quantitative correlations between parameters have been studied.

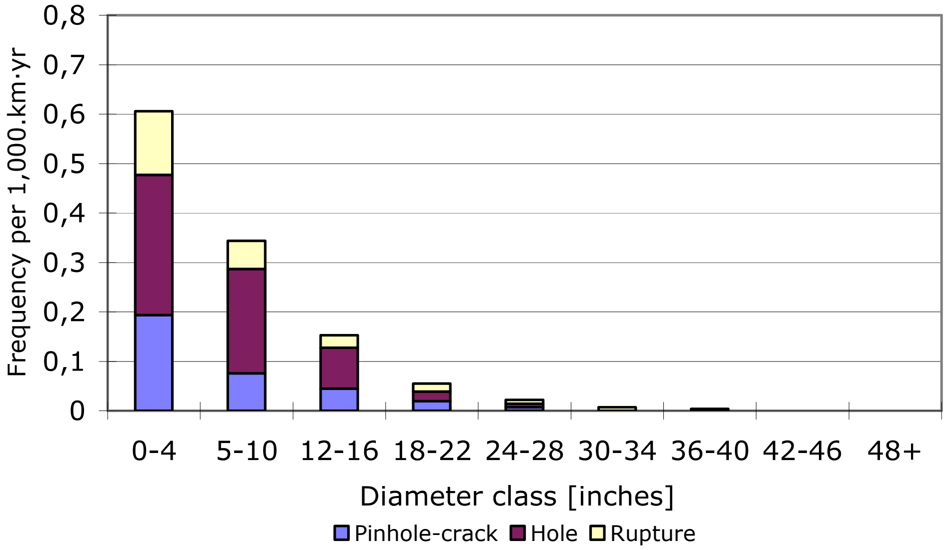

Figure 19: Relation external interference, size of leak and diameter class

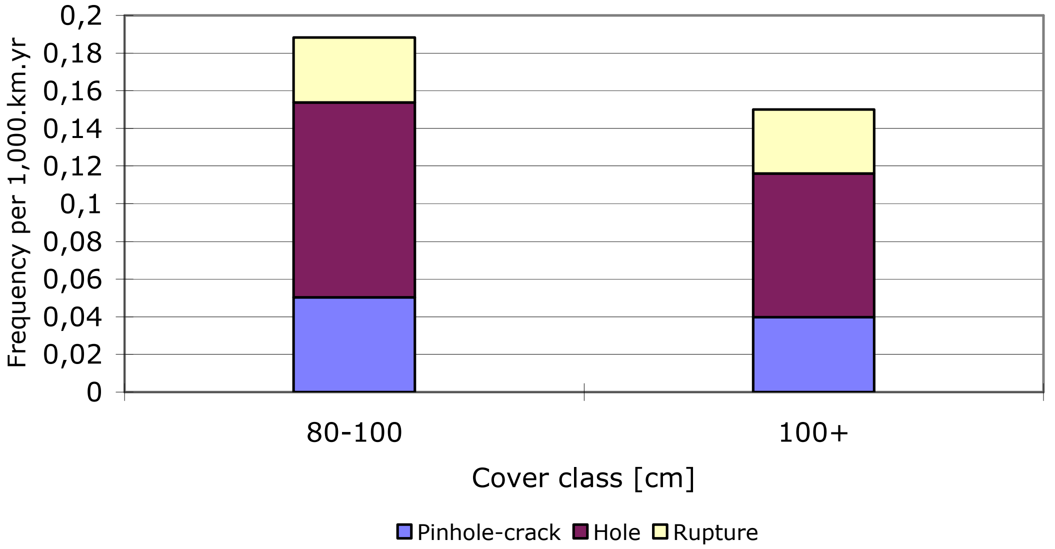

Figure 20: Relation external interference, size of leak and depth of cover class

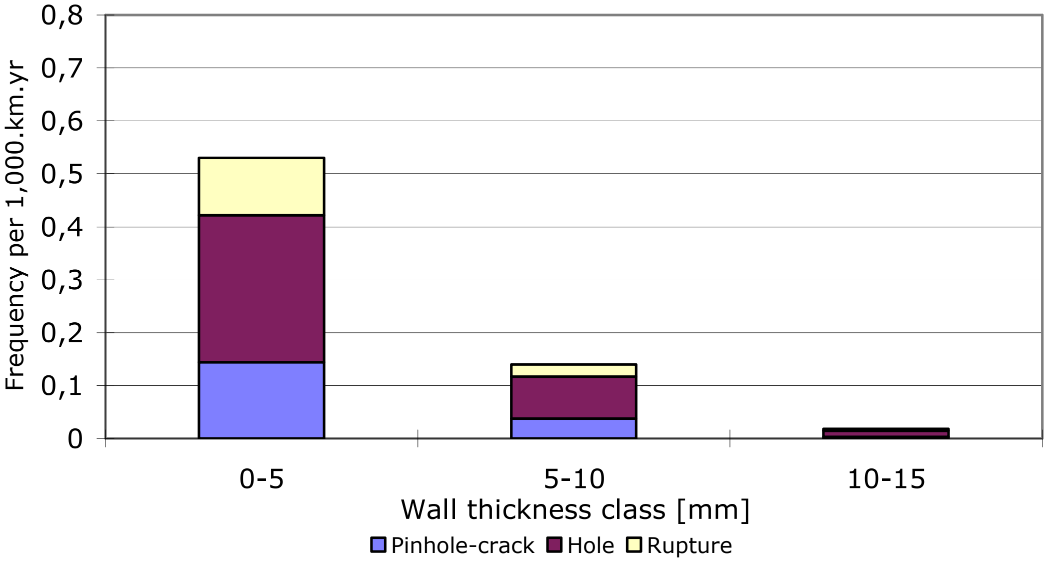

Figure 21: Relation external interference, size of leak and wall thickness class

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

Figure 21 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 much bigger 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 bigger wall thickness is an effective protective measure against external interferences.

3.3.3.2 Relation between corrosion, size of leak and design parameter

Figures 22 to 24 show the relation between the leak sizes of the incidents caused by corrosion and the year of construction of the pipeline, the type of coating and the wall thickness.

