Report Number: 9046
Issue: 1.0

UKOPA PIPELINE FAULT DATABASE

Pipeline Product Loss Incidents

(1962 - 2008)

6th 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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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 2008. 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 2008 is 0.242 incidents per 1000 km.year, whilst in the previous report this figure was 0.248 incidents per 1000 km.year (covering the period from 1962 to 2006).

The failure frequency over the last 5 years is 0.064 incidents per 1000 km.year, whilst in the previous report this figure was 0.028 incidents per 1000 km.year (covering the 5 year period up to the end of 2006).

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 (this report)	Formal	2008	6	9046

1.2 Purpose of the Database

The purpose of the 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 2008 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 22,312.56 km. The total exposure in the period 1952 to the end of 2008 is 740,977.71 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[1])
Length of Pipeline which has unknown commissioning date = 45.77 km. (This has been ignored in the exposure calculations)
Exposure to end 2008 of Elevated Pipeline = 26.50 km.yr (included in totals)
Exposure to end 2008 of Above Ground Pipeline = 331.90 km.yr (included in totals)

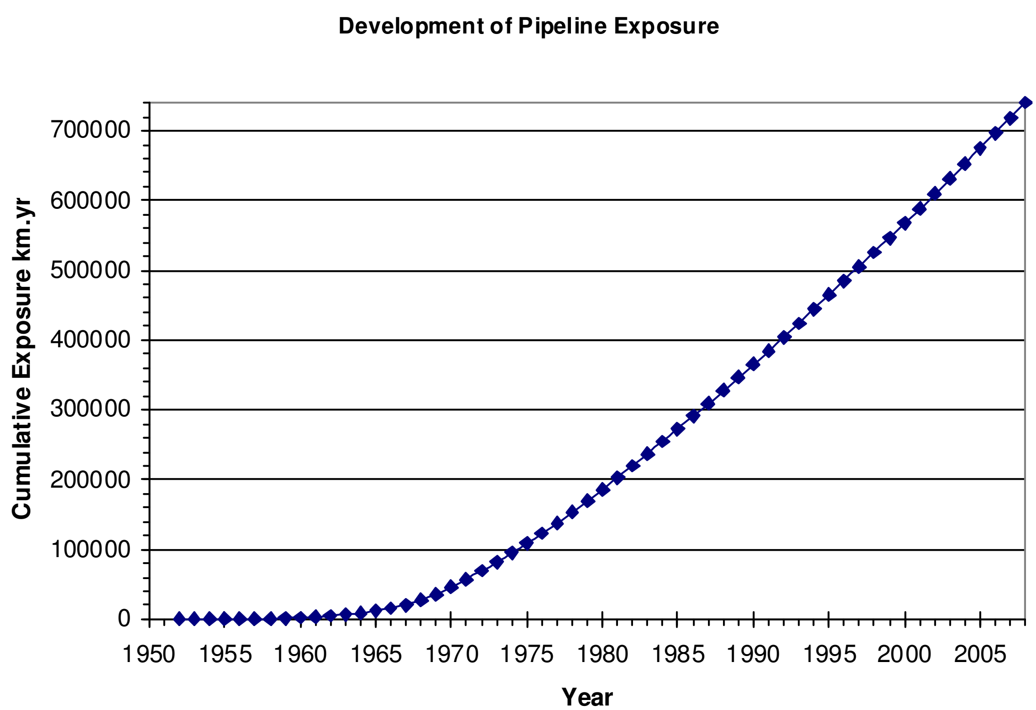


Figure 1

[1] *- This exposure is lower than that recorded in the previous report. A review of the data was carried out; as part of this review some of the commission/decommission dates were revised and this is reflected in the exposure data,*

2.1.2 Transported Products

The lengths of pipeline in operation at the end of 2008, by transported product, are (in km):

Butane	19.5	LPG	0.34
Condensate	24.0	Natural Gas (Dry)	20,574.69
Crude Oil (Spiked)	212.6	Other	225.8
Ethane	38.1	Propane	19.5
Ethylene	1141	Propylene	36.3
Hydrogen	14.14	Gasoline	6.5
		TOTAL PIPELINE LENGTH	**22,312.47**

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 179 product loss incidents were recorded over the period between 1962 and 2008 compared with 174 product loss incidents documented in the previous report. The additional five incidents comprise of 4 incidents recorded in 2008 and one from 2000 which has recently been added to the database. 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 2008 is shown in Figure 2b.

