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UKOPA PIPELINE FAULT DATABASE

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Pipeline Product Loss Incidents

(1962 - 2004)

4th Report of the UKOPA **F**ault **D**atabase **M**anagement **G**roup

Comprising:

Transco
BP
Huntsman
Shell UK
E-ON UK
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 Transco, Shell UK, BP, Huntsman and E-ON UK, covering operating experience up to the end of 2004. 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 2004 is 0.263 incidents per 1000 km.year, whilst in the previous report this figure was 0.270 incidents per 1000 km.year (covering the period from 1962 to 2002).

The failure frequency over the last 5 years is 0.028 incidents per 1000 km.year, whilst in the previous report this figure was 0.083 incidents per 1000 km.year (covering the 5 year period up to the end of 2002).

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, followed in 2002 by the second report covering product loss incidents up to the end of 2000, and a third report in 2003 covering product loss incidents up to the end of 2002. This report is an update of the previous data, covering product loss incidents up to the end of 2004.

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 2004 for all participating companies (Transco, BP, Shell UK, Huntsman and E-ON UK) is 21,727 km. The total exposure in the period 1952 to the end of 2004 is 654,732 km.yr; the development of this exposure is illustrated in Figure 1.

Exposure of Pipeline before first recorded incident in 1962 = 3740 km.yr (included in exposure and incident frequency calculations)
Length of Pipeline which has unknown commissioning date = 46.0 km. (This has been ignored in the exposure calculations)
Exposure to end 2004 of Elevated Pipeline = 23.0 km.yr (included in totals)
Exposure to end 2004 of Above Ground Pipeline = 125.7 km.yr (included in totals)
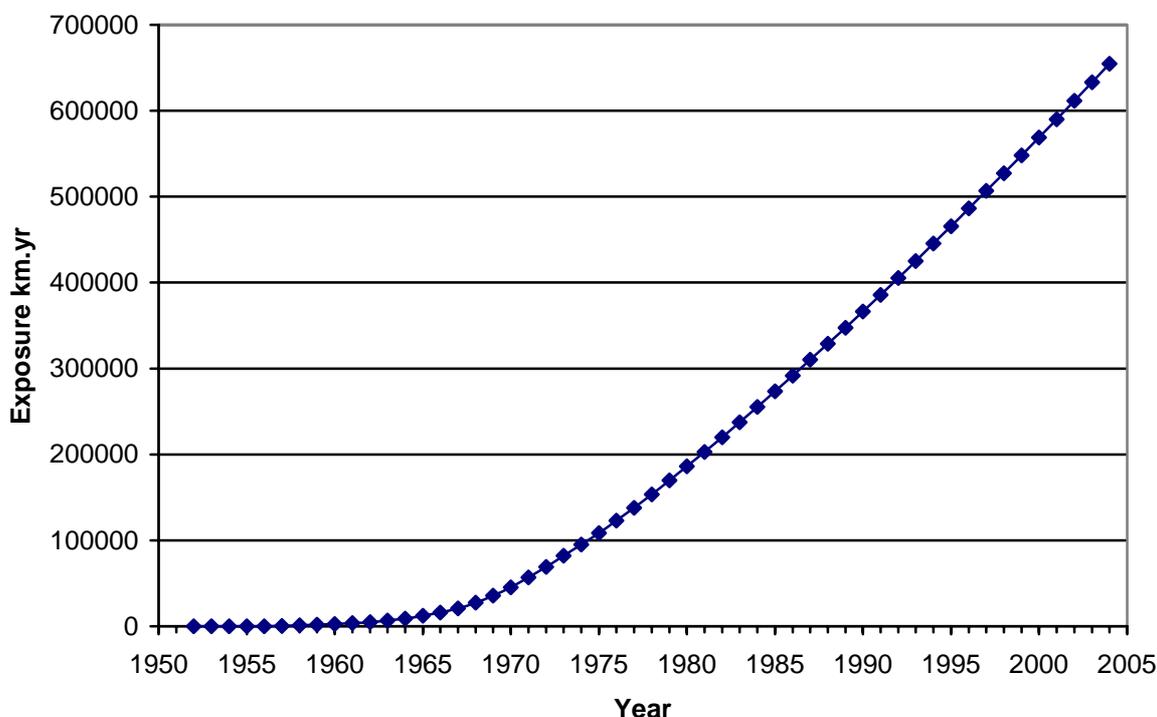
Development of Pipeline Exposure

