UKOPA PIPELINE FAULT DATABASE

Pipeline Product Loss Incidents

(1962 - 2002)

3rd Report of the UKOPA **F**ault **D**atabase **M**anagement **G**roup

Comprising:

Transco
BP
Huntsman
Shell UK
Powergen UK
Health and Safety Executive

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UKOPA

ADVANTICA

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Summary

This report presents collaborative pipeline and product loss incident data from onshore Major Accident Hazard Pipelines (MAHPs) operated by Transco, Shell UK, BP, Huntsman and Powergen UK, covering operating experience up to the end of 2002. 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 2002 is 0.270 incidents per 1000 km.year, whilst in the previous report this figure was 0.289 incidents per 1000 km.year (covering the period from 1962 to 2000).

The failure frequency over the last 5 years is 0.083 incidents per 1000 km.year, whilst in the previous report this figure was 0.093 incidents per 1000 km.year (covering the 5 year period up to the end of 2000).

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 recognised the opportunity to pool data and decided to set up the UKOPA Pipeline Damage Database during May 1998. A steering group called the Fault Database Management Group (FDMG) was established to define the requirements and to direct the development of the database. This FDMG originally comprised representatives from four companies, the current names of which are Transco, Huntsman, BP and Shell UK. The Health & Safety Executive and Powergen UK have since joined the group.

Advantica was selected to set up and manage the database on behalf of UKOPA during November 1998. Development of the database was carried out during 1999 and database ‘empty shells’ were issued to the participating companies to populate with their own pipeline and fault data. Advantica pooled the company data into one collaborative database and 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, followed in 2002 by the second report covering product loss incidents up to the end of 2000. This third biennial report is an update of the previous data, covering product loss incidents up to the end of 2002.

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 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 – 2.41 million km.yr exposure to end of 2001).

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 2002 for all participating companies (Transco, BP, Shell UK, Huntsman and Powergen) is 21,884 km. The total exposure in the period 1952 to the end of 2002 of 635,980 km.yr; the development of this exposure is illustrated in Figure 1.

Exposure of Pipeline before first recorded incident in 1962 = 4004 km.yr (included in exposure and incident frequency calculations)
Length of Pipeline which has unknown commissioning date = 51.22 km. (This has been ignored in the exposure calculations)
Exposure to end 2002 of Elevated Pipeline = 22.47 km.yr (included in totals)
Exposure to end 2002 of Above Ground Pipeline = 169.00 km.yr (included in totals)

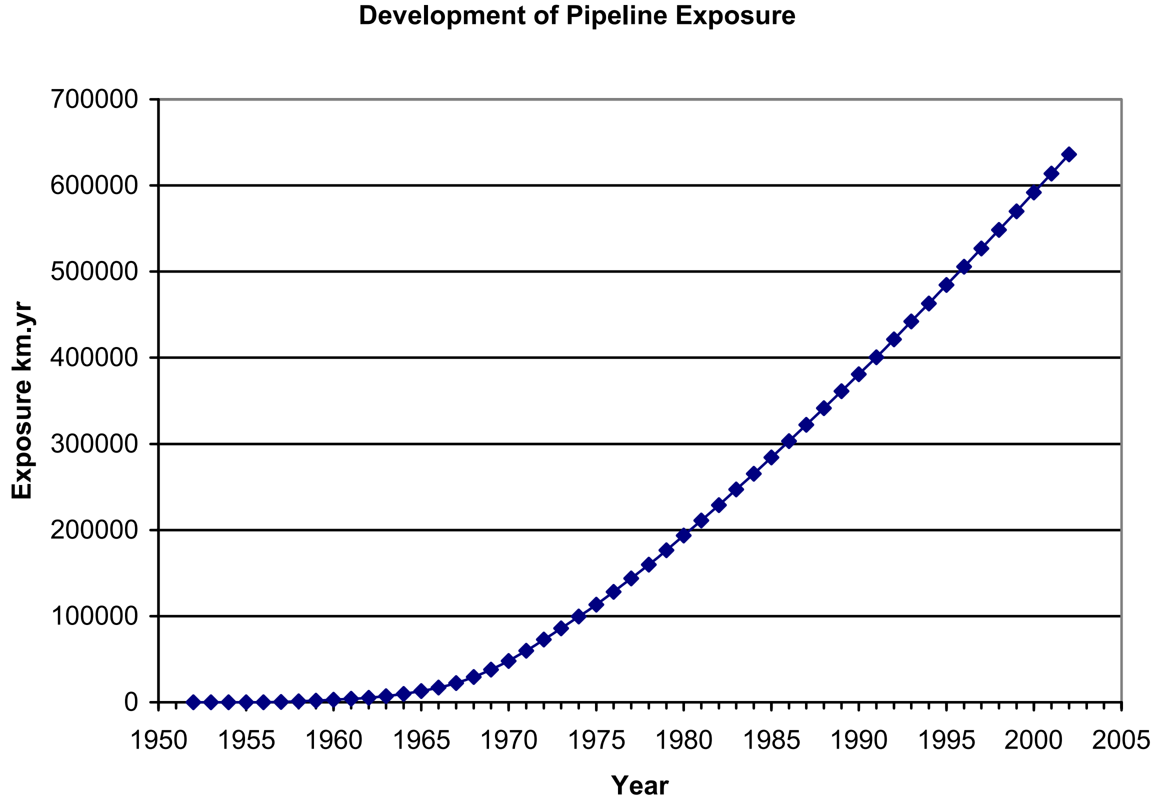


Figure 1

2.1.2 Transported Products

The lengths of pipeline in operation at the end of 2002, by transported product, are (in km):

Butane	19.5	LPG	9.6
CO	0	Natural Gas (Dry)	20,065
Condensate	24.0	Propane	19.5
Crude Oil (Spiked)	212.6	Propylene	36.3
Ethane	38.1	Other	318.3
Ethylene	1,140.9	**TOTAL**	**21,884**

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 172 product loss incidents were recorded over the period between 1962 and 2002. 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 2002 is shown in Figure 2b.

