UKOPA

United Kingdom Onshore Pipeline Operators' Association

Title: UKOPA Pipeline Product Loss Incidents (1962-2009)

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Author: GL-Noble Denton for UKOPA-FDMG

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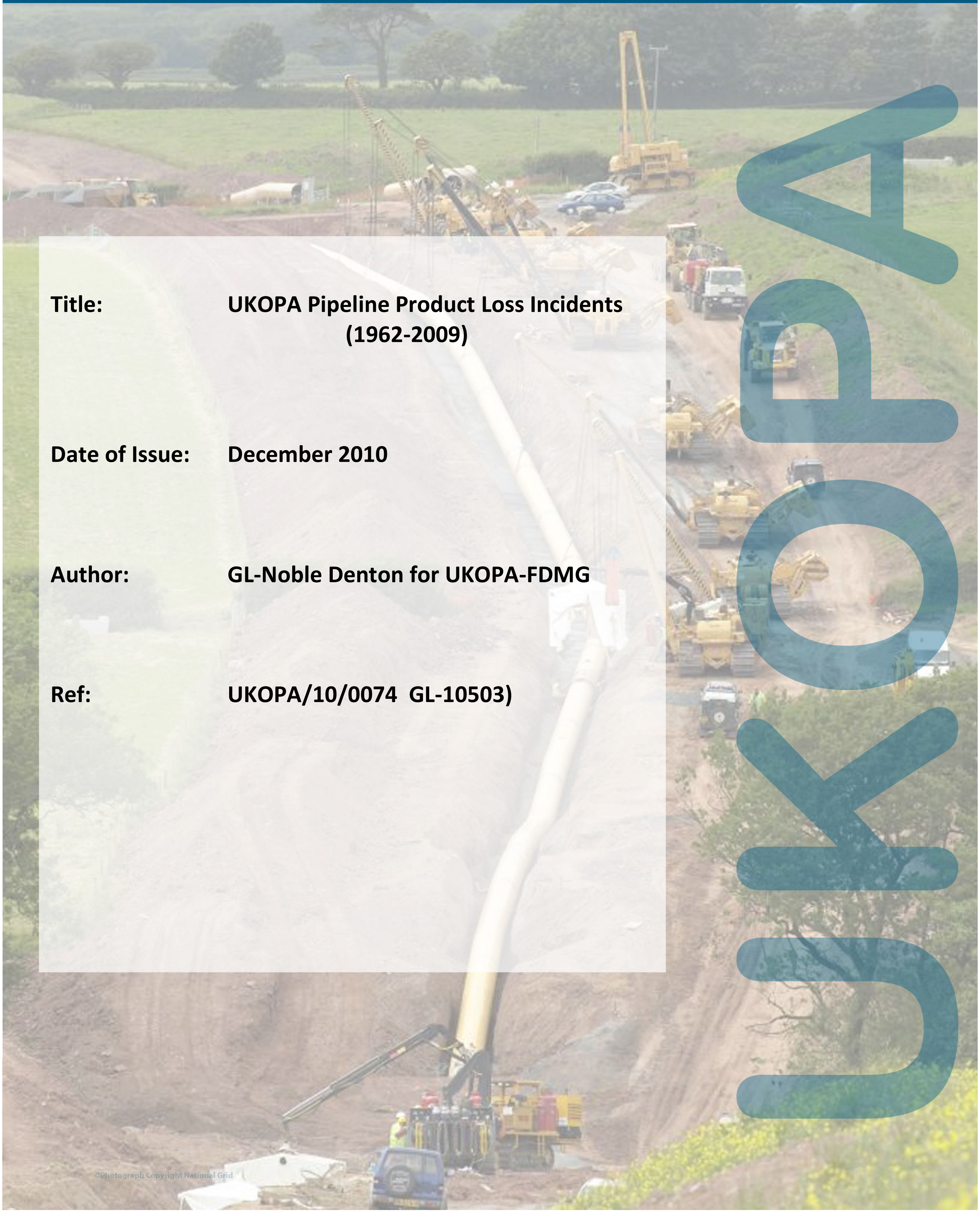

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UKOPA

UKOPA PIPELINE FAULT DATABASE

UKOPA

Pipeline Product Loss Incidents

(1962 - 2009)

Interim Report of the UKOPA **F**ault **D**atabase **M**anagement **G**roup

Comprising:

National Grid
BP
Ineos
SABIC
Shell UK Limited
Shell EPE
E-ON UK
Wales and West Utilities
Scotia Gas Networks
Northern Gas Networks
Health and Safety Executive

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GL Report Reference: ***10503***
December 2010

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Summary

This report presents collaborative pipeline and product loss incident data from onshore Major Accident Hazard Pipelines (MAHPs) operated by National Grid, Scotia Gas Network, Northern Gas Network, Wales and West Utilities, Shell UK Limited, Shell EPE, BP, Ineos, SABIC and E-ON UK, covering operating experience up to the end of 2009. The data presented here cover reported incidents on pipelines within the public domain and not within a compound, where there was an unintentional loss of product from the pipeline.

The overall failure frequency over the period 1962 to 2009 is 0.239 incidents per 1000 km.year, whilst in the previous report this figure was 0.242 incidents per 1000 km.year (covering the period from 1962 to 2008).

The failure frequency over the last 5 years is 0.082 incidents per 1000 km.year, whilst in the previous report this figure was 0.064 incidents per 1000 km.year (covering the 5 year period up to the end of 2008).

Contents

1 INTRODUCTION

1.1 Background

One of the key objectives of UKOPA is to develop a comprehensive view on risk assessment and risk criteria as they affect Land Use Planning aspects adjacent to high hazard pipelines. The main multiplier in pipeline risk assessments is the per unit length failure rate which directly relates to the extent of risk zones adjacent to the pipelines. Regulators and consultants who carry out risk assessments for UK pipelines have generally relied on US and European data to provide the basis for deriving failure rates due to the shortage of verified published data relating to UK pipelines. UKOPA published the first report in November 2000, presenting the first set of incident data for pipeline incidents resulting in the unintentional release of product up to the end of 1998. A full list of reports is listed in the table below.

Report Date	Type of Report	Covering Incidents to end of	Report Number	Reference
2000	Formal	1998	1	R 4092
2002	Formal	2000	2	R 4798
2003	Formal	2002	3	R 6575
2005	Formal	2004	4	R 8099
2007	Formal	2006	5	6957
2008	Interim	2007	N/A	8148
2009	Formal	2008	6	9046
2010 (this report)	Interim	2009	N/A	10503

1.2 Purpose of the UKOPA Database

The purpose of the UKOPA database is to:

- Estimate leak and pipeline rupture frequencies for UK pipelines, based directly on historical failure rate data for UK pipelines
- Provide the means to estimate failure rates for UK pipelines for risk assessment purposes based on analysis of damage data for UK pipelines
- Provide a more realistic and rigorous approach to the design and routing of pipelines
- Provide the means to test design intentions and determine the effect of engineering changes (e.g. wall thickness of pipe, depth of burial, diameter, protection measures, inspection methods and frequencies, design factor etc).