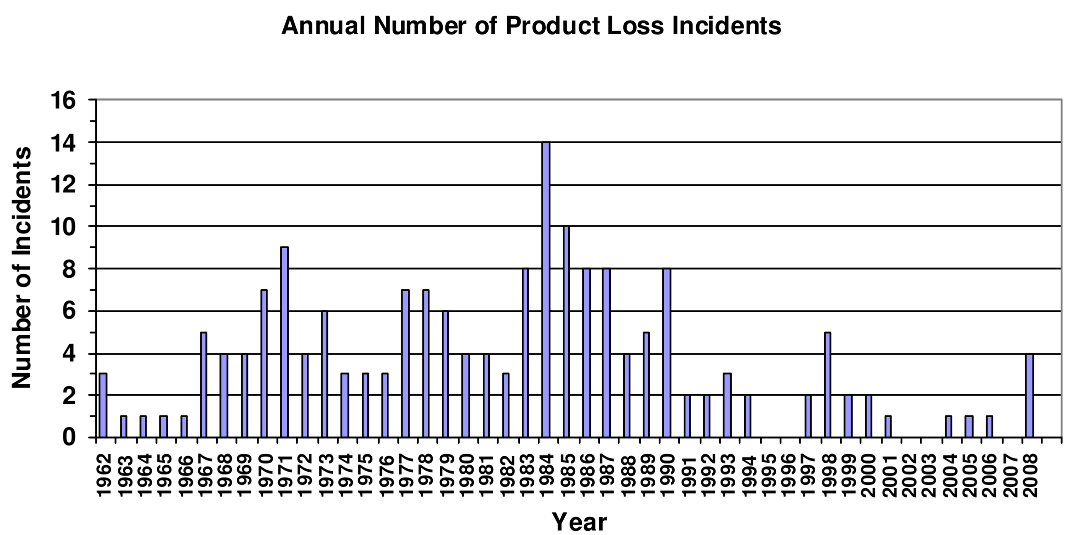


Figure 2a

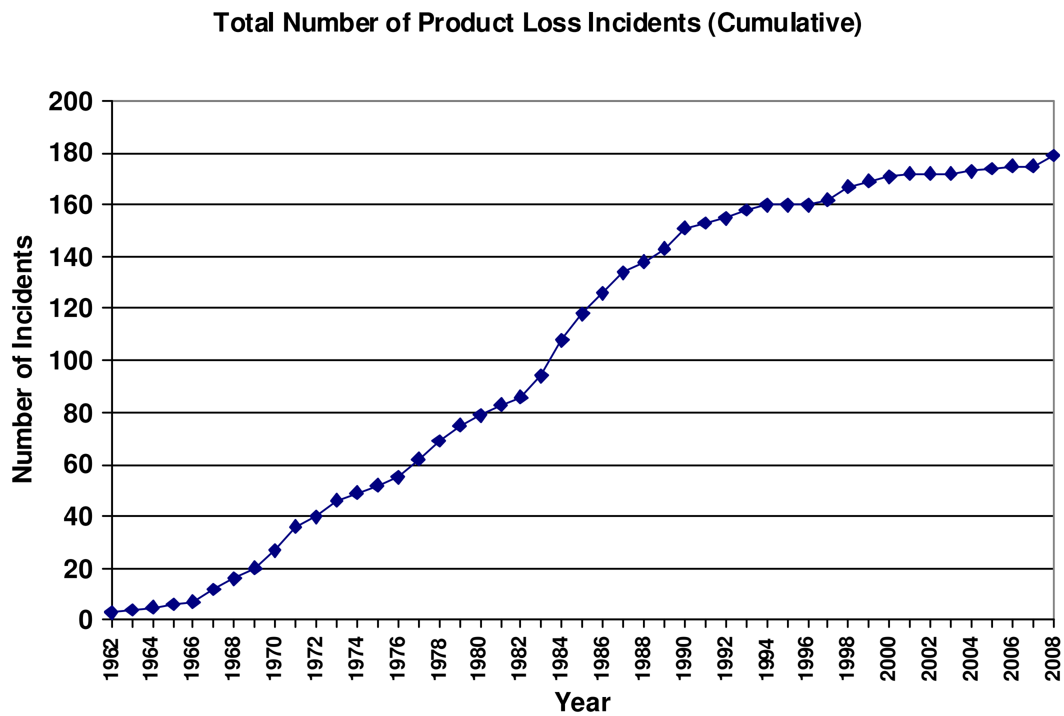


Figure 2b

2.2.1 Incident Ignition

There were 9 out of 179 (5%) product loss incidents that resulted in ignition. Table 1 below provides more detail:

Affected Component	Cause Of Fault	Hole Diameter Class
Pipe	Seam Weld Defect	0-6 mm
Pipe	Ground Movement	Full Bore and Above (18" Diameter Pipe)
Pipe	Girth Weld Defect	6-20 mm
Pipe	Unknown	6-20 mm
Pipe	Pipe Defect	0 – 6 mm
Pipe	Unknown	40 – 110 mm
Pipe	Lightning Strike	0-6 mm
Bend	Internal Corrosion	0-6 mm
Bend	Pipe Defect	6-20 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 2008 is shown in Table 2.

Period	Number of Incidents	Total Exposure [1000 km.yr]	Frequency [Incidents per 1000 km.yr]
1969 - 1973	30	54.749	0.548
1974 - 1978	23	71.168	0.323
1979 - 1983	25	83.716	0.299
1984 - 1988	44	90.979	0.484
1989 - 1993	20	96.087	0.208
1994 - 1998	9	101.799	0.088
1999 - 2003	5	105.792	0.047
2004 - 2008	7	109.295	0.064

Table 2

The overall incident frequency by hole size over the period 1962 - 2008 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	0.036
0 – 6mm	110	0.148
Unknown	4	0.005

Table 3

* Full Bore ≡ diameter of pipeline

Note that there are 4 incidents of unknown hole size.

The failure frequency over the last 5 years (2004-2008) is 0.064 incidents per 1000 km.yr as compared to the failure frequency during the period 1962-2008 which is 0.242 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 2008 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 (2004-2008, 1999-2003, 1994-1998 etc).