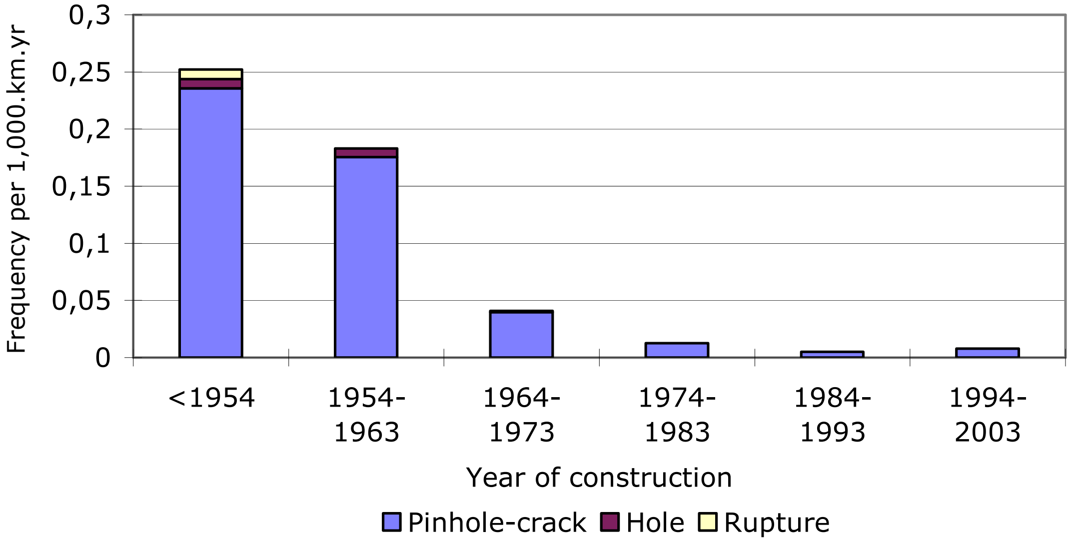

Figure 22: Relation corrosion, size of leak and year of construction

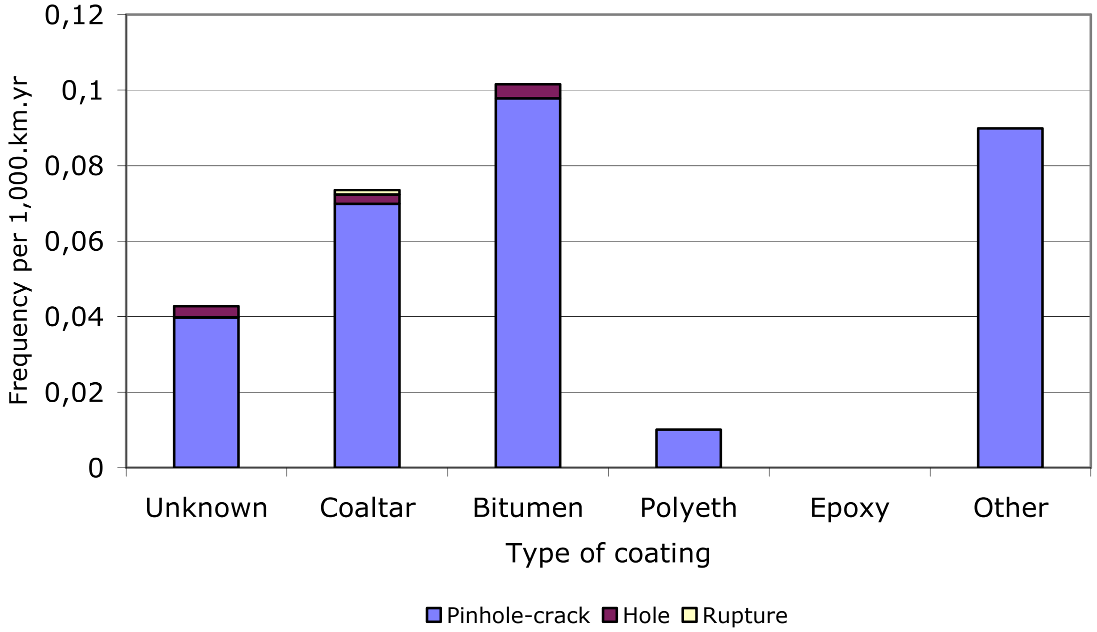

Figure 23: Relation corrosion, size of leak and type of coating

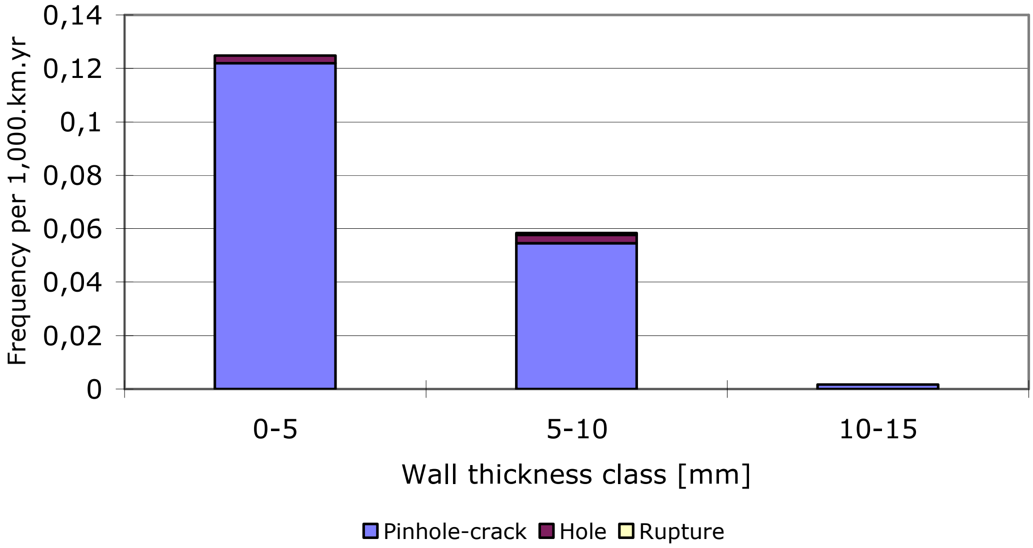

Figure 24: Relation corrosion, size of leak and wall thickness class

Corrosion has been identified as the third main cause of incidents (15%). Study of figures 22 to 24 shows 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.