1.3 Key Advantages

The database is designed to reflect the ways in which the UKOPA operators design, build, operate, inspect and maintain their pipeline systems. Although the pipeline and failure data are extensive, there are pipeline groups (e.g. large diameter, recently constructed pipelines) on which no failures have occurred; however, it is unreasonable to assume that the failure frequency for these pipelines is zero. Similarly, further pipeline groups exist for which the historical failure data are not statistically significant.

Unlike its Europe-wide EGIG* counterpart, this UKOPA database contains extensive data on pipeline failures and on part-wall damage, allowing prediction of failure frequencies for pipelines for which inadequate failure data exist. Using Structural Reliability Analysis it is possible to determine the range of defect dimensions that will cause a specific pipeline to fail; analysis of the statistical distributions of actual defect dimensions from the part-wall defect data allows the probability of a critical defect to be determined and failure frequencies for any credible failure mechanism to be calculated. This approach has been used extensively and successfully by one of the contributing companies in recent pipeline uprating projects.

*European Gas Pipeline Incident Data Group (gas loss incidents in gas transmission pipelines operating above 15 bar).

2 DATABASE CONTENT

2.1 Pipeline System Data

2.1.1 Exposure

The total length of Major Accident Hazard Pipelines (MAHPs - see UK statutory legislation, The Pipelines Safety Regulations 1996 (PSR96), for their definition), above ground, below ground and elevated, in operation at the end of 2009 for all participating companies (National Grid, Scotia Gas Networks, Northern Gas Networks, Wales and West Utilities, BP, Shell UK Limited, Shell EPE, Ineos, SABIC and E-ON UK) is 22,314.53 km. The total exposure in the period 1952 to the end of 2009 is 762,350.03 km.yr; the development of this exposure is illustrated in Figure 1.

Exposure of Pipeline before first recorded incident in 1962 = 3644.28 km.yr (included in exposure and incident frequency calculations)
Length of Pipeline which has unknown commissioning date = 45.30 km [1]. (This has been ignored in the exposure calculations)
Exposure to end 2009 of Elevated Pipeline = 26.10 km.yr (included in totals)
Exposure to end 2009 of Above Ground Pipeline = 437.74 km.yr (included in totals)

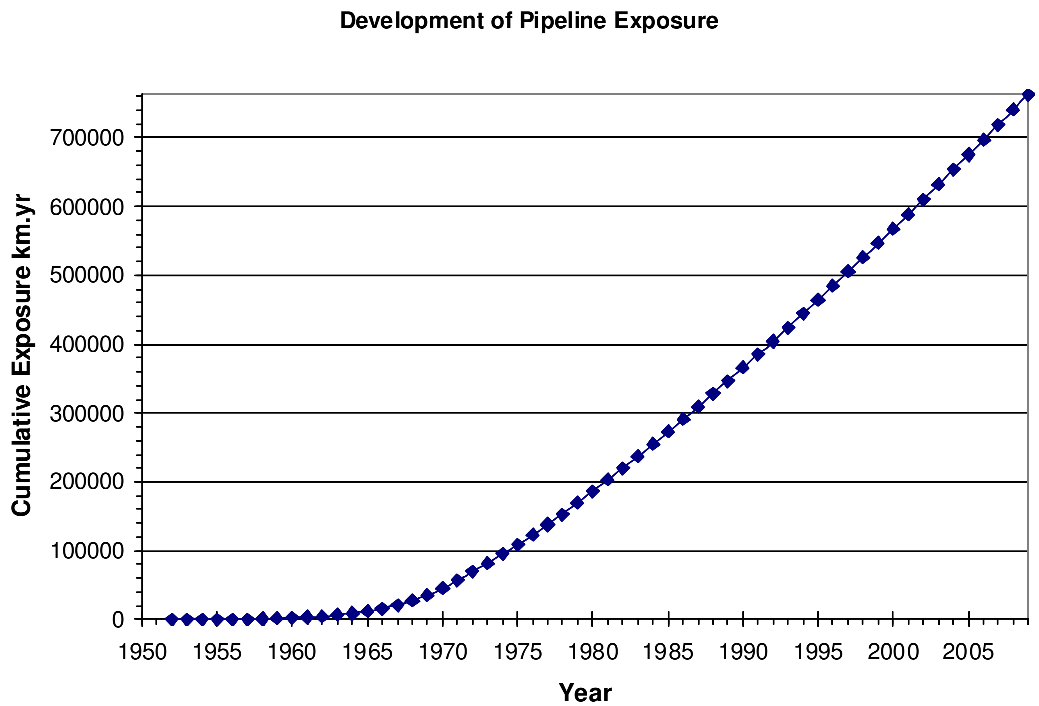


Figure 1

[1] The length of pipeline with unknown commissioning date has slightly reduced from 45.77 km in 2008 to 45.30 due to decommissioning.

2.1.2 Transported Products

The lengths of pipeline in operation at the end of 2009, by transported product, are (in km):

Butane	19.5	LPG	0.34
Condensate	24.0	Natural Gas (Dry)	20,575.36
Crude Oil (Spiked)	212.6	Other	233.05
Ethane	38.1	Propane	19.5
Ethylene	1141	Propylene	37
Hydrogen	14.14		
		TOTAL PIPELINE LENGTH	**22,314.59**

2.2 Product Loss Incident Data

A product loss incident is defined in the context of this report as:

- an unintentional loss of product from the pipeline
- within the public domain and outside the fences of installations
- excluding associated equipment (e.g. valves, compressors) or parts other than the pipeline itself

A total of 182 product loss incidents were recorded over the period between 1962 and 2009 compared with 179 product loss incidents documented in the previous report. The additional 3 incidents have been recorded during 2009. No product loss incidents were recorded prior to 1962. An annual breakdown of incidents is illustrated in Figure 2a. The cumulative number of incidents over the period 1962 to 2009 is shown in Figure 2b.