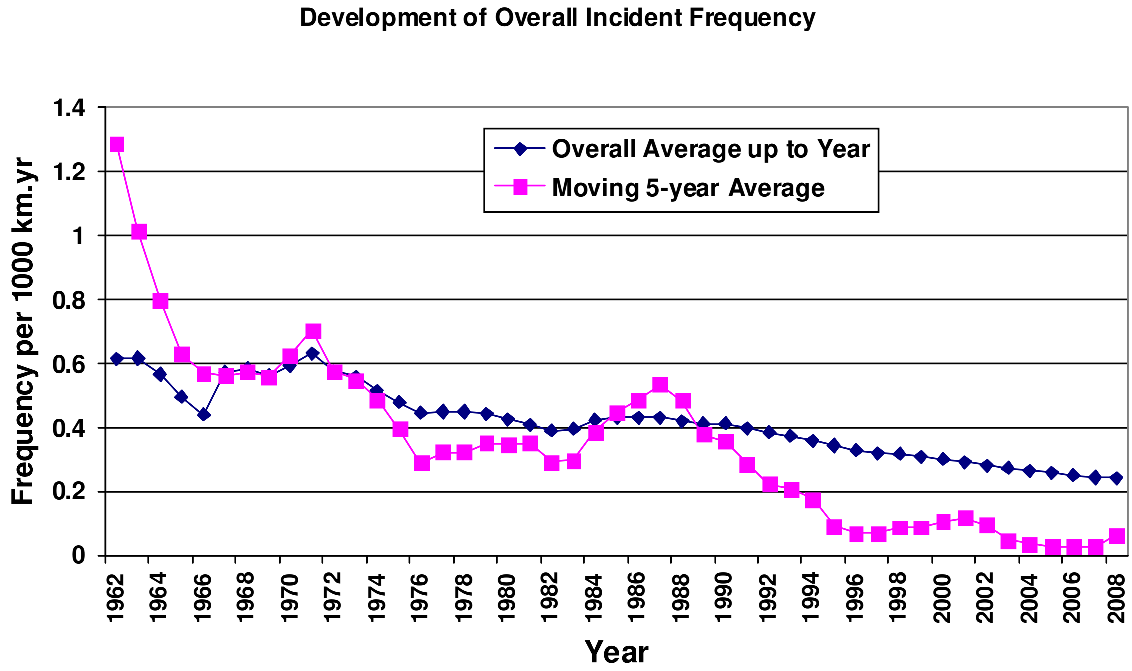

Development of Overall Incident Frequency
Overall Average up to Year
Moving 5-year Average
Frequency per 1000 km.yr
Year
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008

Figure 3

2.2.3 Incident Frequency by Cause

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

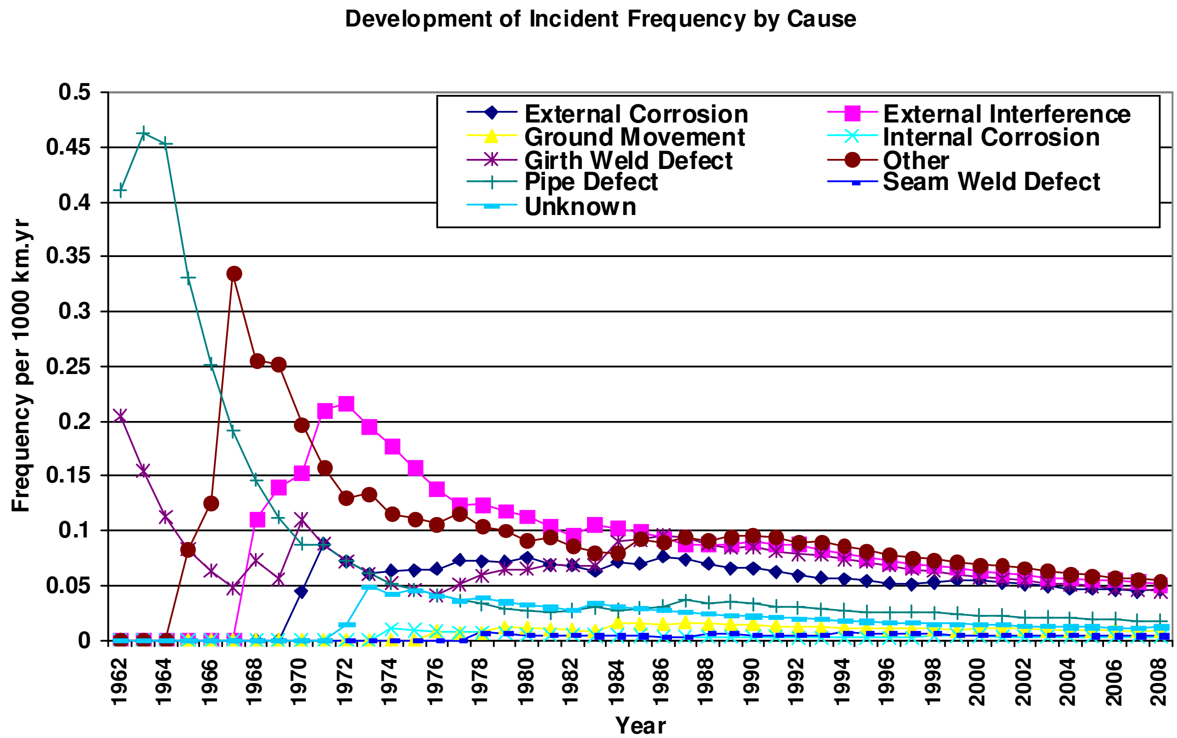


Figure 4

Product Loss Cause	**No. of Incidents**
Girth Weld Defect	33
External Interference	38
Internal Corrosion	2
External Corrosion	34
Unknown	9
Other	40
Pipe Defect	13
Ground Movement	7
Seam Weld Defect	3
Total	**179**

Cause = 'Other':

Other Cause	**Incidents**
Internal cracking due to wet town gas	30
Pipe-Fitting Welds	4
Leaking Clamps	2
Lightning	1
Soil stress	1
Threaded Joint	1
Electric Cable Arc Strike	1
Total	**40**

Table 4 – Product Loss Incidents by Cause

Figure 5 shows the product loss incident frequency by cause over the period 1962-2008 compared with the frequency over only the last 5 years (2004-2008).