Figures 22 illustrates the link between the year of construction of the pipelines and the failure frequencies whereas figure 23 shows the relation between the type of coating and the failure frequencies. From these figures it can be concluded that the older the pipeline, which generally used bitumen and coal tar, the higher the failure frequencies are.

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 24 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. Different protective measures are undertaken by pipeline owners to overcome the problem of corrosion. These measures are for example cathodic protection and pipeline coating. In line inspections and pigging operations also allow detecting corrosion at early stage.

Three types of corrosion have been addressed by the EGIG: external corrosion, internal corrosion and corrosion with an unknown cause. Up to 2004 they represented respectively 79%, 16% and 5% of all incidents due to corrosion. 71% of the cases of external corrosion was due to pitting. Galvanic corrosion and unknown causes represented both 13% of the external corrosion incidents whereas stress corrosion cracking was responsible for only 2%.

3.3.3.3 Relation between construction defect, size of leak and design parameter

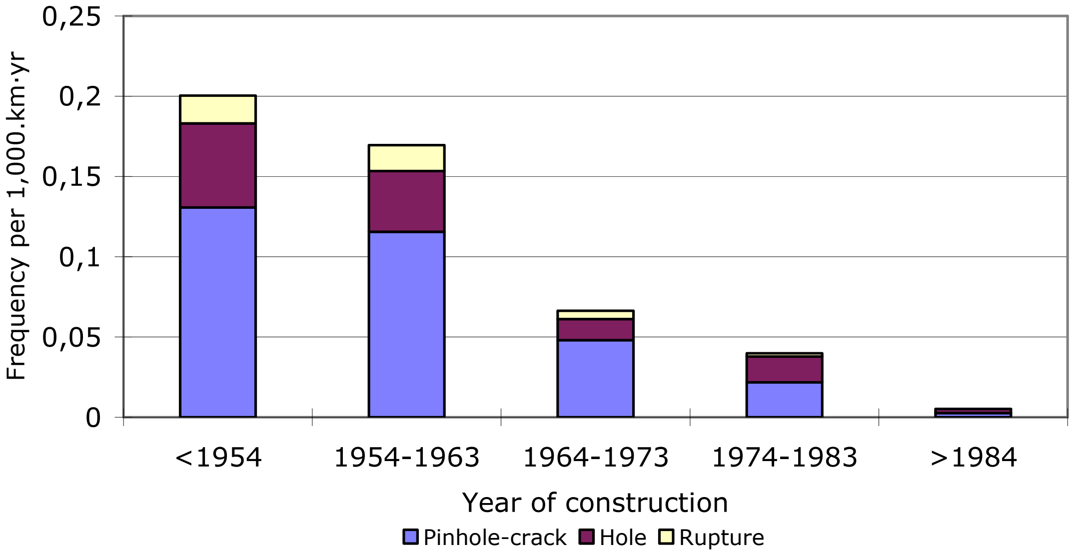

Figure 25: Relation construction defect/material, size of leak and year of construction

Figure 25 shows that the older the pipelines, the higher the failure frequencies (due to construction defect/material). It seems that the new pipelines are less vulnerable to construction defect/material, which is synonymous to technical improvements. This phenomenon has already been observed in the ageing analysis (Figure 17).

3.3.3.4 Relation between hot tap made by error, size of leak and design parameter

The term "hot tap made by error" means that a connection has been made by error to a high pressure gas transmission pipeline incorrectly identified as a low pressure distribution pipeline or even as a water pipeline. Figure 26 illustrates this phenomenon and also shows that this kind of error can lead not only to small size of leak (pinholes), but also to large size of leak (holes), especially with very small diameter pipelines. .