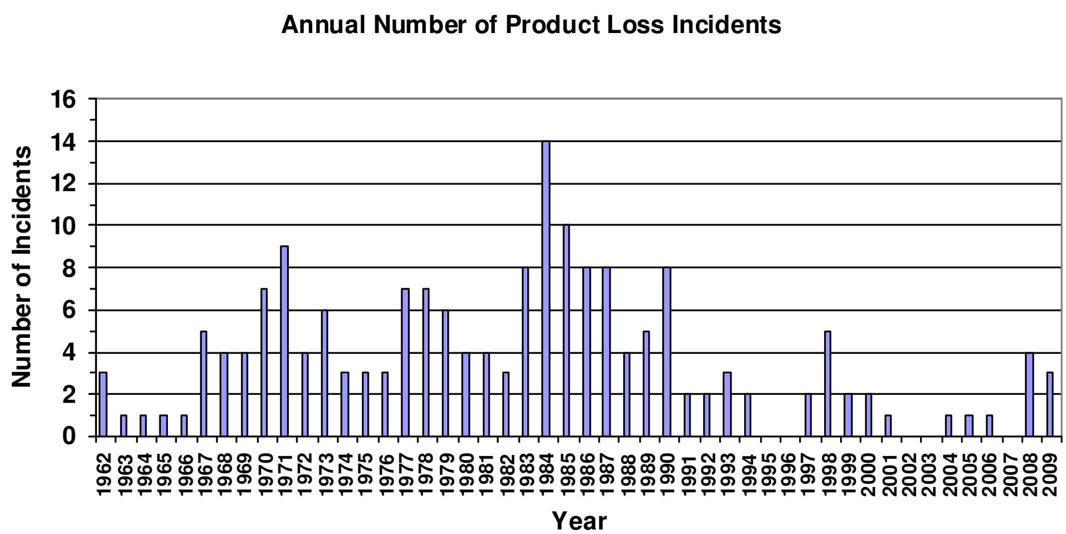


Figure 2a

Figure 2b

2.2.1 Incident Ignition

There were 9 out of 182 (4.9%) product loss incidents that resulted in ignition. Table 1 below provides more detail:

Affected Component	Cause Of Fault	Hole Diameter Class
Pipe	Pipe Defect	0-6 mm
Bend	Pipe Defect	0-6 mm
Pipe	Girth Weld Defect	6-20 mm
Bend	Pipe Defect	6-20 mm
Pipe	Unknown	6-20 mm
Pipe	Ground Movement	Full Bore and Above (18" Diameter Pipe)
Pipe	Unknown	40-110 mm
Pipe	Seam Weld Defect	0-6 mm
Pipe	Lightning Strike	0-6 mm

Table 1 – Incidents that Resulted in Ignition

2.2.2 Incident Frequency

The incident frequency over eight consecutive 5-year periods up to the end of 2009 is shown in Table 2.

Period	Number of Incidents	Total Exposure [1000 km.yr]	Frequency [Incidents per 1000 km.yr]
1970 - 1974	29	59.501	0.487
1975 - 1979	26	74.132	0.351
1980 - 1984	33	85.069	0.388
1985 - 1989	35	91.945	0.381
1990 - 1994	17	97.417	0.175
1995 - 1999	9	102.242	0.088
2000 - 2004	4	106.724	0.037
2005 - 2009	9	109.724	0.082

Table 2

The overall incident frequency by hole size over the period 1962 - 2009 is shown in Table 3.

Hole Size Class	Number of Incidents	Frequency [Incidents per 1000 km.yr]
Full Bore* and Above	7	0.009
110mm – Full Bore*	3	0.004
40mm – 110mm	7	0.009
20mm – 40mm	21	0.028
6mm – 20mm	27	0.035
0 – 6mm	110	0.144
Unknown	7	0.009

Table 3

* Full Bore ≡ diameter of pipeline

Note that there are 7 incidents of unknown hole size.

The failure frequency over the last 5 years (2005-2009) is 0.082 incidents per 1000 km.yr as compared to the failure frequency during the period 1962-2009 which is 0.239 incidents per year per 1000 km.yr. There is an increase over the last 5 year incident rate, but is within the expected variation shown over the last ten years. An overview of the development of this failure frequency over the period 1962 to 2009 is shown in Figure 3.

In order to see the results over recent periods, without influence of the past, the moving average for each year is calculated with reference to the incidents from the previous 5 years (2005-2009, 2000-2004, 1995-1999 etc).

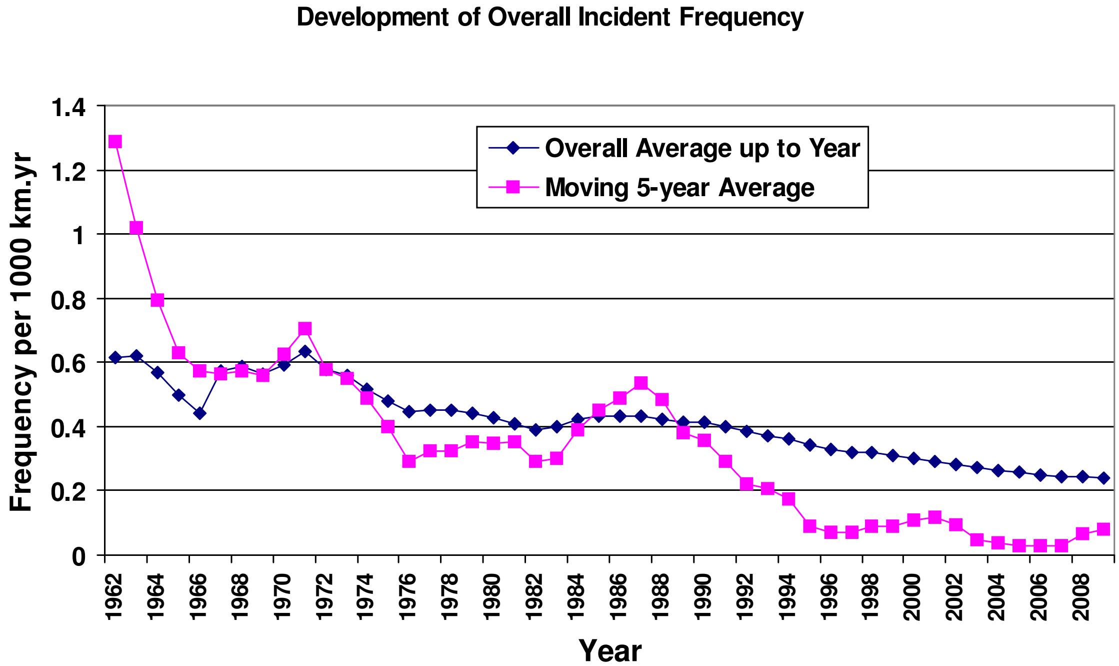


Figure 3

2.2.3 Incident Frequency by Cause

The development of product loss incident frequency by cause is shown in Figure 4.