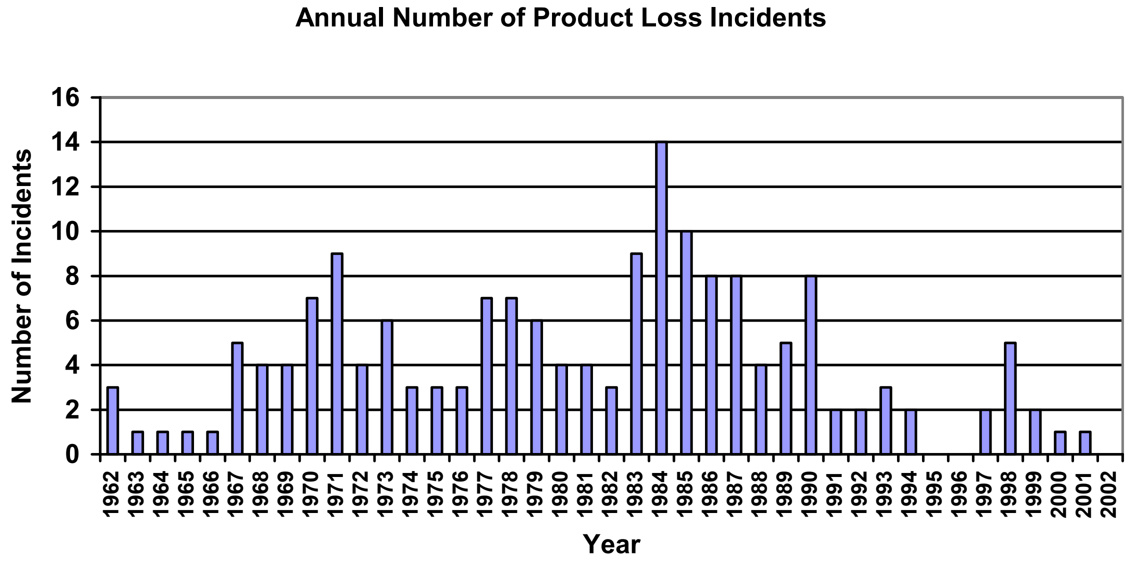


Figure 2a

Differences between 2000 and 2002 product loss statistics

One product loss incident was recorded in the last two years.

As a result of audits of individual company fault databases, one incident has been re-classified as an ignition incident and the cause of another ignition incident has been identified as a pipe defect rather than unknown. See Table 1 for full details.

Figure 2b

2.2.1 Incident Ignition

There were 9 out of 172 (5.2%) 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 (18” Diameter Pipe)
Pipe	Girth Weld Defect	6-20 mm
Pipe	Unknown	6-20 mm
Pipe	Pipe Defect	0-6 mm
Pipe	Unknown	>50 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 2002 is shown in Table 2.

Period	Number of Incidents	Total Exposure [km.yr]	Frequency [Incidents per 1000 km.yr]
1963 - 1967	9	17.053	0.528
1968 - 1972	28	50.399	0.556
1973 - 1977	22	70.898	0.310
1978 - 1982	24	85.247	0.282
1983 - 1987	49	93.273	0.525
1988 - 1992	21	98.953	0.212
1993 - 1997	7	105.780	0.066
1998 - 2002	**9**	**109.038**	**0.083**

Table 2

The overall incident frequency by hole size over the period 1962 - 2002 is shown in Table 3.

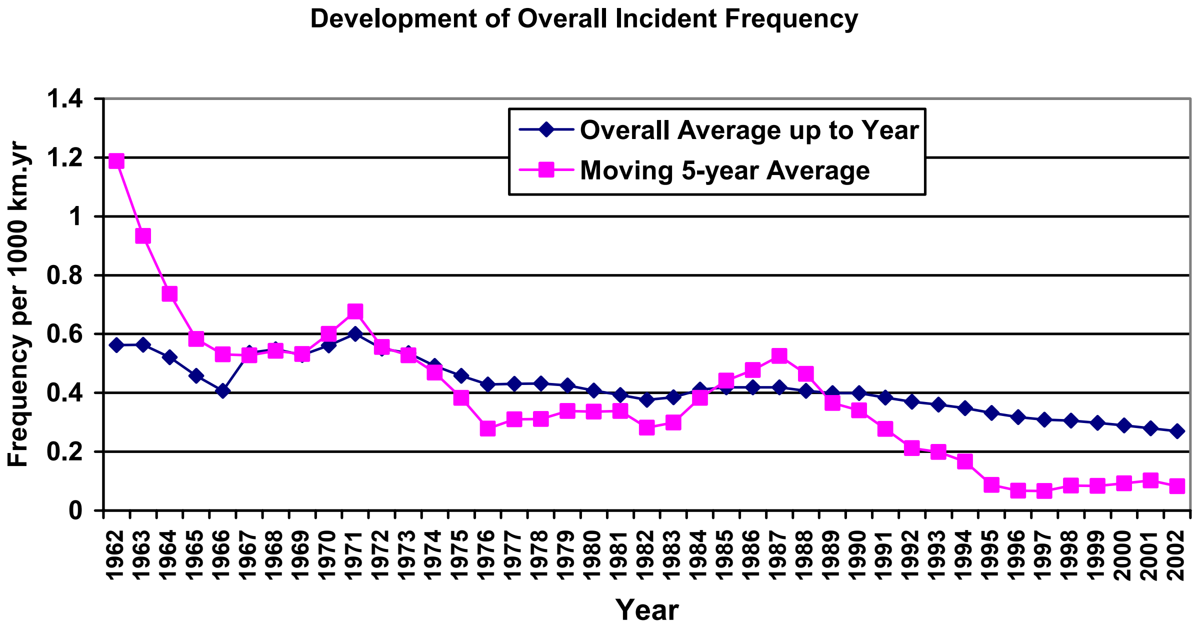
Hole Size Class	Number of Incidents	Frequency [Incidents per 1000 km.yr]
Full Bore*	7	0.011
≥ 50mm	16	0.025
≥ 20mm	37	0.058
≥ 6mm	64	0.101
0 – Full Bore	172	0.270

Table 3

* Full Bore ≡ diameter of pipeline

The failure frequency over the last 5 years (1998-2002) is 0.083 incidents per 1000 km.yr as compared to the failure frequency during the period 1962-2002 which is 0.270 incidents per year per 1000 km.yr. An overview of the development of this failure frequency over the period 1962 to 2002 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 (1998-2002,1997-2001,1996-2000 etc).