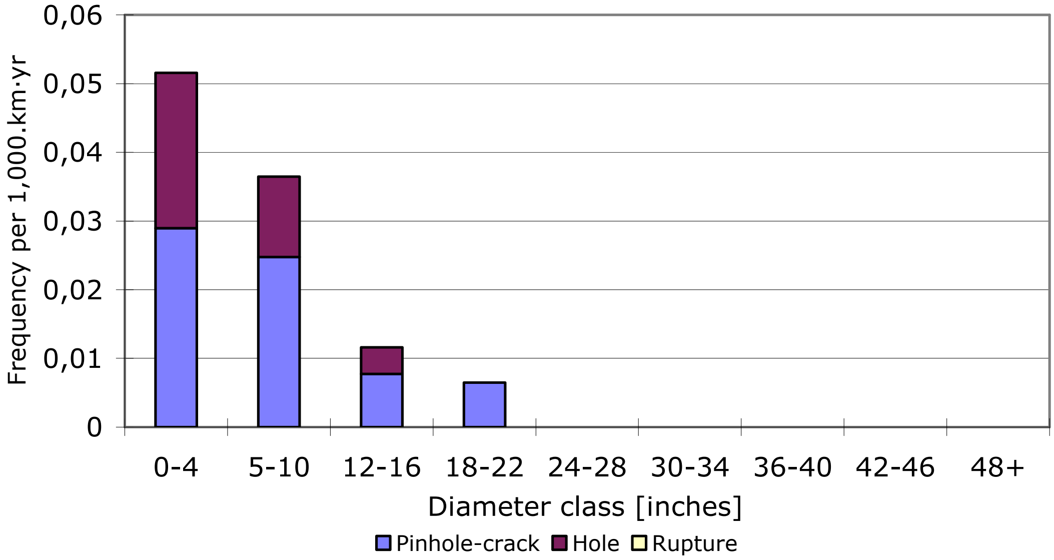

Figure 26: Relation hot tap made by error, size of leak and diameter class

3.3.3.5 Ground movement

Ground movement is responsible for 7% of the total incidents of the database.

Figure 27 depicts the relation between ground movement, size of leak and diameter class. Ground movement incidents causes serious leak sizes, however it also can be concluded that smaller diameters are more vulnerable for ground movement than larger diameters.