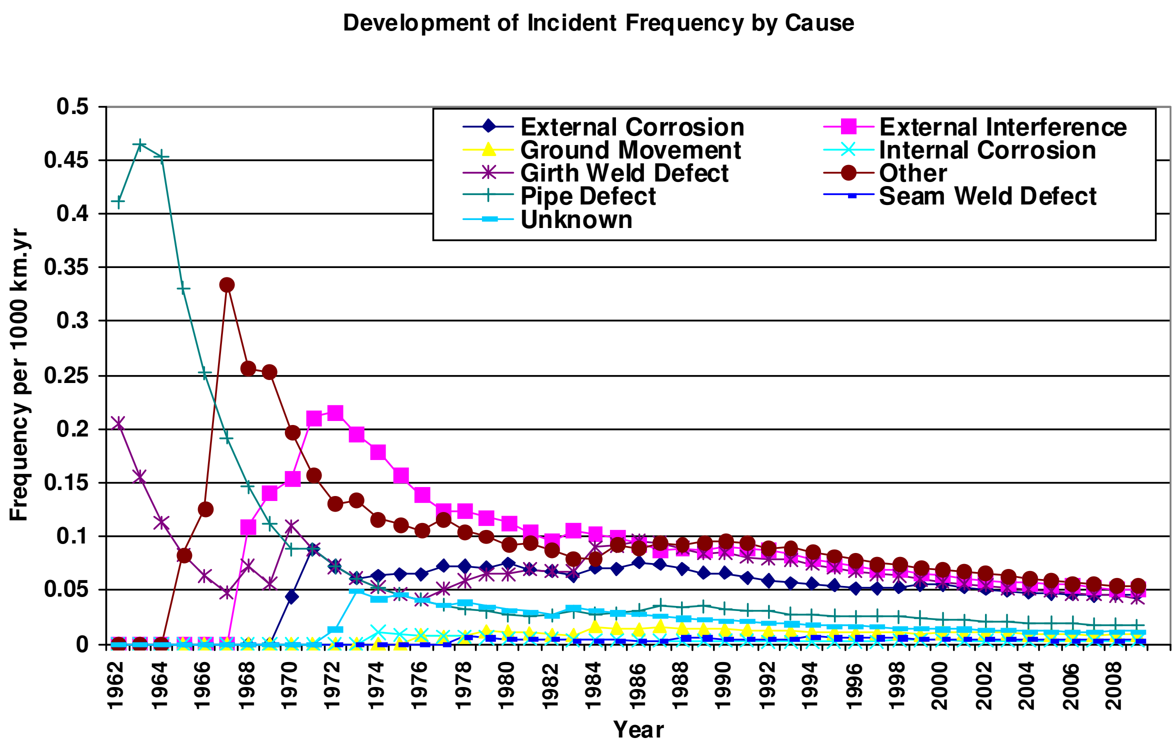


Figure 4

Product Loss Cause	No. of Incidents
Girth Weld Defect	34
External Interference	39
Internal Corrosion	2
External Corrosion	35
Unknown	8
Other	41
Pipe Defect	13
Ground Movement	7
Seam Weld Defect	3
Total	**182**

Cause = 'Other':

Other Cause	Incidents
Internal cracking due to wet town gas	30
Pipe-Fitting Welds	4