Figure 1

2.1.2 Transported Products

The lengths of pipeline in operation at the end of 2004, by transported product, are (in km):

Butane	19.5	LPG	9.6
CO*	0	Natural Gas (Dry)	20,001
Condensate	24.0	Natural Gas Liquid	225.8
Crude Oil (Spiked)	212.6	Propane	19.5
Ethane	38.1	Propylene	36.3
Ethylene	1,141	**TOTAL**	**21,727**

* Note that the database includes 36.3 km of decommissioned pipeline that used to transport CO.

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 2004. 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 2004 is shown in Figure 2b.
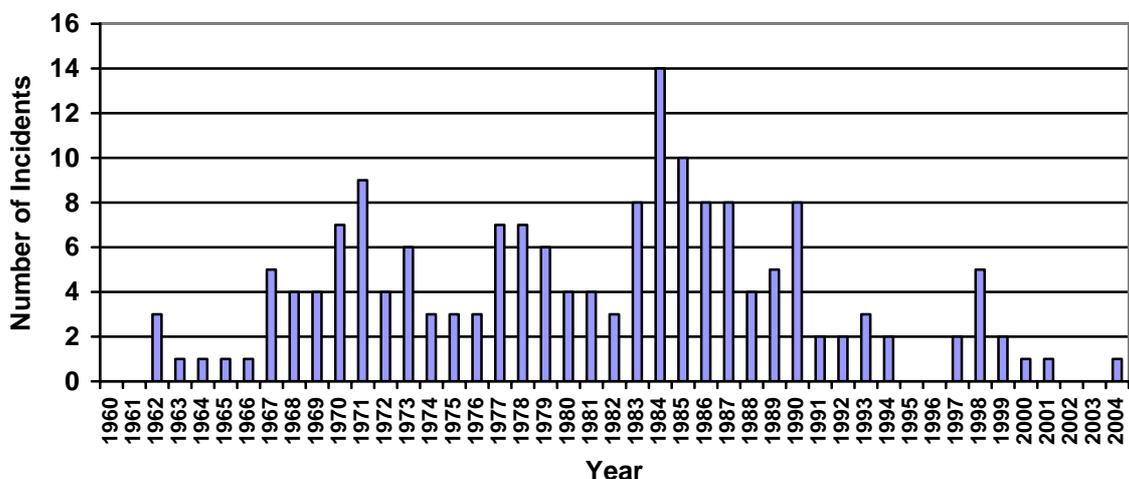
Annual Number of Product Loss Incidents

Figure 2a

Differences between 2002 and 2004 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 product loss incident is no longer included in the analysis as it occurred on a pipeline that was not an MAHP at the time of the incident (having been de-rated prior to this).

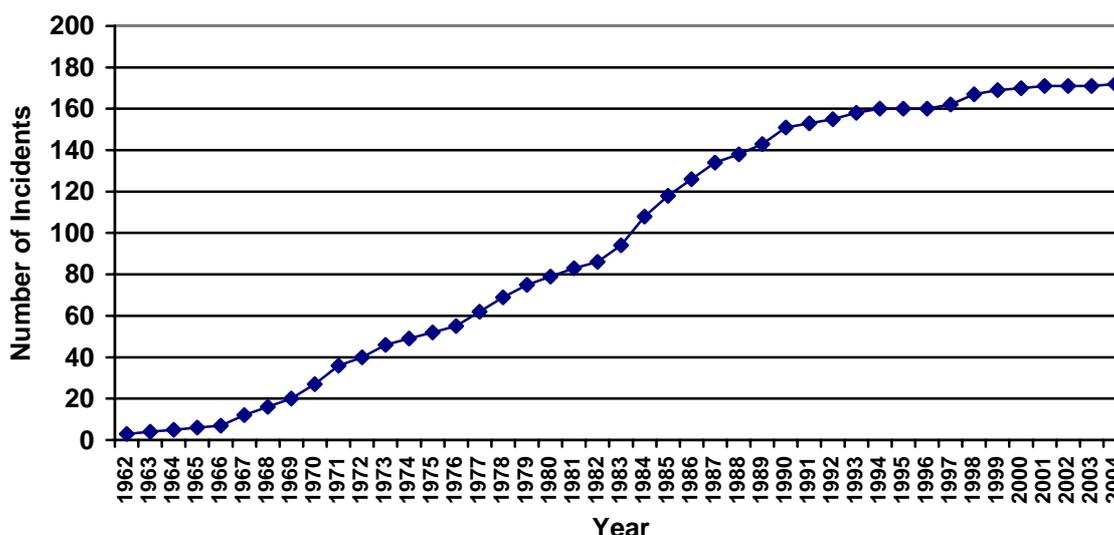**Total Number of Product Loss Incidents (Cumulative)**