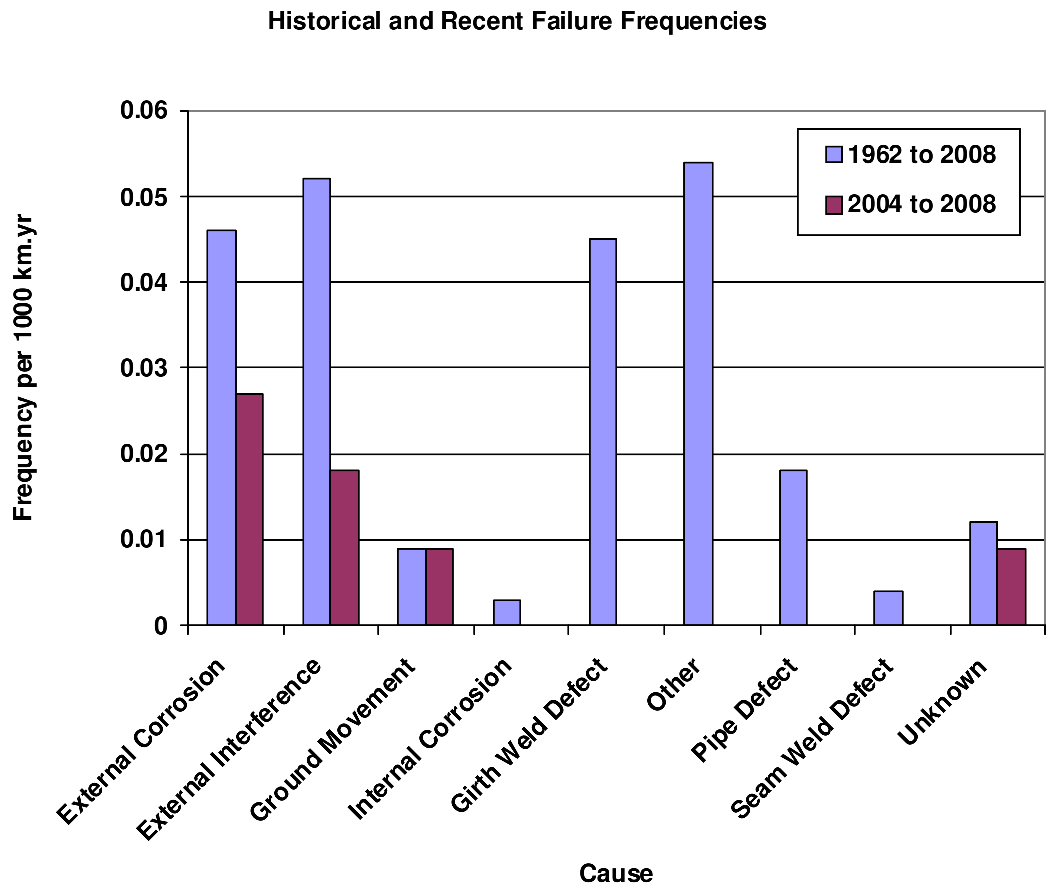
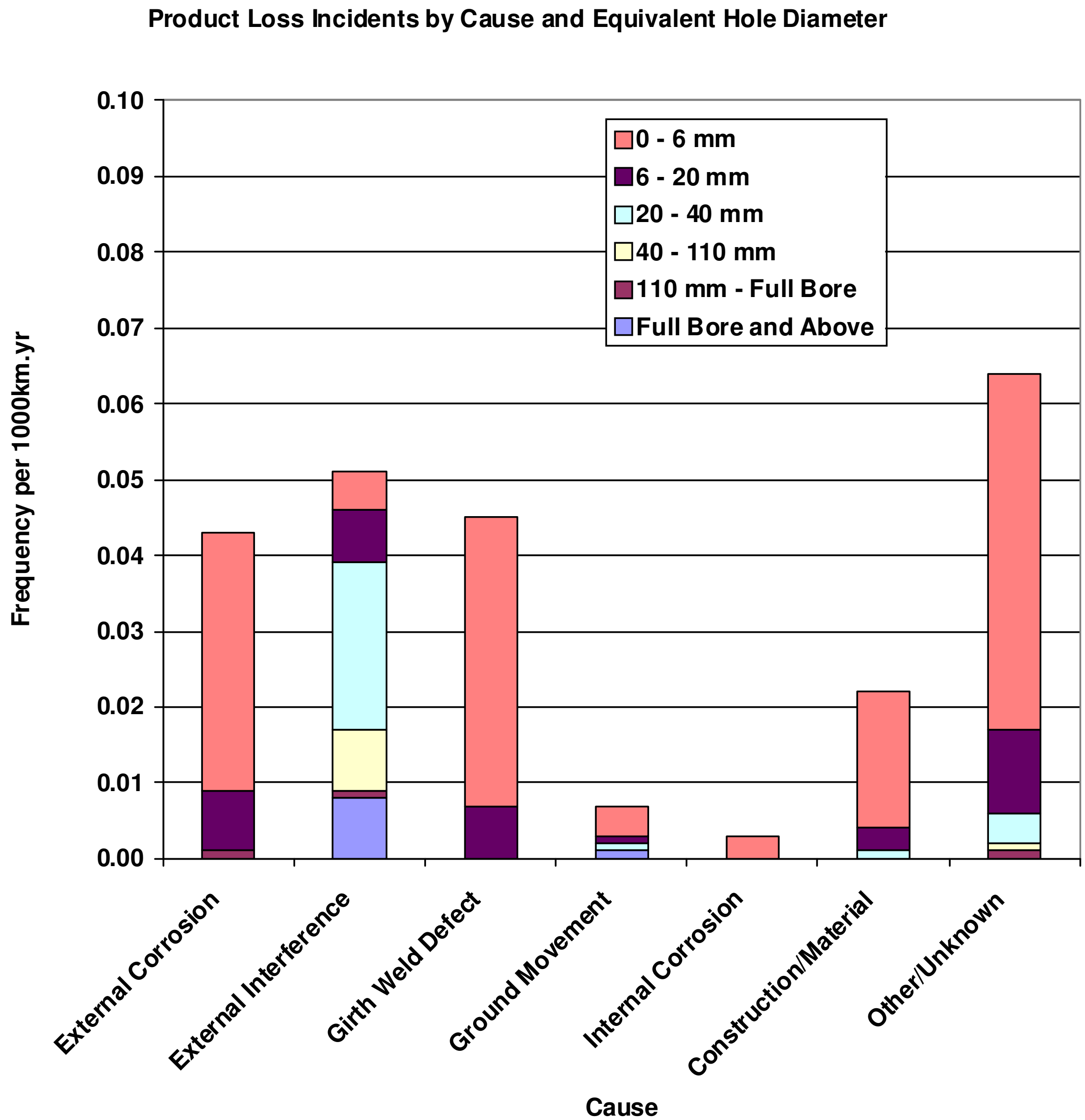


Figure 5

An overview of the product loss incident frequency by cause and size of leak in the period 1962 to 2008 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.