Leaking Clamps	3
Lightning	1
Soil stress	1
Threaded Joint	1
Electric Cable Arc Strike	1
Total	**41**

Table 4 – Product Loss Incidents by Cause

Figure 5 shows the product loss incident frequency by cause over the period 1962-2009 compared with the frequency over only the last 5 years (2005-2009).

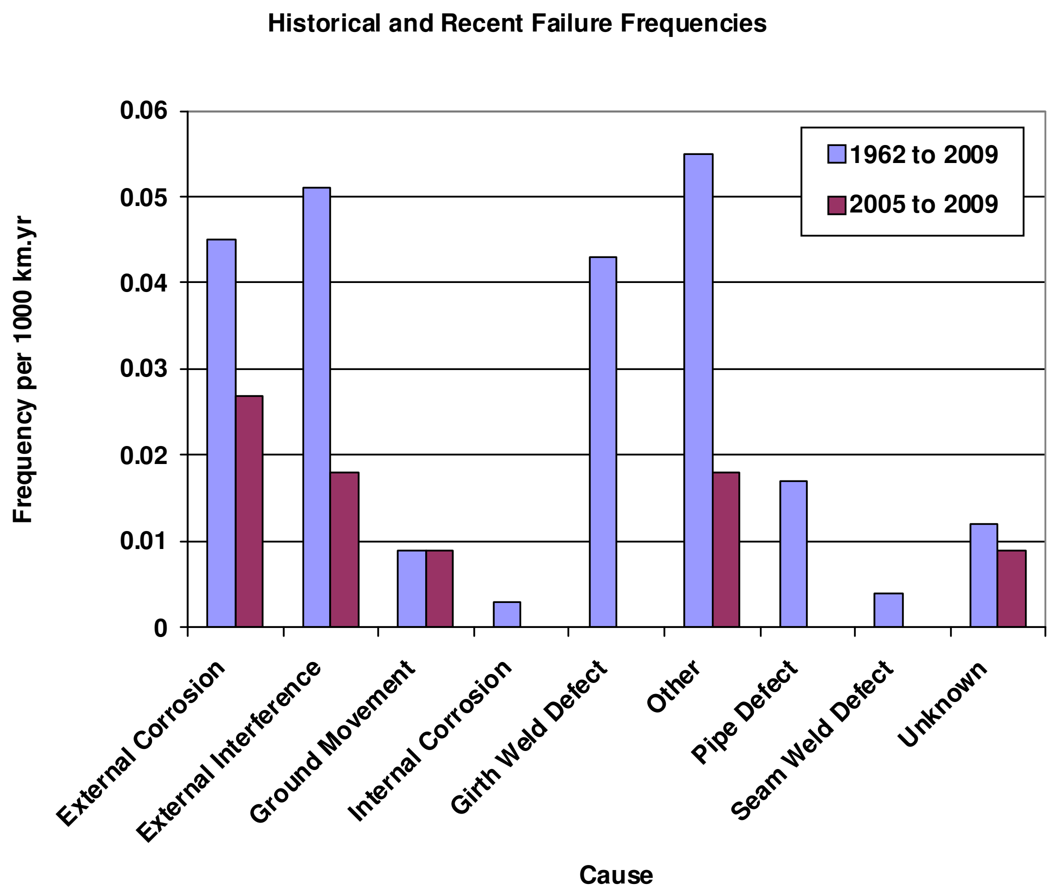
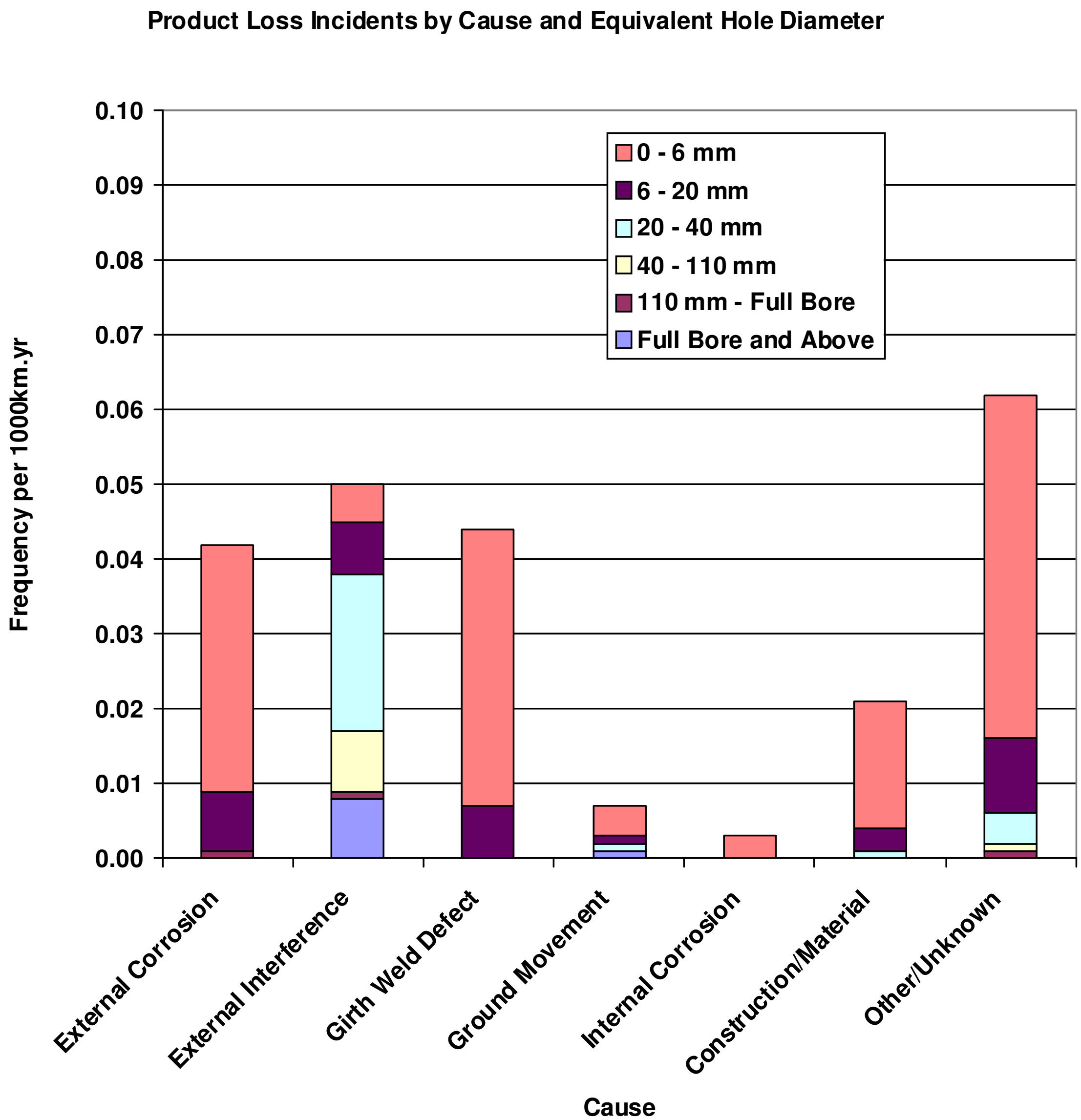