Development of Overall Incident Frequency
Overall Average up to Year
Moving 5-year Average
Frequency per 1000 km.yr
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1962
1963
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2000
2001
2002
Year

Figure 3

2.2.3 Incident Frequency by Cause

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

Development of Incident Frequency by Cause

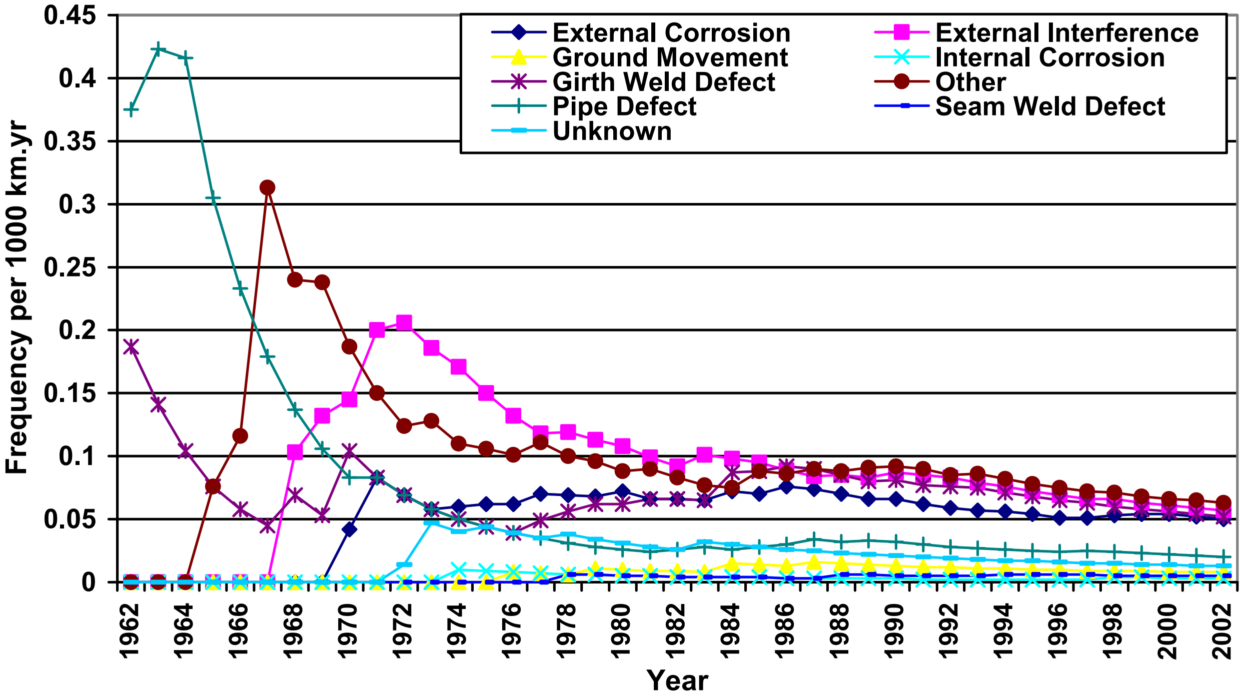


Figure 4

Product Loss Cause	No. of Incidents
Girth Weld Defect	33
External Interference	36
Internal Corrosion	2
External Corrosion	32
Unknown	8
Other	40
Pipe Defect	13
Ground Movement	5
Seam Weld Defect	3
Total	**172**

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 1962-2002 compared with the frequency over only the last 5 years (1998-2002).