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 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 2004 is shown in Table 2.

Period	Number of Incidents	Total Exposure [km.yr]	Frequency [Incidents per 1000 km.yr]
1965 - 1969	15	26.639	0.563
1970 - 1974	29	59.598	0.487
1975 - 1979	26	74.486	0.349
1980 - 1984	33	85.534	0.386
1985 - 1989	35	92.406	0.379
1990 - 1994	17	97.839	0.174
1995 - 1999	9	102.527	0.088
2000 - 2004	3	106.799	0.028

Table 2

The overall incident frequency by hole size over the period 1962 - 2004 is shown in Table 3.

Hole Size Class	Number of Incidents	Frequency [Incidents per 1000 km.yr]
Full Bore* and Above	7	0.011
110mm – Full Bore*	3	0.005
40mm – 110mm	7	0.011
20mm – 40mm	20	0.031
6mm – 20mm	27	0.041
0 – 6mm	106	0.162

Table 3

* Full Bore $\equiv$ diameter of pipeline

Note that in addition to the incidents shown in Table 3 above, there are 2 incidents of unknown hole size.

The failure frequency over the last 5 years (2000-2004) is 0.028 incidents per 1000 km.yr as compared to the failure frequency during the period 1962-2004 which is 0.263 incidents per year per 1000 km.yr. An overview of the development of this failure frequency over the period 1962 to 2004 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 (2000-2004,1999-2003,1998-2002 etc).

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Development of Overall Incident Frequency

Figure 3

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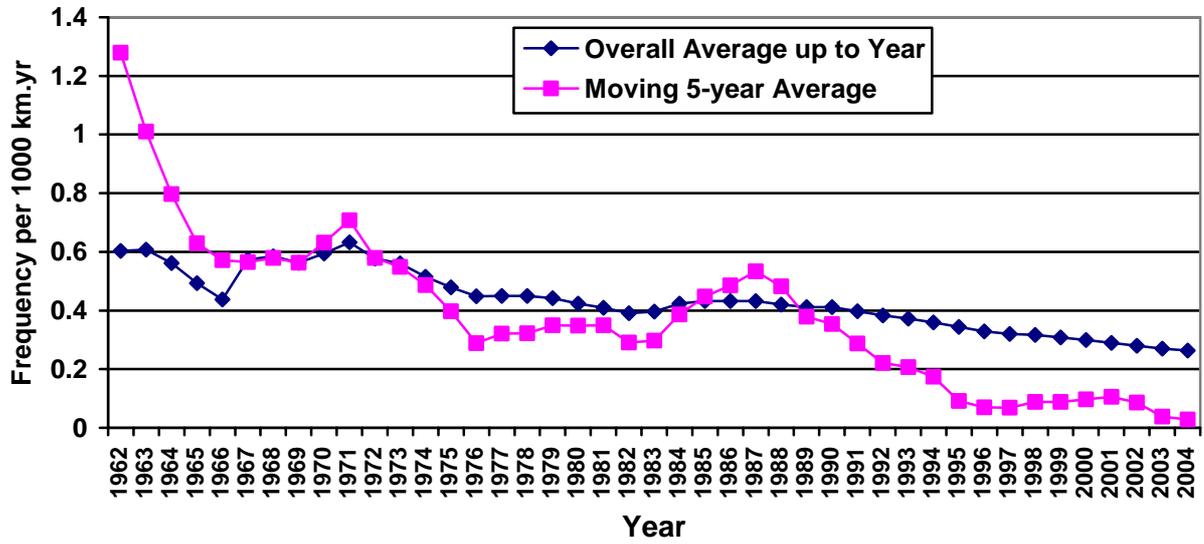## 2.2.3 Incident Frequency by Cause