Historical and Recent Failure Frequencies
0.06
0.05
0.04
0.03
0.02
0.01
0
Frequency per 1000 km.yr
1962 to 2009
2005 to 2009
External Corrosion
External Interference
Ground Movement
Internal Corrosion
Girth Weld Defect
Other
Pipe Defect
Seam Weld Defect
Unknown
Cause

Figure 5

An overview of the product loss incident frequency by cause and size of leak in the period 1962 to 2009 is shown in Figure 6.



Construction/Material = Seam Weld Defect + Pipe Defect + Pipe Mill Defect + Damage During Original Construction

Figure 6

2.2.4 External Interference

Figure 6 shows that external interference is one of the main causes of product loss incident data.

2.2.4.1 External Interference by Diameter Class

Figure 7 shows the product loss incident frequencies associated with external interference by diameter class and by hole size.

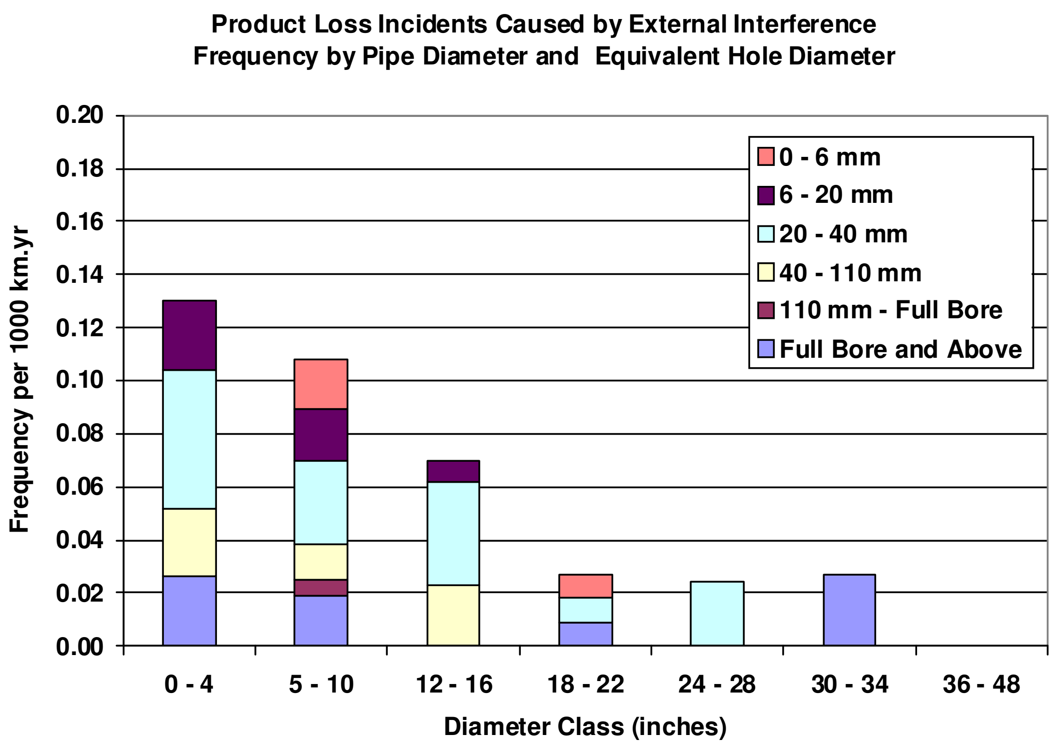


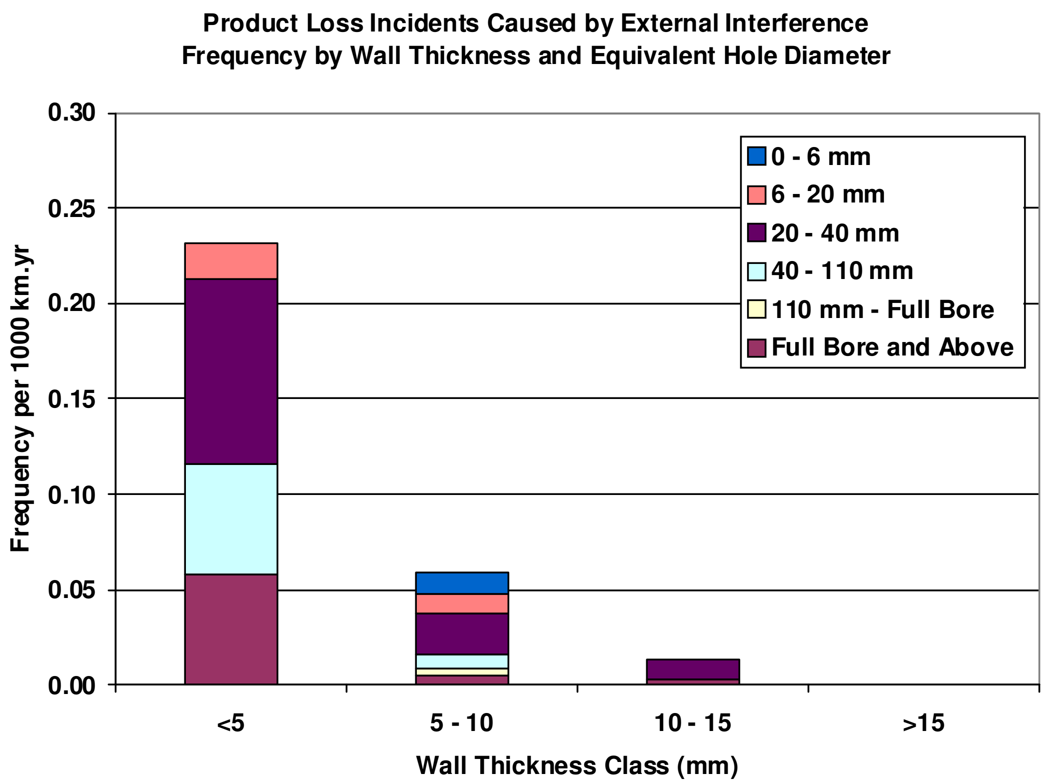
Figure 7

Diameter inches	Exposure km.yr	Incidents	Frequency /1000km.yr
0-4	38309	5	0.131
5-10	156734	18	0.115
12-16	129427	9	0.070
18-22	113995	3	0.026
24-28	123563	3	0.024
30-34	37000	1	0.027
36-48	163321	0	0.000
Total	**762350**	**39**	**0.051**

Table 5 – Exposure by Diameter Class

2.2.4.2 External Interference by Measured Wall Thickness Class

The relationship between product loss incidents caused by third party interference and wall thickness is shown in Figure 8.



Note: Largest wall thickness for loss of product incident caused by external interference to date is 12.7mm.

Figure 8

Wall Thickness mm	Exposure km.yr	Incidents	Frequency /1000 km.yr
<5	51475	12	0.233
5-10	372173	23	0.062
10-15	287861	4	0.014
>15	50840	0	0.000
Total	**762350**	**39**	**0.051**

Table 6 – Exposure by Wall Thickness Class

2.2.4.3 External Interference by Area Classification

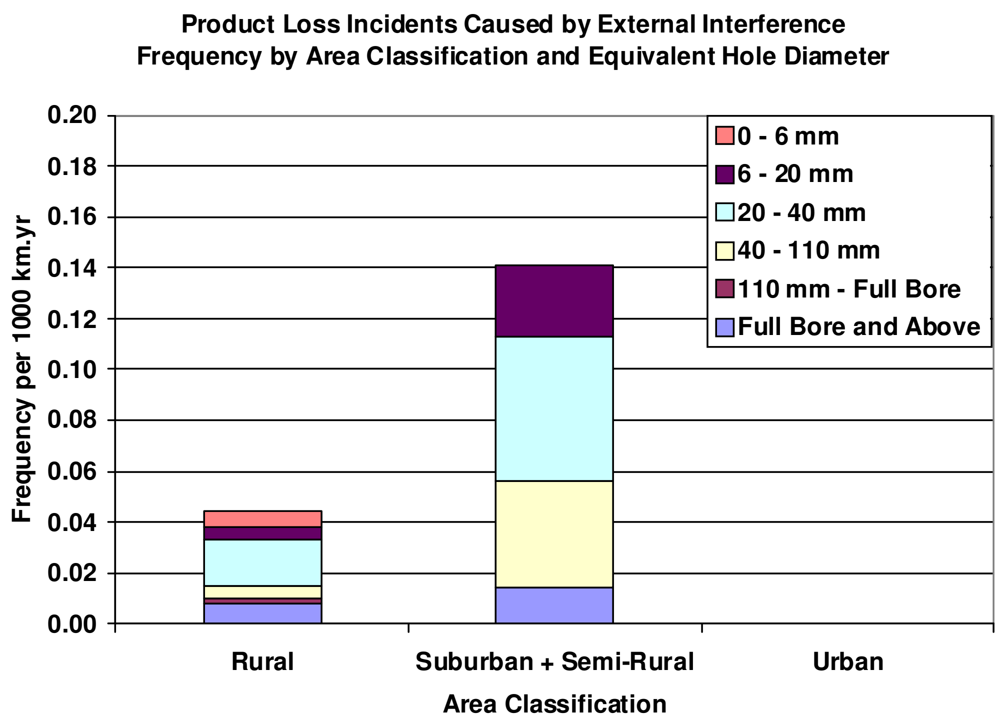


Figure 9

Area Classification	Exposure km.yr	Incidents	Frequency /1000 km.yr
Rural	650479	28	0.043
Suburban + Semi-Rural	70718	11	0.156
Urban	939	0	0.000
Total	**722135**	**39**	**0.054**

Table 7 – Exposure by Area Classification in km.yr

Note: Rural = population density < 2.5 persons per hectare
Suburban and Semi-rural = population density > 2.5 persons per hectare and which may be extensively developed with residential properties
Urban = Central areas of towns or cities with a high population density

The total exposure given in Table 7 is lower than the actual exposure total presented in Section 2. In some cases this is because the area classification is unknown. However, the pipeline length in terms of its location above or below ground is entered independently from the pipeline length entered in terms of area classification for the same pipeline. This may lead to circumstances where there are inconsistencies between the two datasets.