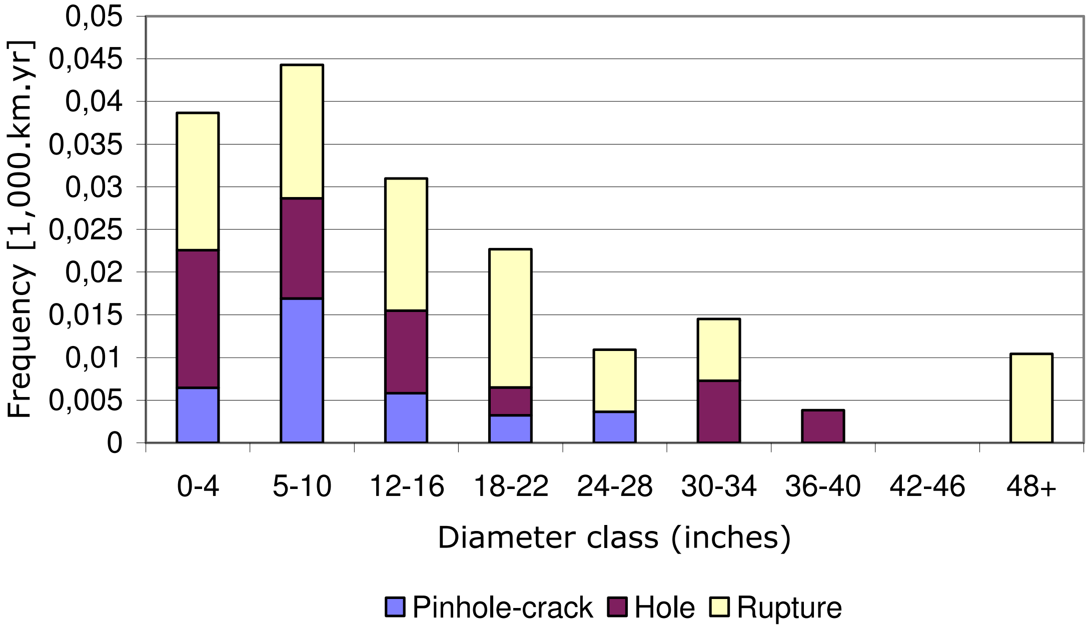

Figure 27: Relation ground movement, size of leak and diameter class

Analysing the information recorded about these failure cause damages it is possible to point out some important elements considering the sub-causes which are divided into "Ground Movement".

The sub-causes for ground movement are:

- Landslide
- Flood
- River
- Mining
- Dike break

Figure 28 shows the distribution of the sub-causes in the category ground movement.

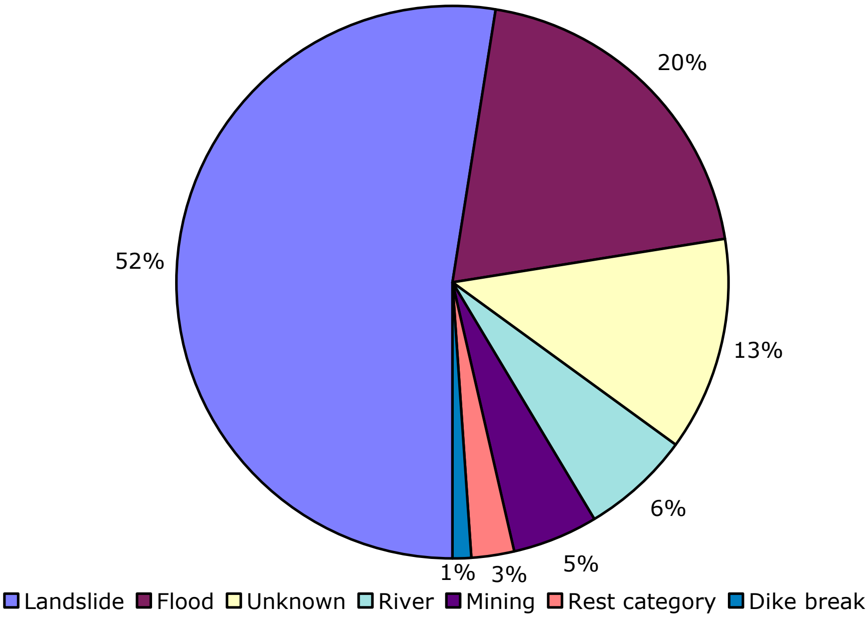

Figure 28: Distribution of the sub-causes of ground movement

3.3.3.6 Other and unknown

The main cause for the category "Other and unknown" is lightning.
The sub-cause lightning represents almost 24% of the incidents within this category.

Within the period 1970-2004, 18 incidents due to lightning have been recorded in the EGIG database, which represents a failure frequency due to lightning equal to 0.0065 per 1,000 km.yr.
The EGIG examined the distribution of the consequences of lightning in terms of leak sizes.
Out of 18 incidents, 17 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 3.4.2).

3.4 Other analysis

3.4.1 Detection of incidents

Figure 29 shows the distribution of the type of detection. With almost 40% of all incidents detected, the public is the most common detector. Up to 2004 almost 20% of the incidents were detected by the patrols, which demonstrates their usefulness and effectiveness.