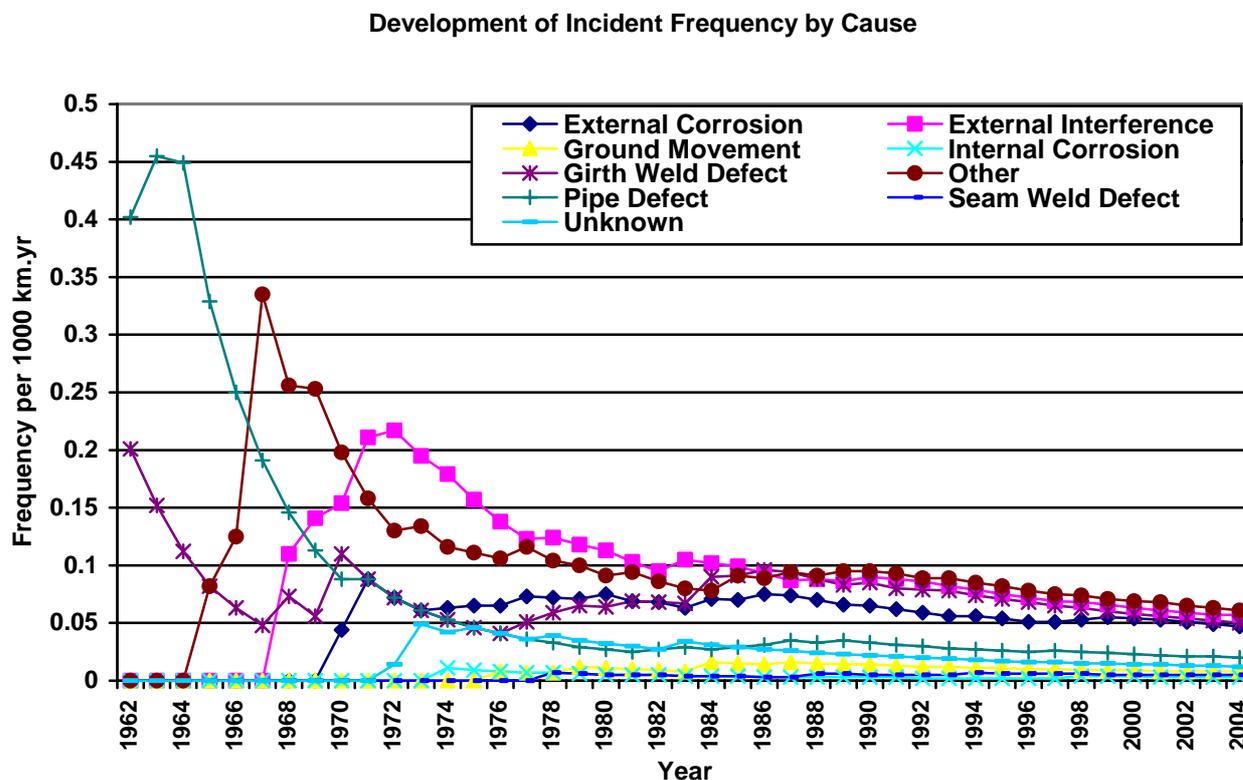The development of product loss incident frequency by cause is shown in Figure 4.