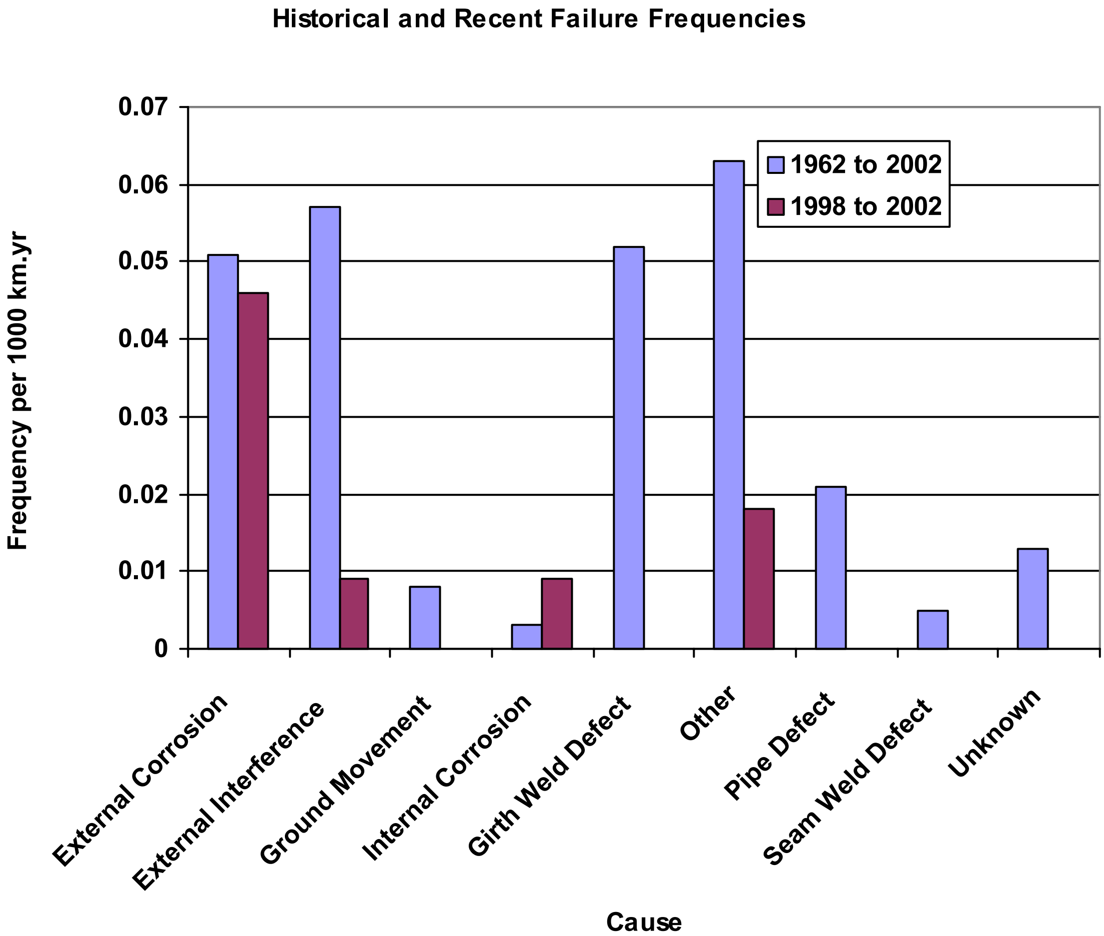
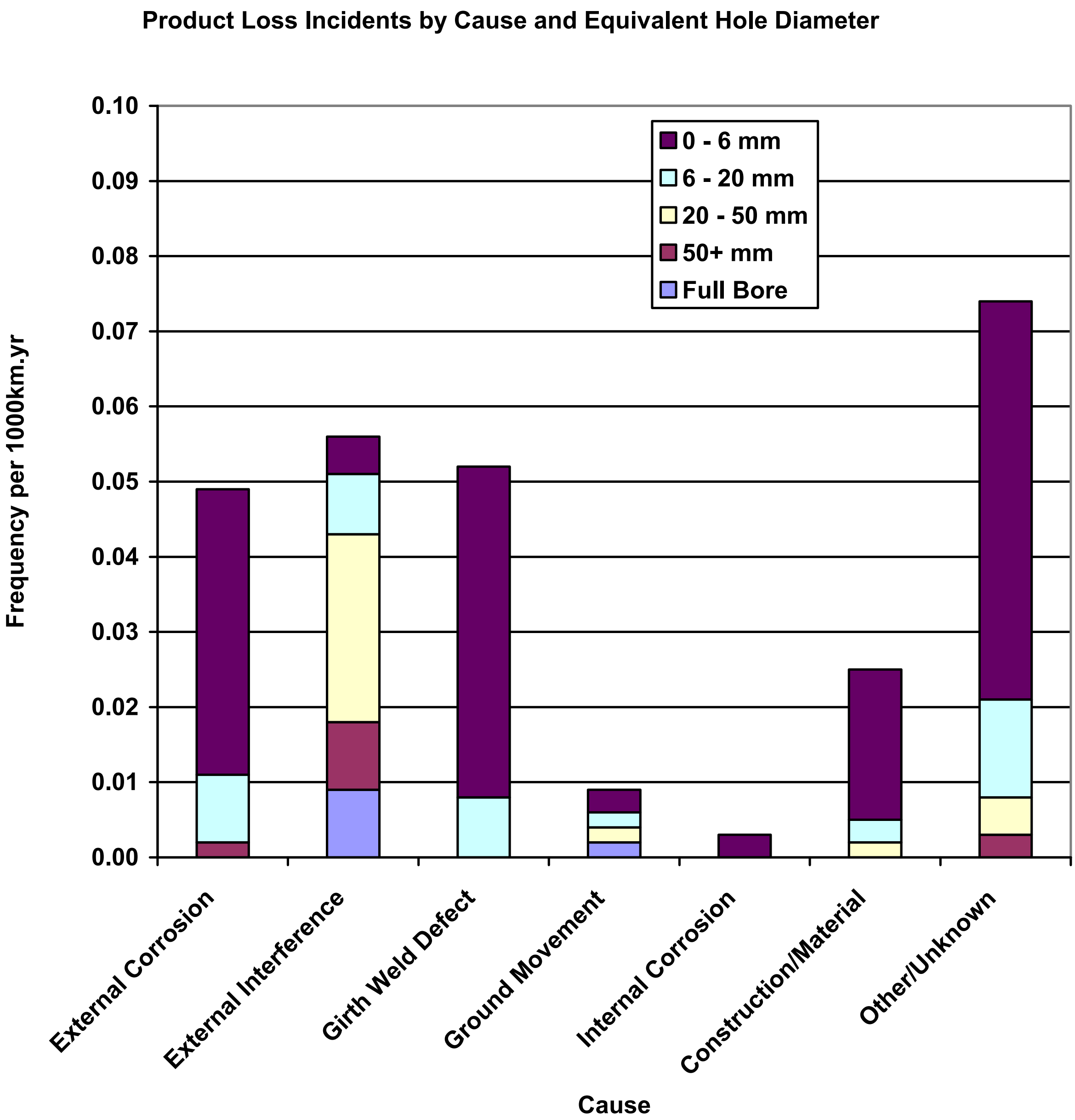


Figure 5

An overview of the product loss incident frequency by cause and size of leak in the period 1962 to 2002 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.