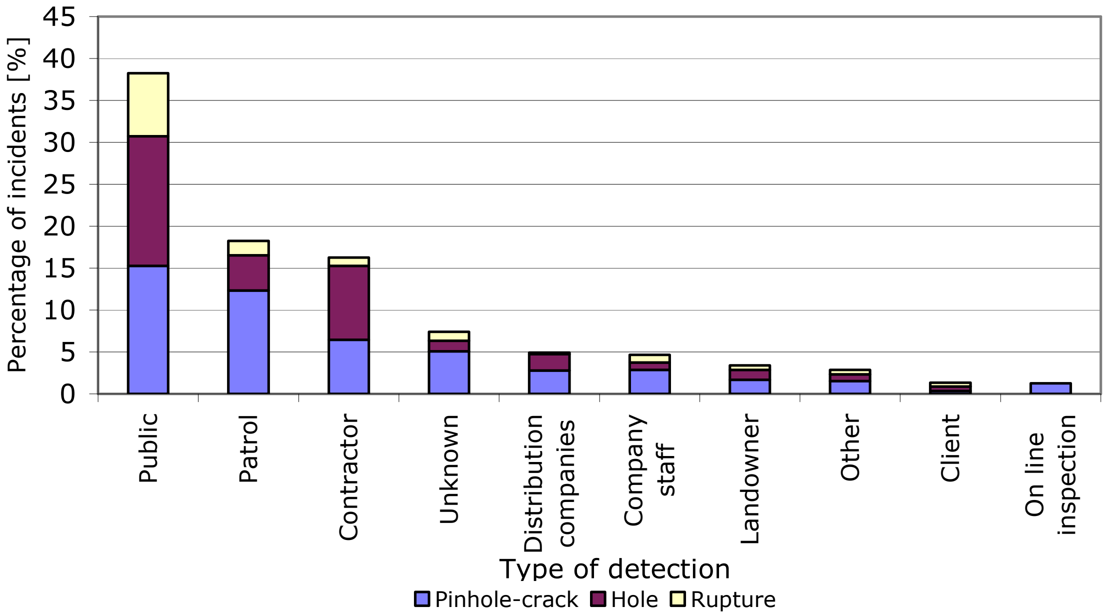

Figure 29: Detection of incidents

3.4.2 Ignition probability

Fortunately not every gas release ignites, which seriously limits the consequences of the incidents. In the period 1970-2004, only 4.1% 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 possibility to evaluate the link between ignition and leak size.

Table 2 gives the ignition probabilities per size of leak.

Size of leak	Ignition probabilities [%]
Pinhole-crack	3
Hole	2
Rupture <= 16 inches	9
Rupture > 16 inches	30

Table 2: Ignition probabilities per leak type

Table 2 clearly shows that gas releases from big diameter pipelines are more likely to ignite than releases from smaller diameter pipelines. It can be noticed that the larger diameter pipelines are also more likely to be higher in pressure.

This table gives the ignition probabilities of all incidents together no matter their causes. It is obvious that these probabilities vary according to their causes. The EGIG specifically looked at the ignition probabilities of gas releases caused by lightning.

Out of 18 gas releases in the period 1970-2004, 9 ignited, which brings the ignition probability of gas releases due to lightning up to 50%.

3.4.3 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.

No statistical information about consequences are shown in the report since these events are actually rare.

In general there is a need of implementing coordination procedures with Emergency Services.

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 twelve European countries now collect incident data on more than 122,000 km of pipelines every year. The total exposure, which expresses the length of a pipeline and its period of operation, is 2.77 million km.yr.
- The statistics of incidents collected in the database give reliable failure frequencies. The overall incident frequency is equal to 0.41 incidents per year per 1,000 km over the period 1970 to 2004.
- The 5 year moving average overall failure frequency, which represents the average incident frequency over the past 5 years, equals 0.17 per year per 1,000 km. This frequency is almost 5 times lower than the one reported in the first years of the data base (1970-1974).
- The failure frequencies have been reducing consistently over the years, although they recently tend to stabilize.
- The major cause of incidents remains external interference (50% of all incidents), followed by construction defects/material failures (17%) and corrosion (15%). Over the past five years, 51% of all incidents were due to external interference. The relatively high contribution of external inference emphasises its importance to pipeline operators and authorities.
- External interference incidents are characterised by potentially severe consequences (holes and ruptures), and the incident in Ghislenghien on 30 July 2004 reminds us of this fact.

5 REFERENCE

5th Report of the **E**uropean **G**as Pipeline **I**ncident Data **G**roup, 1970-2001, December 2002.