2.2.5 External Corrosion

2.2.5.1 External Corrosion by Wall Thickness Class

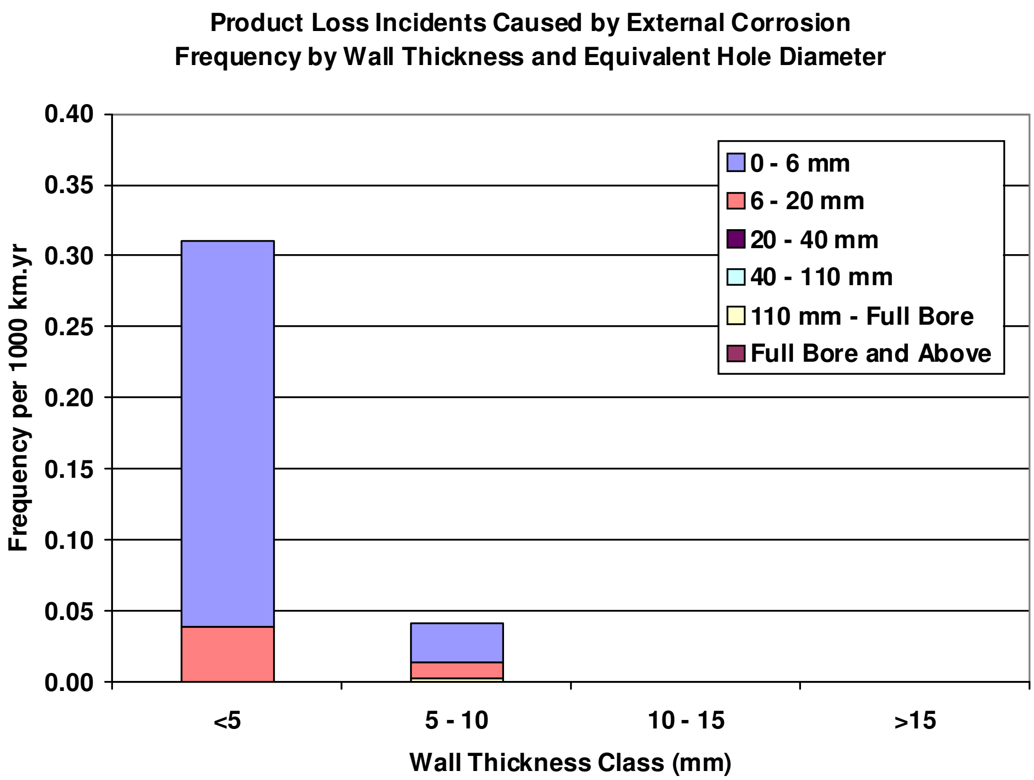


Figure 10

Wall Thickness (mm)	Exposure km.yr	Incidents	Frequency /1000 km.yr
<5	51475	18	0.350
5-10	372173	17	0.045
10-15	287861	0	0.000
>15	50840	0	0.000
Total	**762350**	**35**	**0.045**

Table 8 – Exposure by Wall Thickness Class

2.2.5.2 External Corrosion by Year of Construction

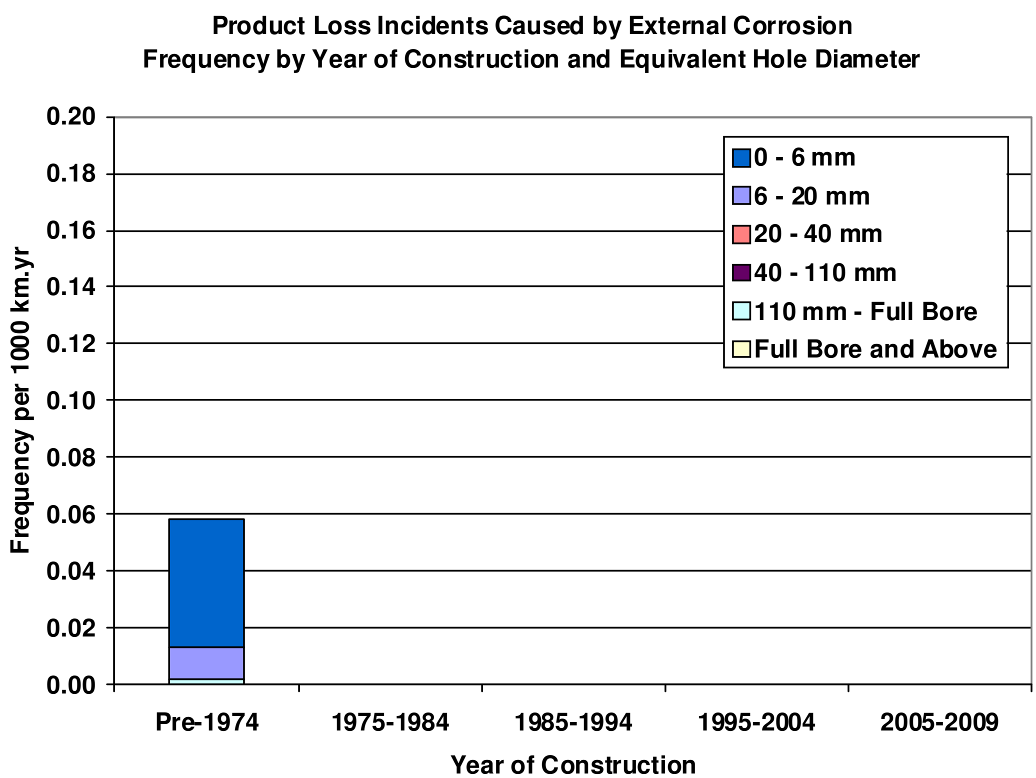


Figure 11

Construction Year	Exposure km.yr	Incidents	Frequency /1000 km.yr
Pre-1974	551000	35	0.064
1975-1984	150687	0	0.000
1985-1994	44600	0	0.000
1995-2004	14054	0	0.000
2005-2009	2009	0	0.000
Total	**762350**	**35**	**0.046**