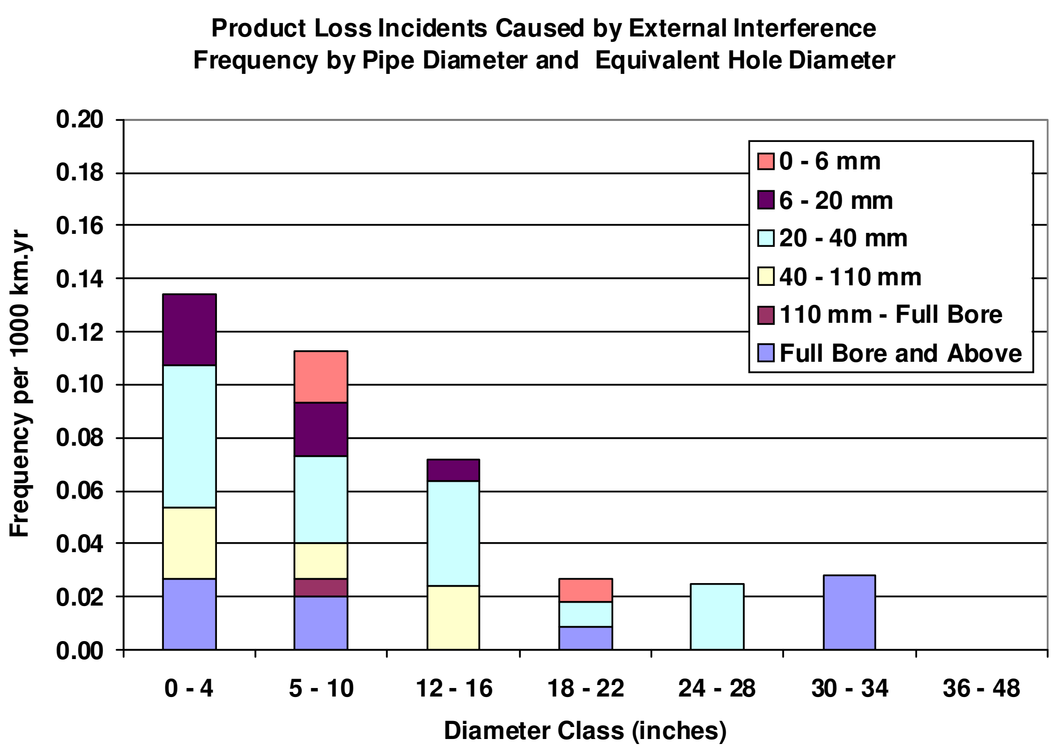


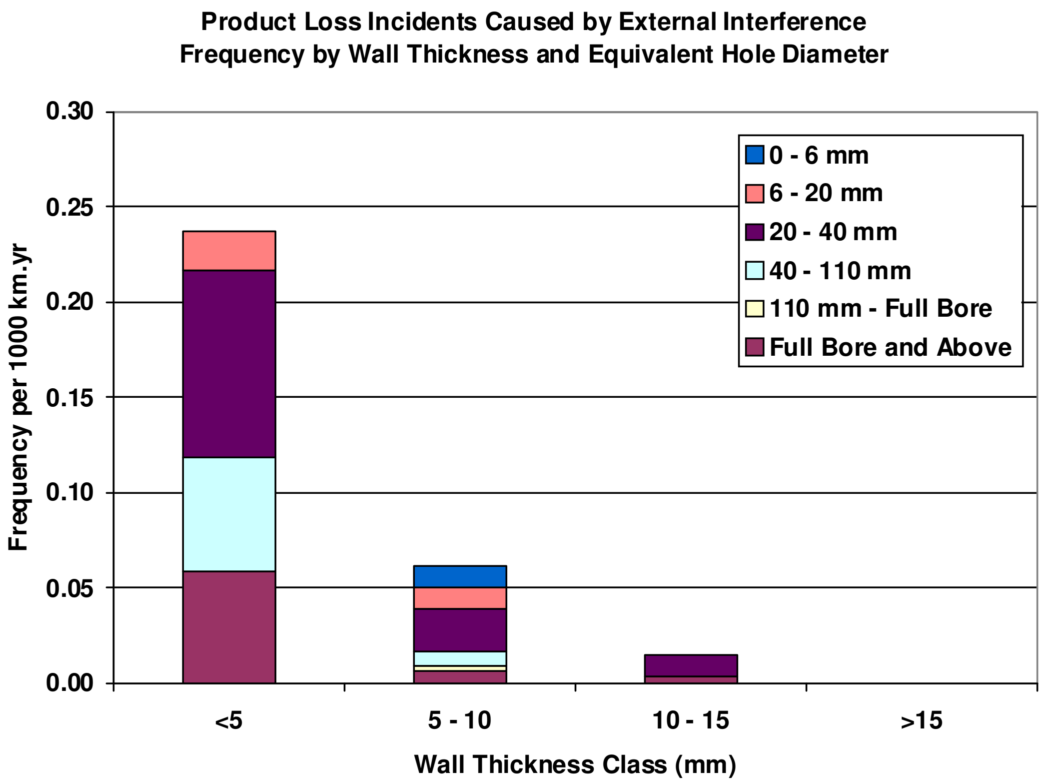
Figure 7

Diameter inches	Exposure km.yr	Incidents	Frequency /1000km.yr
0-4	37467	5	0.133
5-10	153141	17	0.111
12-16	126229	9	0.071
18-22	111132	3	0.027
24-28	120232	3	0.025
30-34	35990	1	0.028
36-48	156786	0	0.000
Total	**740978**	**38**	**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	50499	12	0.238
5-10	362585	22	0.061
10-15	279036	4	0.014
>15	48858	0	0.000
Total	**740978**	**38**	**0.051**