Development of Incident Frequency by Cause

Figure 4

Product Loss Cause	No. of Incidents
Girth Weld Defect	33
External Interference	37
Internal Corrosion	2
External Corrosion	31
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 1962-2004 compared with the frequency over only the last 5 years (2000-2004).
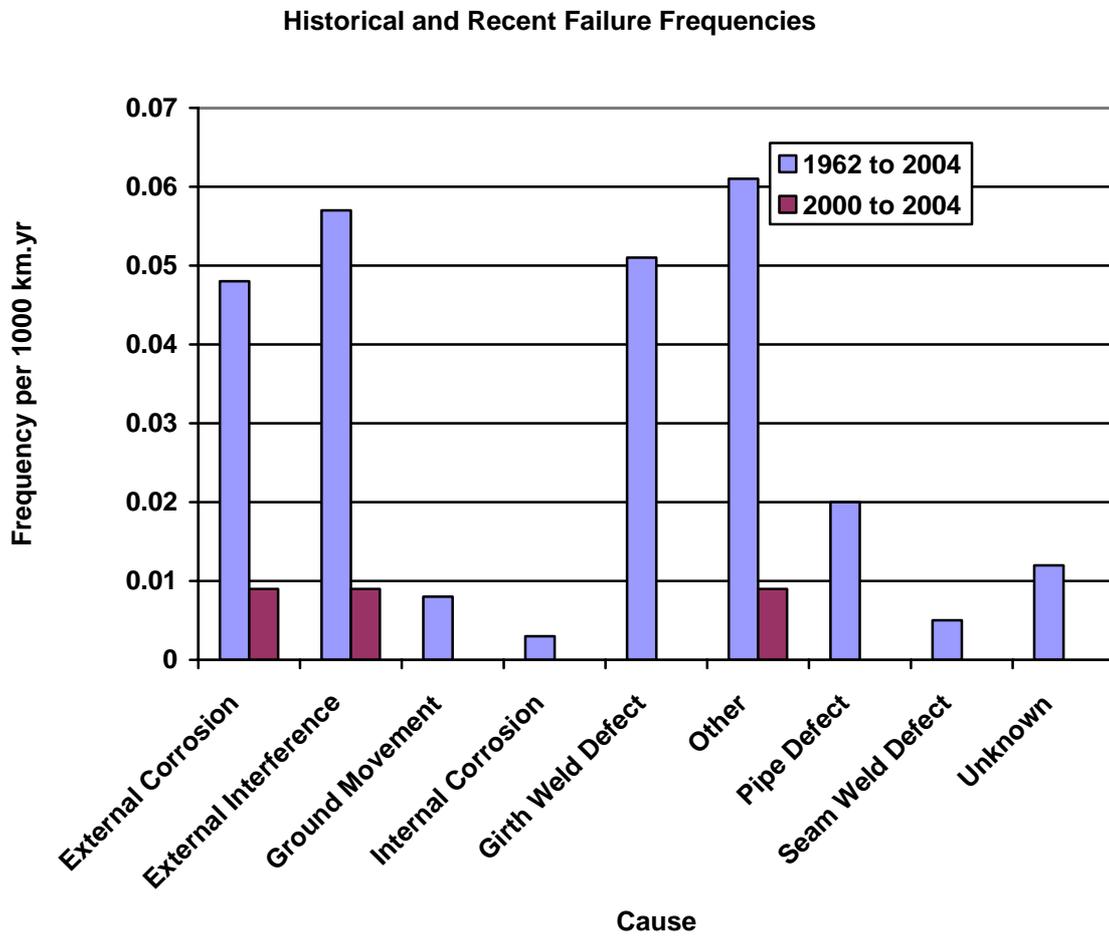
Historical and Recent Failure Frequencies