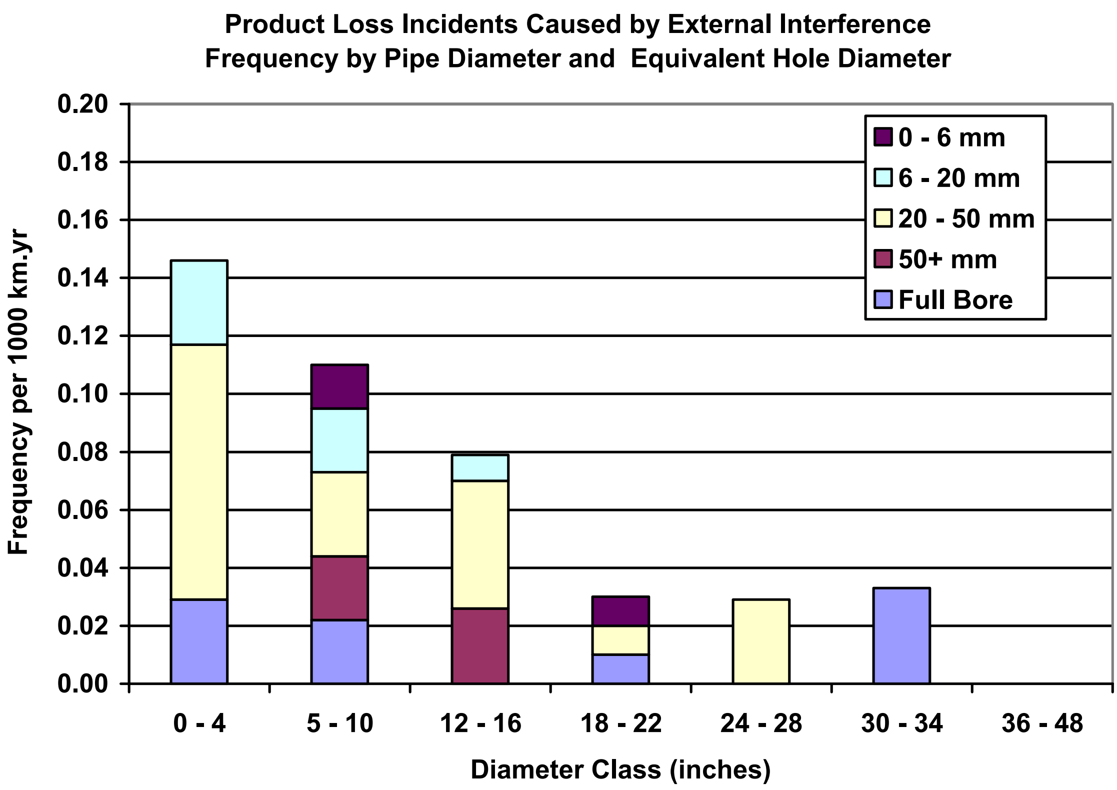


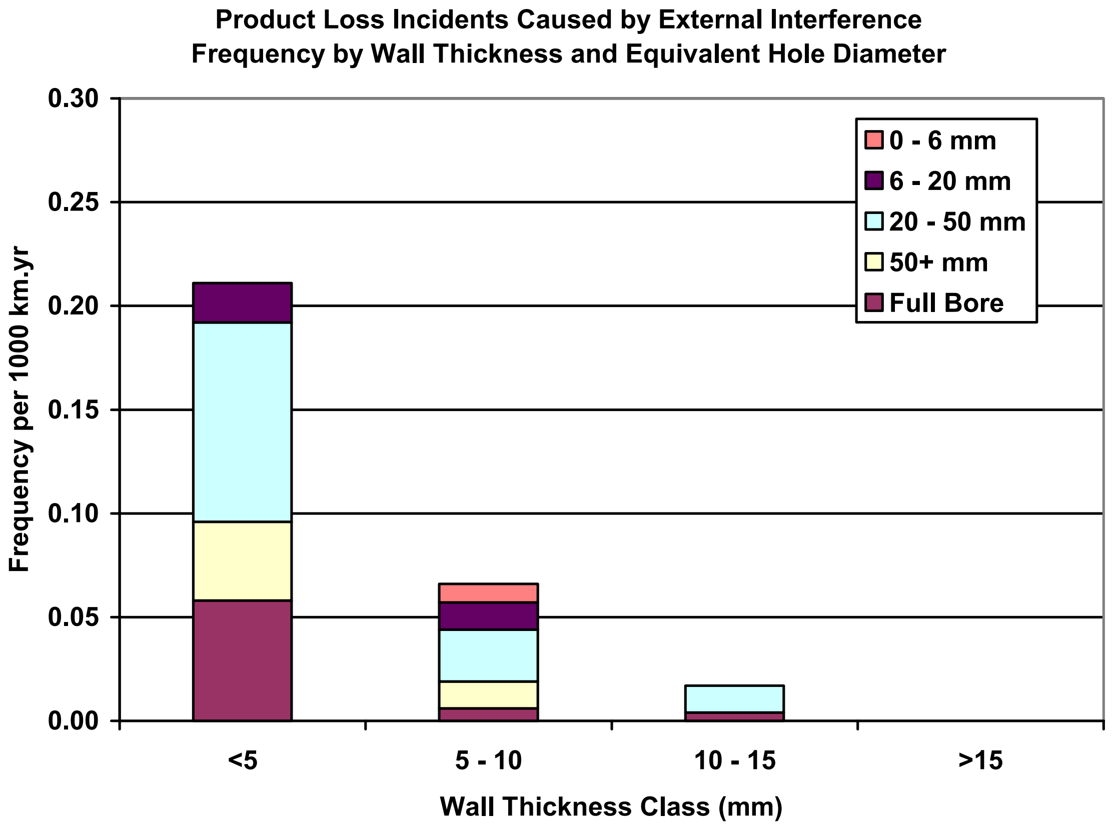
Figure 7

Diameter inches	Exposure km.yr	Incidents	Frequency /1000km.yr
0-4	34081	5	0.147
5-10	136114	15	0.110
12-16	113356	9	0.079
18-22	98131	3	0.031
24-28	102558	3	0.029
30-34	30598	1	0.033
36-48	121143	0	0.000
Total	**635980**	**36**	**0.057**

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	52025	11	0.211
5-10	317090	21	0.066
10-15	227758	4	0.018
>15	39106	0	0.000
Total	**635980**	**36**	**0.057**