Table 6 – Exposure by Wall Thickness Class

2.2.4.3** External **Interference by Area Classification

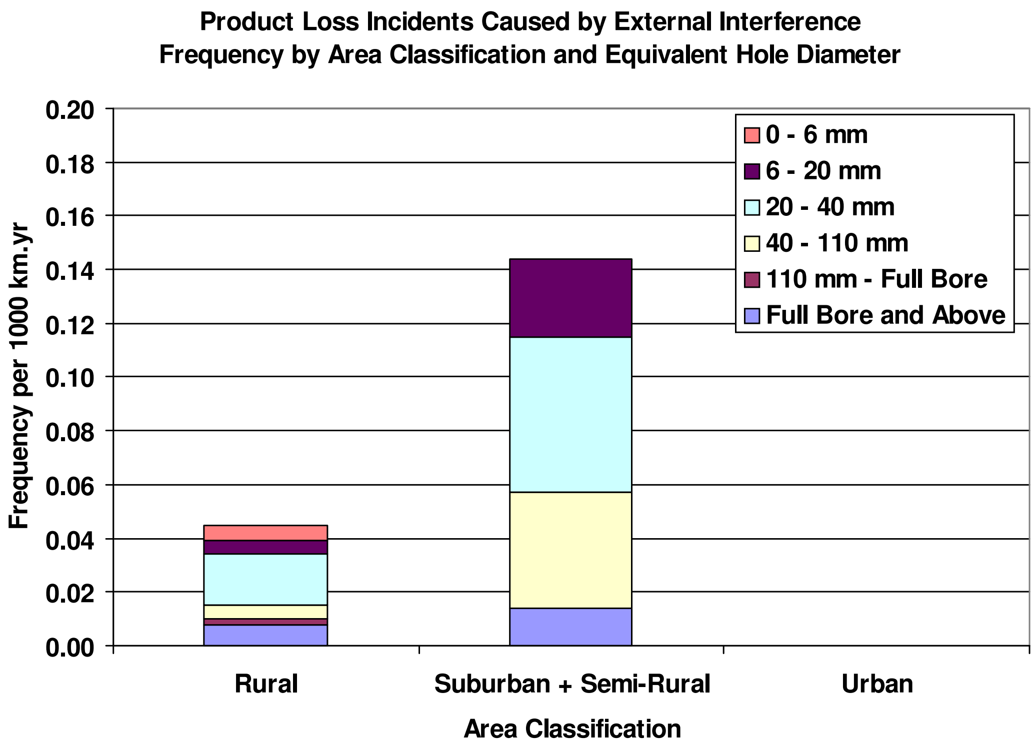


Figure 9

Area Classification	Exposure km.yr	Incidents	Frequency /1000 km.yr
Rural	631019	28	0.044
Suburban + Semi-Rural	68984	10	0.145
Urban	819	0	0.000
Total	**700823**	**38**	**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

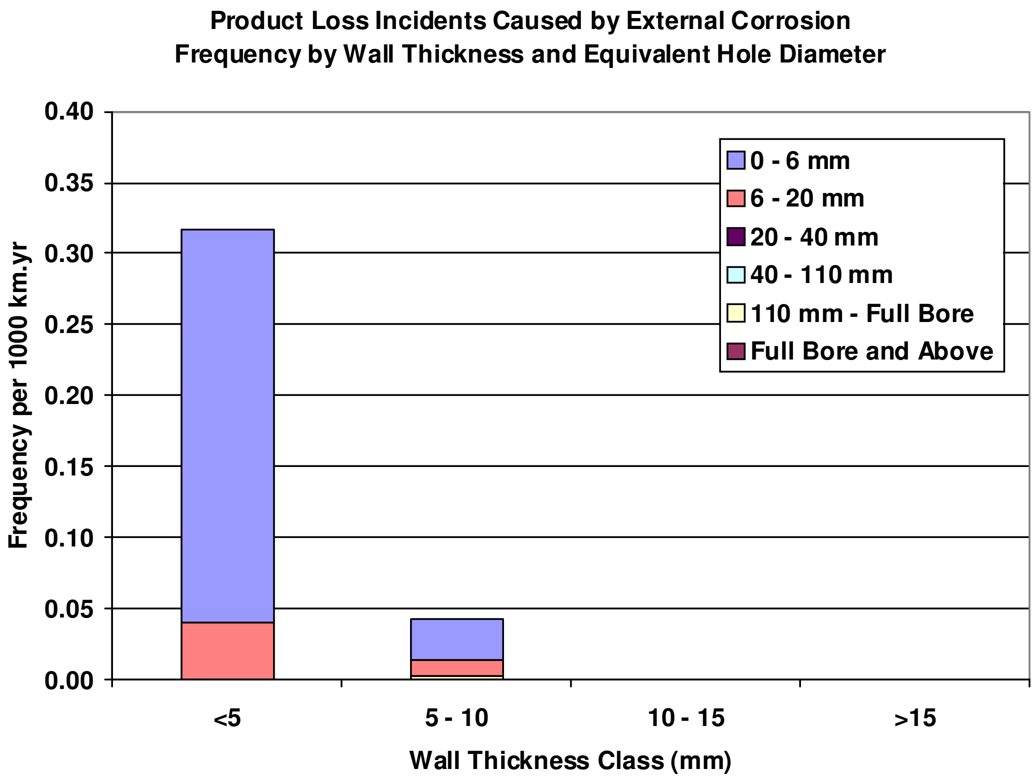


Figure 10

Wall Thickness (mm)	Exposure km.yr	Incidents	Frequency /1000 km.yr
<5	50499	18	0.356
5-10	362585	16	0.044
10-15	279036	0	0.000
>15	48858	0	0.000
Total	**740978**	**34**	**0.046**