Table 9 – Exposure by Year of Construction

2.2.5.3 External Corrosion by External Coating Type

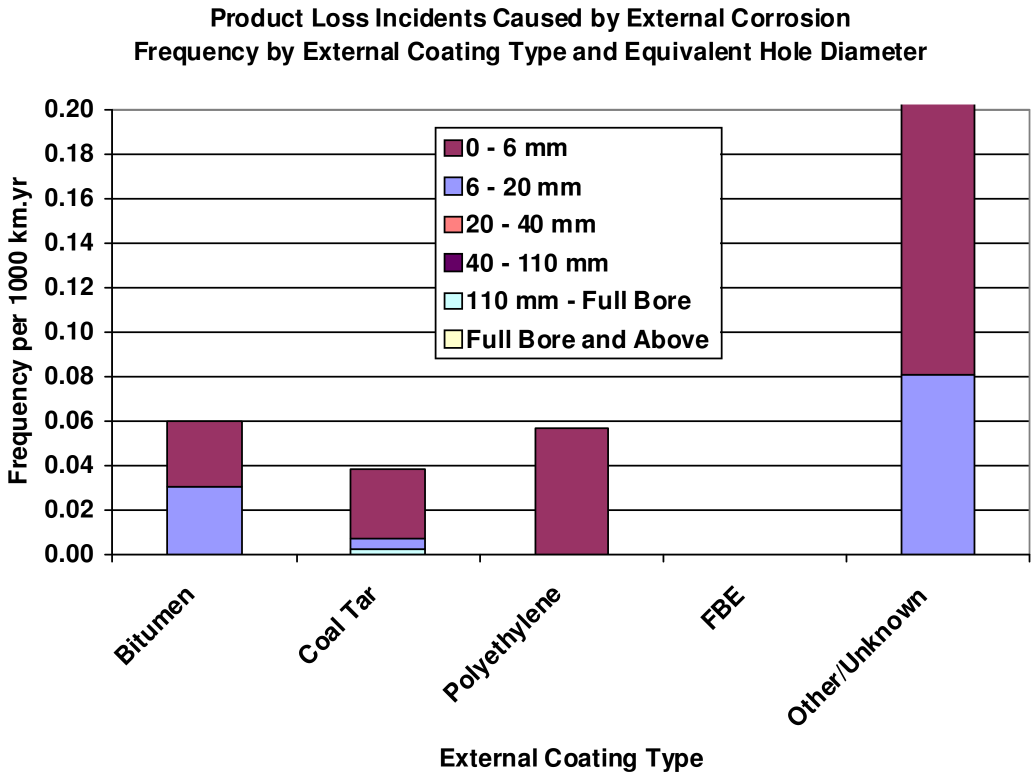


Figure 12

External Coating	Exposure km.yr	Incidents	Frequency /1000 km.yr
Bitumen	33775	3	0.089
Coal Tar	589896	24	0.041
Polyethylene	52640	3	0.057
FBE	71288	0	0.000
Other/Unknown	24620	5	0.203
Total	**772221**	**35**	**0.045**

Table 10 – Exposure by External Coating Type

The total exposure in Table 10 above is higher than the actual exposure reported in Section 2. This is because a pipe section may have more than one coating and the database double counts the pipe length, once for each coating type.

2.2.5.4 External Corrosion by Type of Backfill

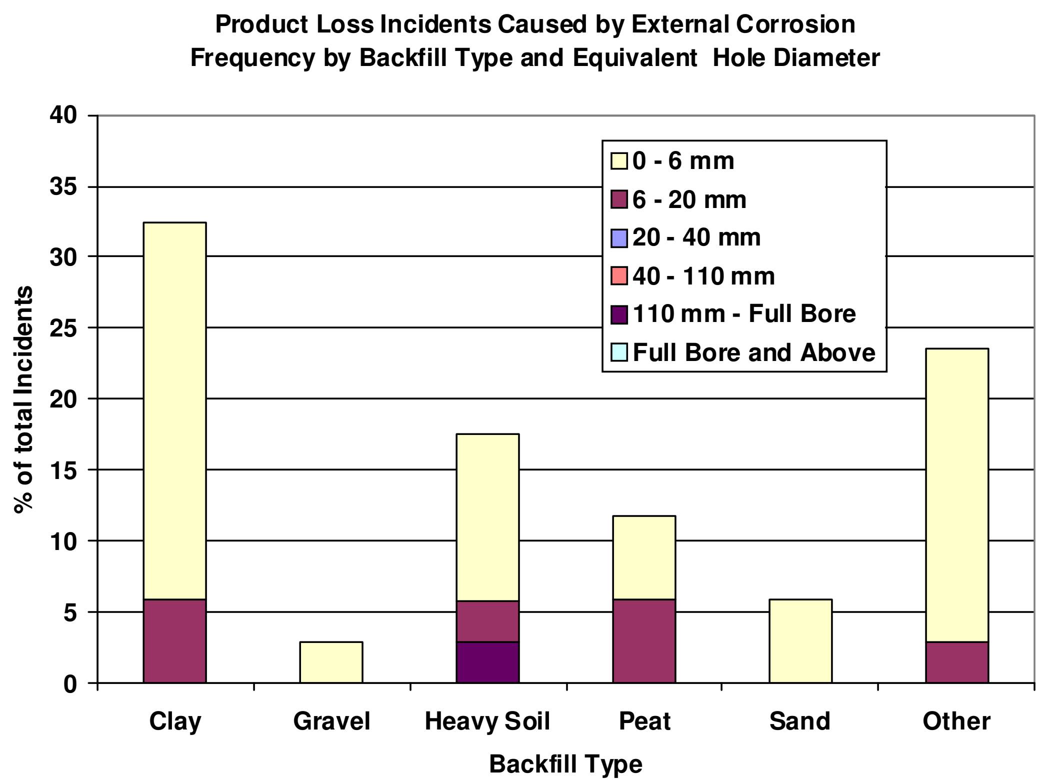


Figure 13

2.2.6 Detection

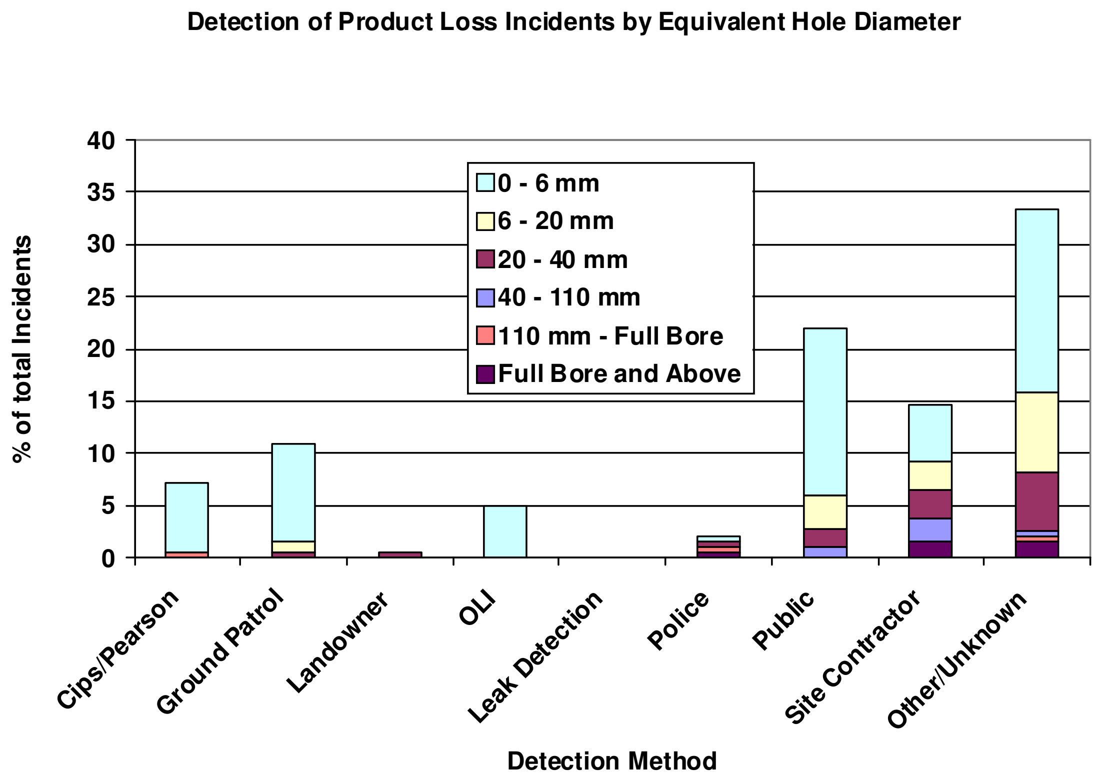


Figure 14

Note: Leak detection and In-Line Inspection (ILI) are not applicable to all pipelines.