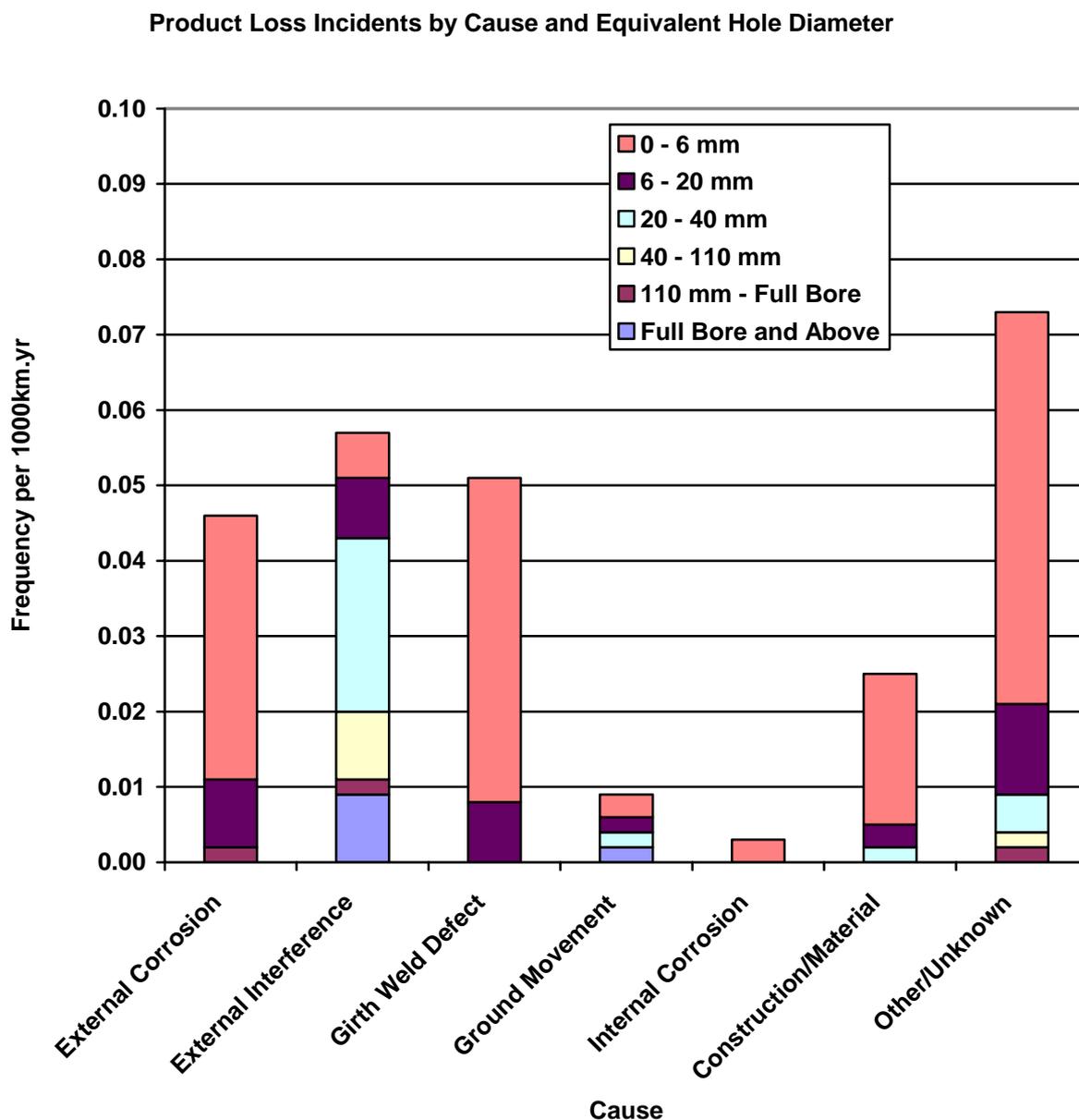**Figure 5**

An overview of the product loss incident frequency by cause and size of leak in the period 1962 to 2004 is shown in Figure 6.

Product Loss Incidents by Cause and Equivalent Hole Diameter

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.
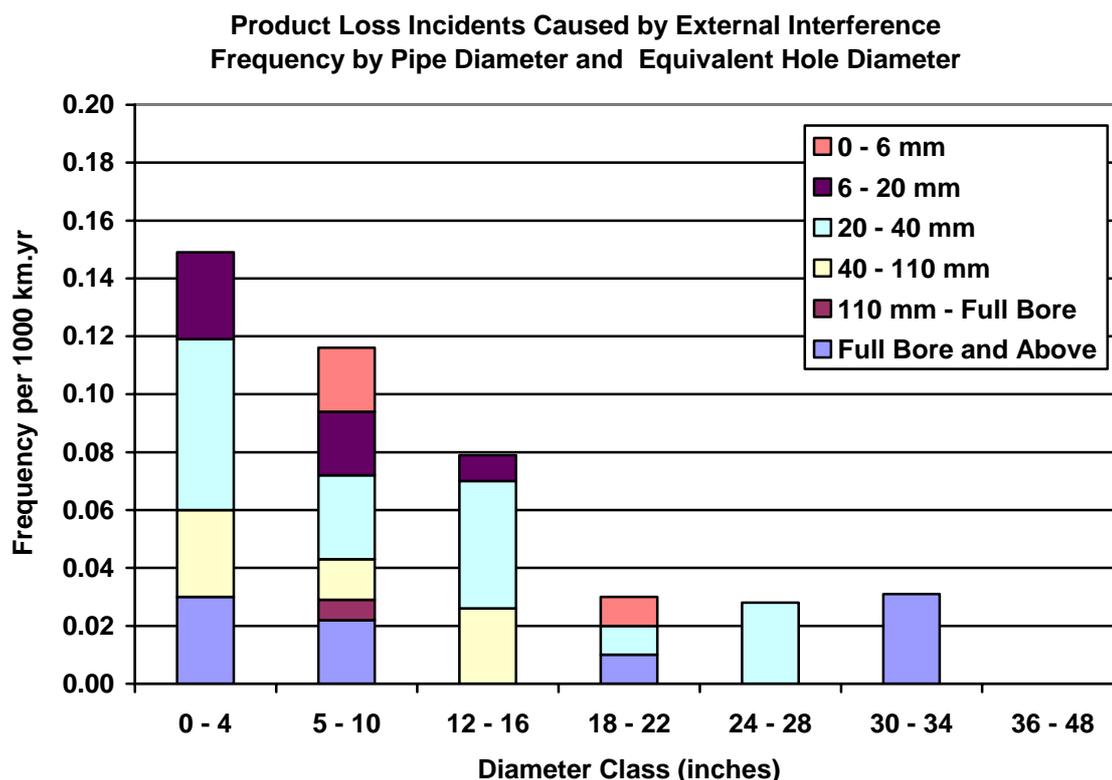
**Product Loss Incidents Caused by External Interference
Frequency by Pipe Diameter and Equivalent Hole Diameter**