Table 6 – Exposure by Wall Thickness Class

2.2.4.3 External Interference by Area Classification

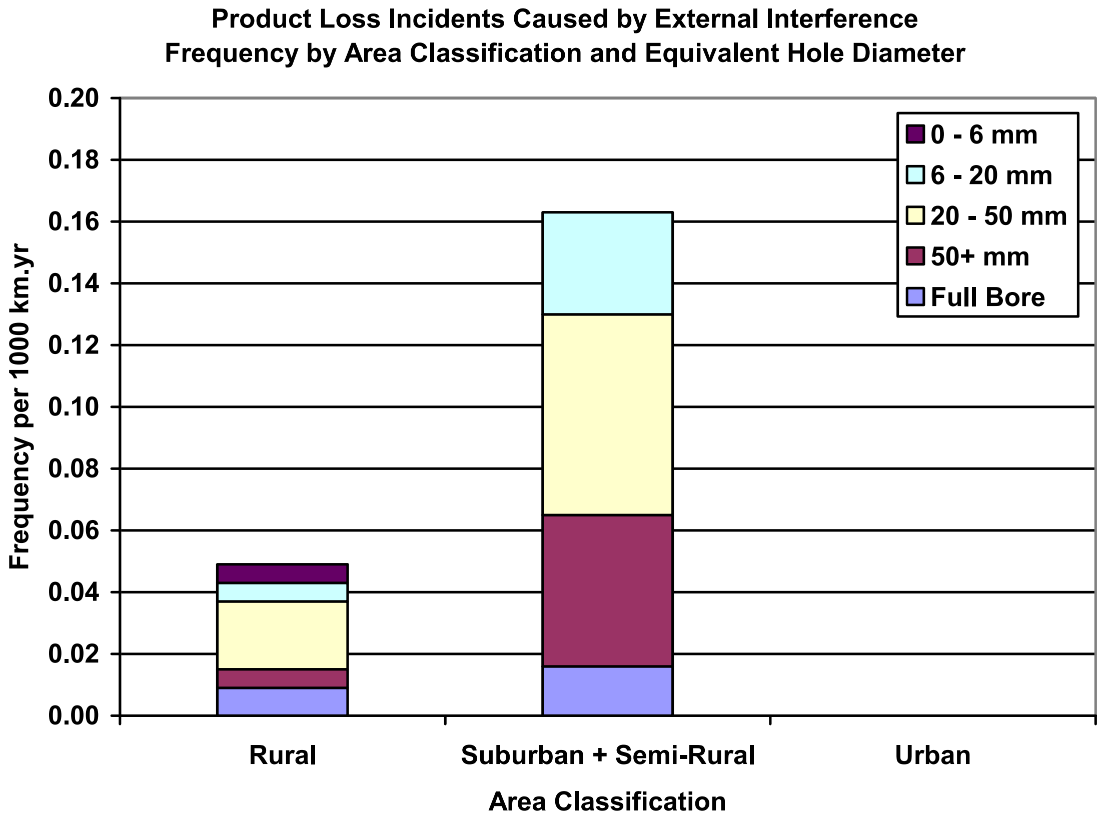


Figure 9

Area Classification	Exposure km.yr	Incidents	Frequency /1000 km.yr
Rural	536143	26	0.048
Suburban + Semi-Rural	61394	10	0.163
Urban	855	0	0.000
Total	**598391**	**36**	**0.060**

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

2.2.5 External Corrosion

2.2.5.1 External Corrosion by Wall Thickness Class

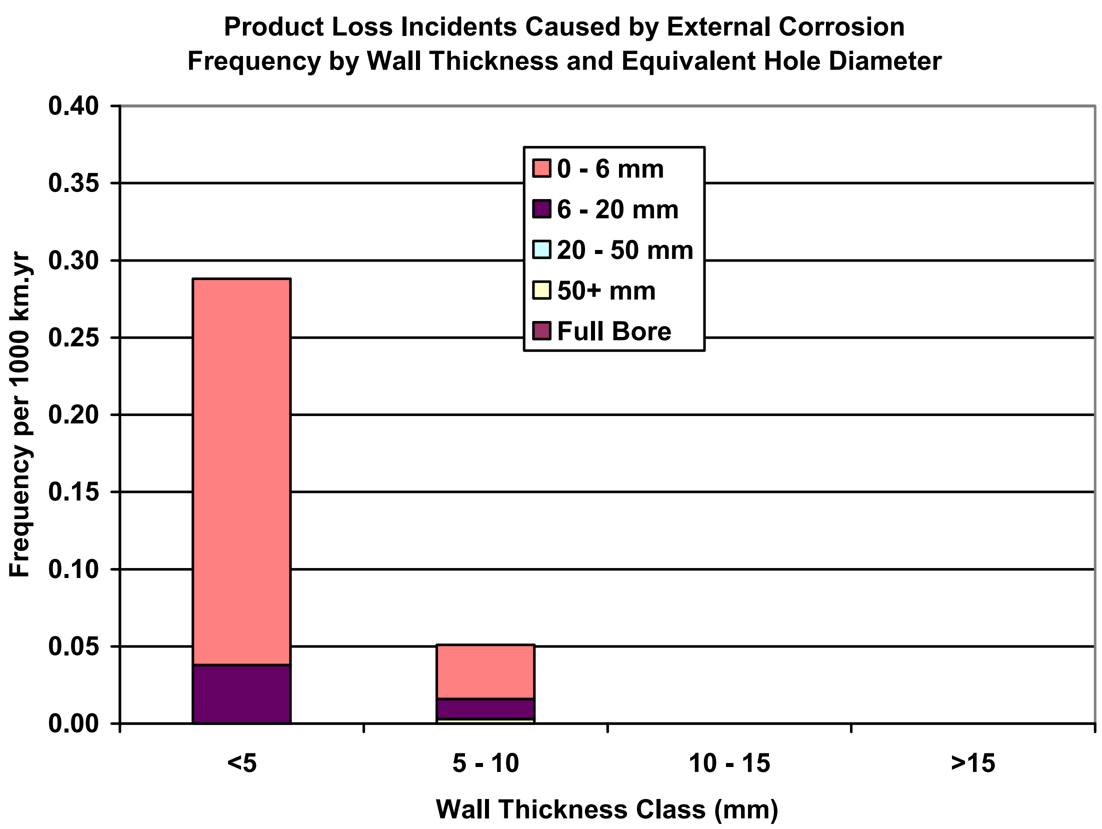


Figure 10

Wall Thickness mm	Exposure km.yr	Incidents	Frequency /1000 km.yr
<5	52025	15	0.288
5-10	317090	17	0.054
10-15	227758	0	0.000
>15	39106	0	0.000
Total	**635980**	**32**	**0.050**