Table 8 – Exposure by Wall Thickness Class

2.2.5.2 External Corrosion by Year of Construction

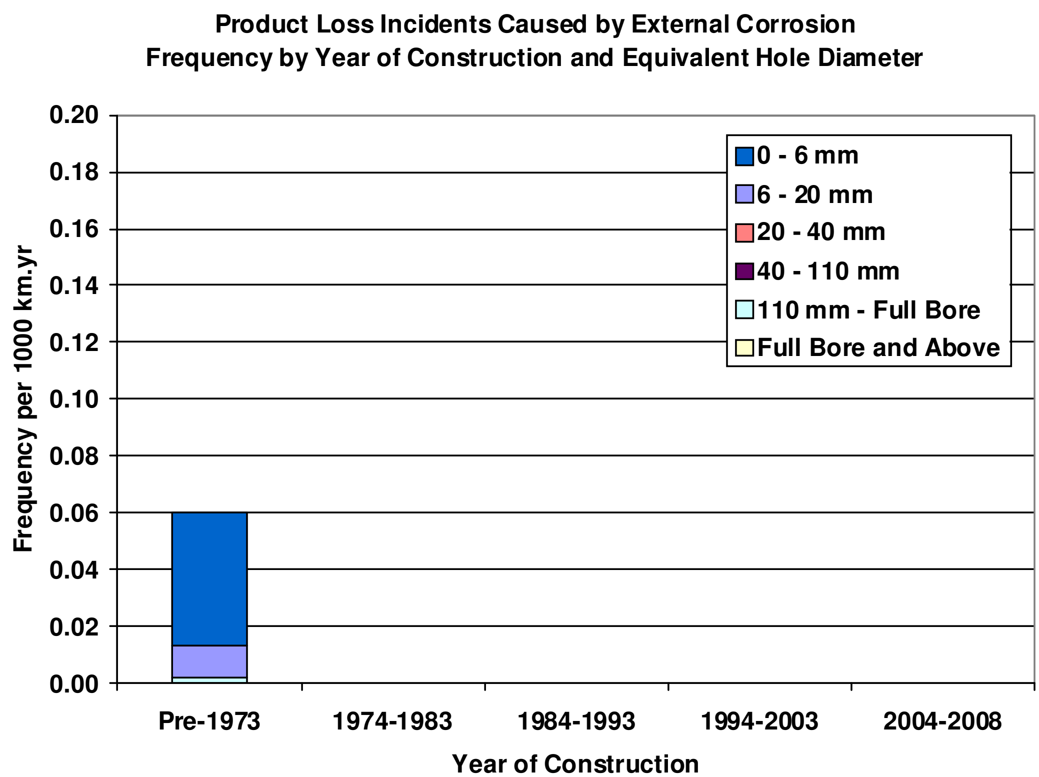


Figure 11

Construction Year	Exposure km.yr	Incidents	Frequency /1000 km.yr
Pre-1973	531647	34	0.064
1974-1983	138858	0	0.000
1984-1993	53973	0	0.000
1994-2003	15123	0	0.000
2004-2008	1377	0	0.000
Total	**740978**	**34**	**0.046**

Table 9 – Exposure by Year of Construction

2.2.5.3 External Corrosion by External Coating Type

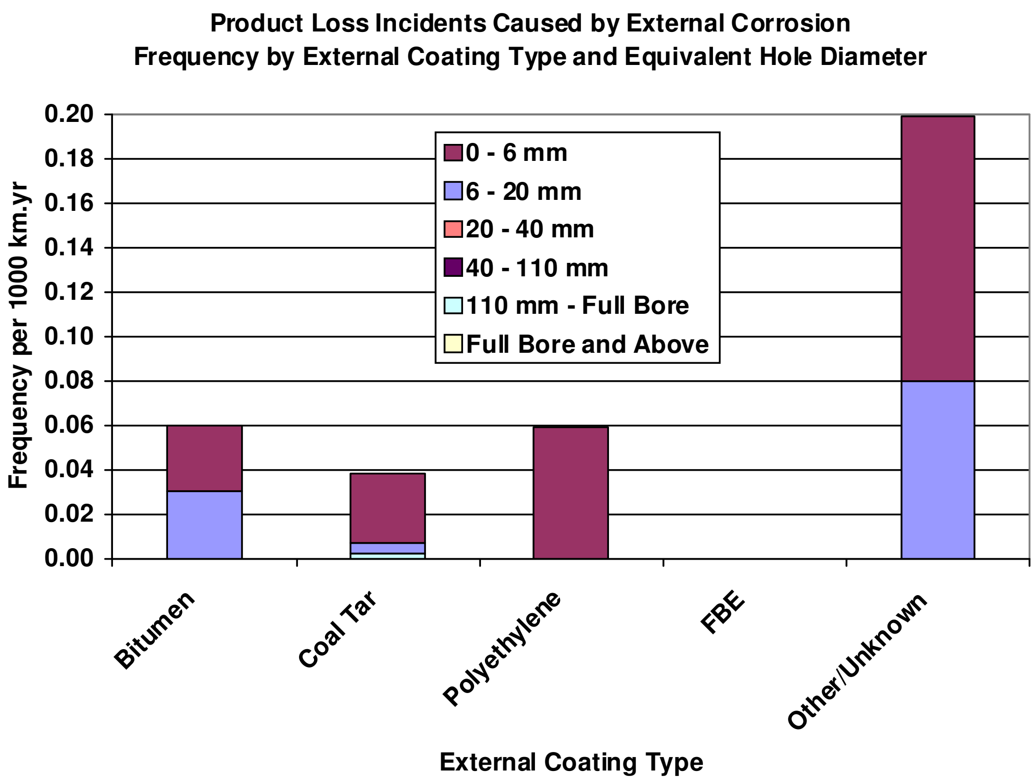


Figure 12

External Coating	Exposure km.yr	Incidents	Frequency /1000 km.yr
Bitumen	33040	3	0.091
Coal Tar	575175	23	0.040
Polyethylene	50904	3	0.059
FBE	66692	0	0.000
Other/Unknown	25127	5	0.199
Total	**750938**	**34**	**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