Figure 7

Diameter inches	Exposure km.yr	Incidents	Frequency /1000km.yr
0-4	33792	5	0.148
5-10	138216	16	0.116
12-16	113254	9	0.079
18-22	98969	3	0.030
24-28	106219	3	0.028
30-34	31960	1	0.031
36-48	132322	0	0.000
Total	**654732**	**37**	**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.

Product Loss Incidents Caused by External Interference
Frequency by Wall Thickness and Equivalent Hole Diameter
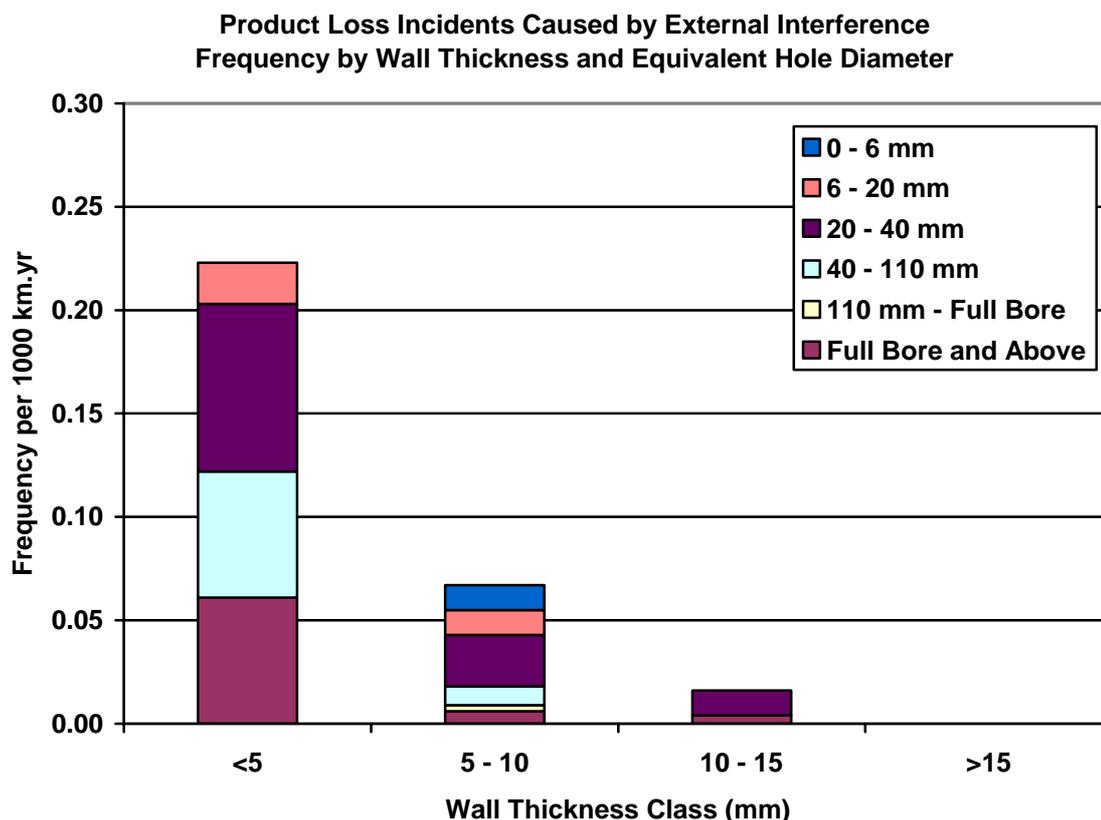
Note: Largest wall thickness for loss of product incident caused by external interference to date is 12.7mm.