Table 8 – Exposure by Wall Thickness Class

2.2.5.2 External Corrosion by Year of Construction

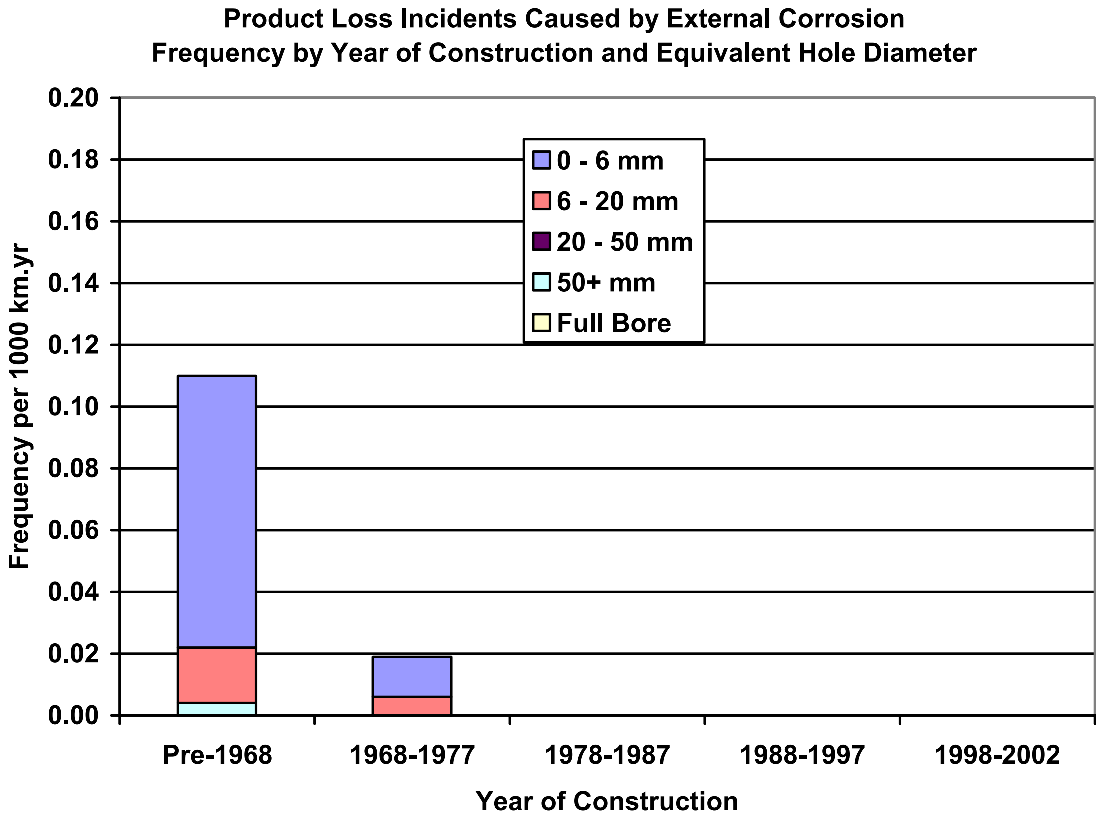


Figure 11

Construction Year	Exposure km.yr	Incidents	Frequency /1000 km.yr
Pre-1968	227687	25	0.110
1968-1977	309039	7	0.023
1978-1987	74290	0	0.000
1988-1997	22727	0	0.000
1998-2002	2236	0	0.000
Total	**635980**	**32**	**0.050**

Table 9 – Exposure by Year of Construction

2.2.5.3 External Corrosion by External Coating Type

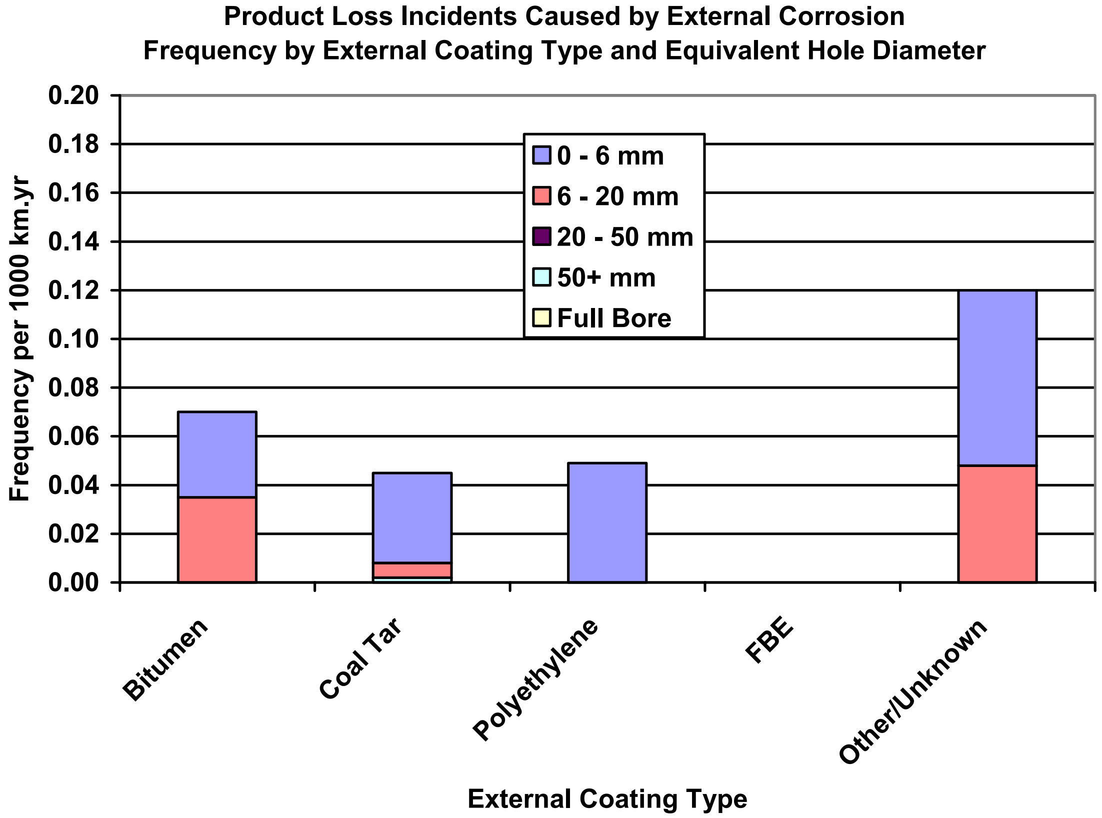


Figure 12

External Coating	Exposure km.yr	Incidents	Frequency /1000 km.yr
Bitumen	28905	3	0.104
Coal Tar	491333	22	0.045
Polyethylene	40504	2	0.049
FBE	43294	0	0.000
Other/Unknown	41407	5	0.121
Total	**645442**	**32**	**0.050**