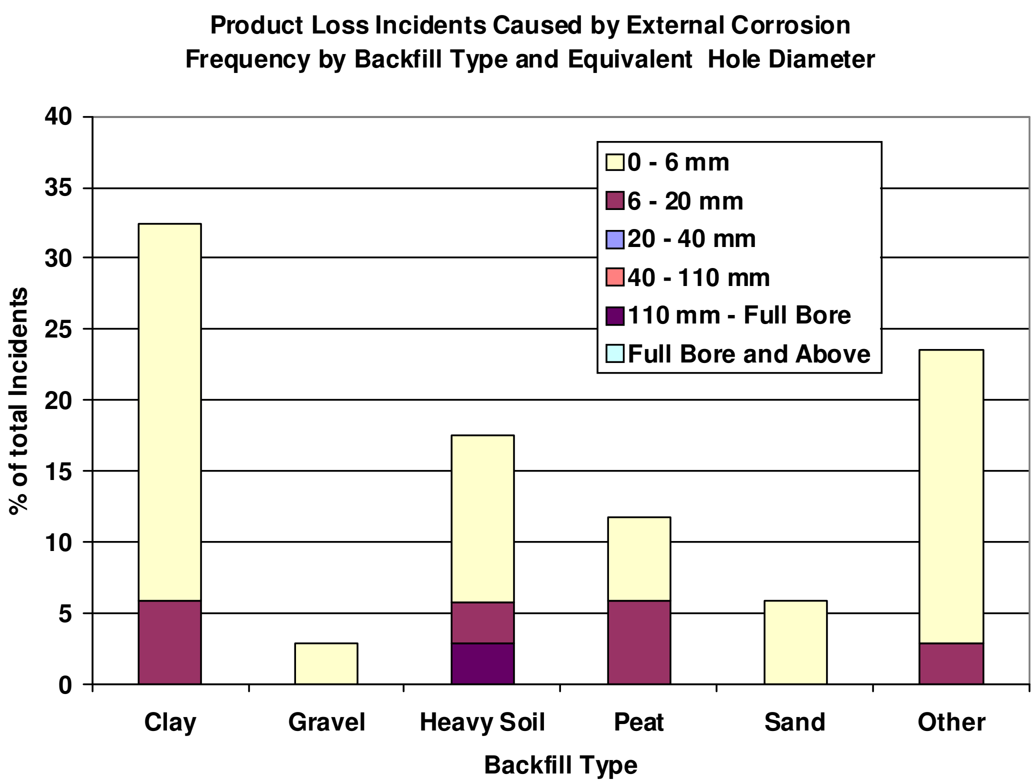


Figure 13

2.2.6 Detection

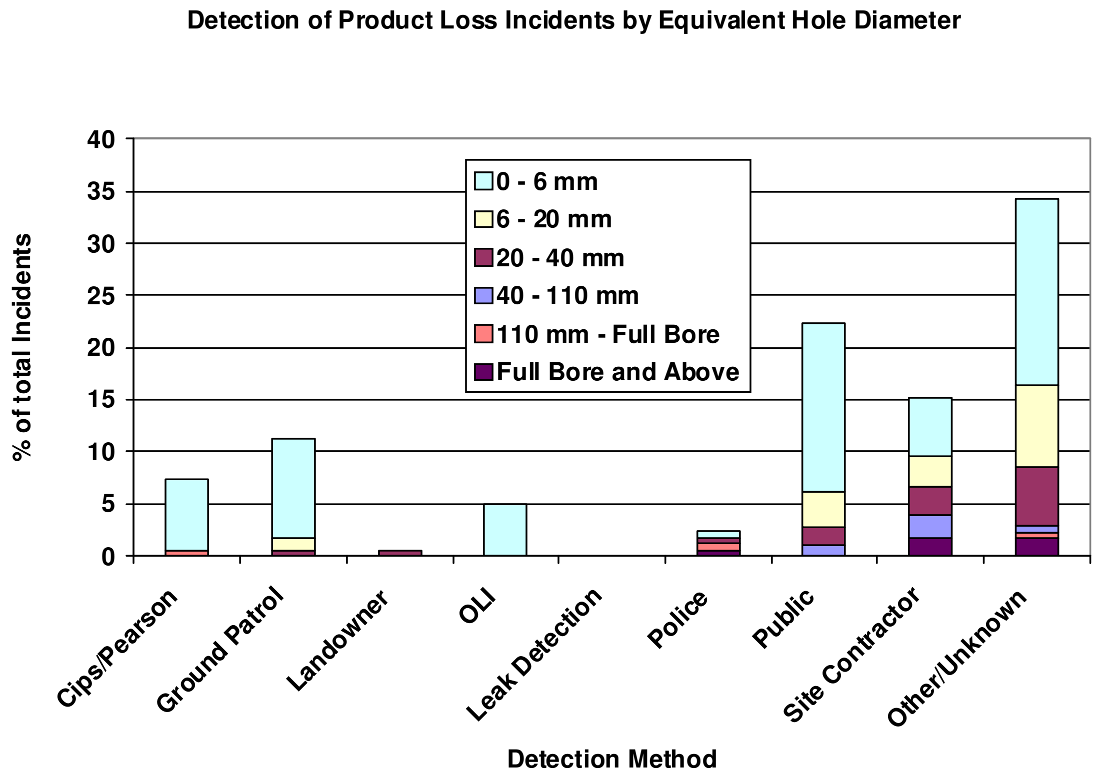


Figure 14

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