Table 10 – Exposure by External Coating Type

2.2.5.4 External Corrosion by Type of Backfill

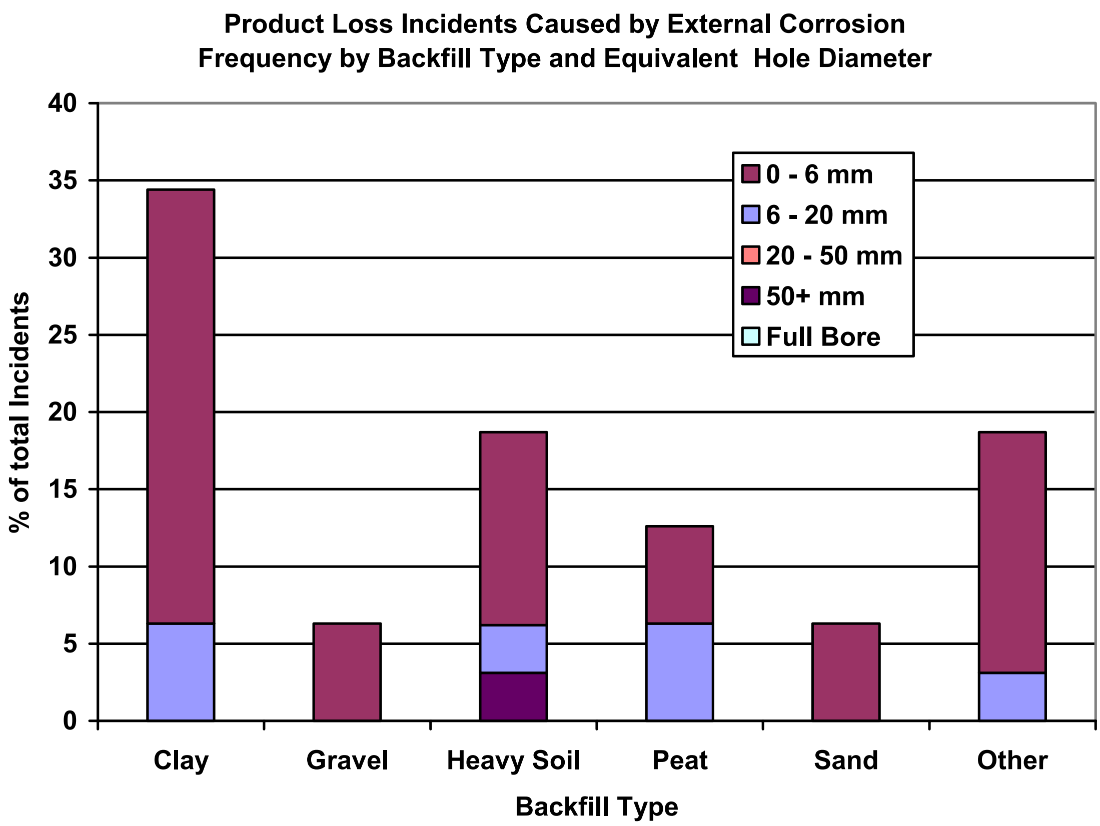


Figure 13

2.2.6 Detection

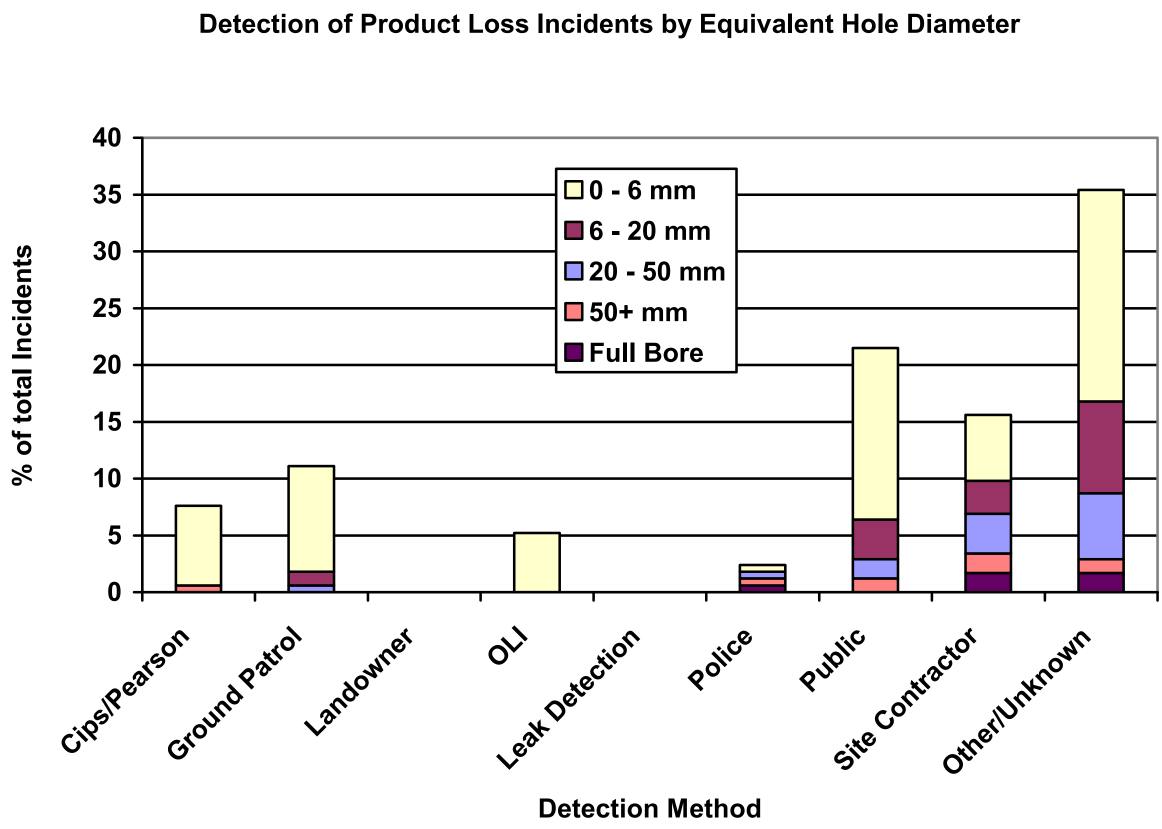


Figure 14

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