Figure 8

Wall Thickness mm	Exposure km.yr	Incidents	Frequency /1000 km.yr
<5	49537	11	0.222
5-10	320504	22	0.069
10-15	242744	4	0.016
>15	41947	0	0.000
Total	**654732**	**37**	**0.057**

Table 6 – Exposure by Wall Thickness Class

2.2.4.3 External Interference by Area Classification

Product Loss Incidents Caused by External Interference Frequency by Area Classification and Equivalent Hole Diameter
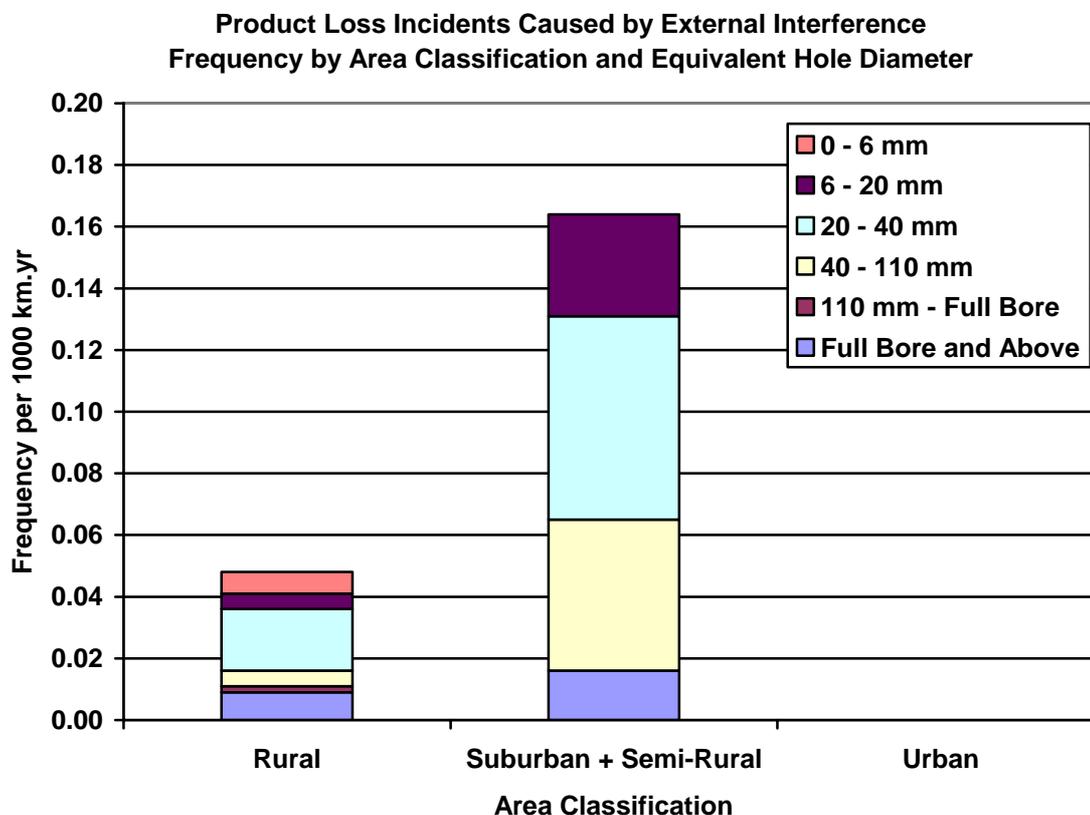
Figure 9

Area Classification	Exposure km.yr	Incidents	Frequency /1000 km.yr
Rural	558948	27	0.048
Suburban + Semi-Rural	60642	10	0.165
Urban	723	0	0.000
Total	**620313**	**37**	**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
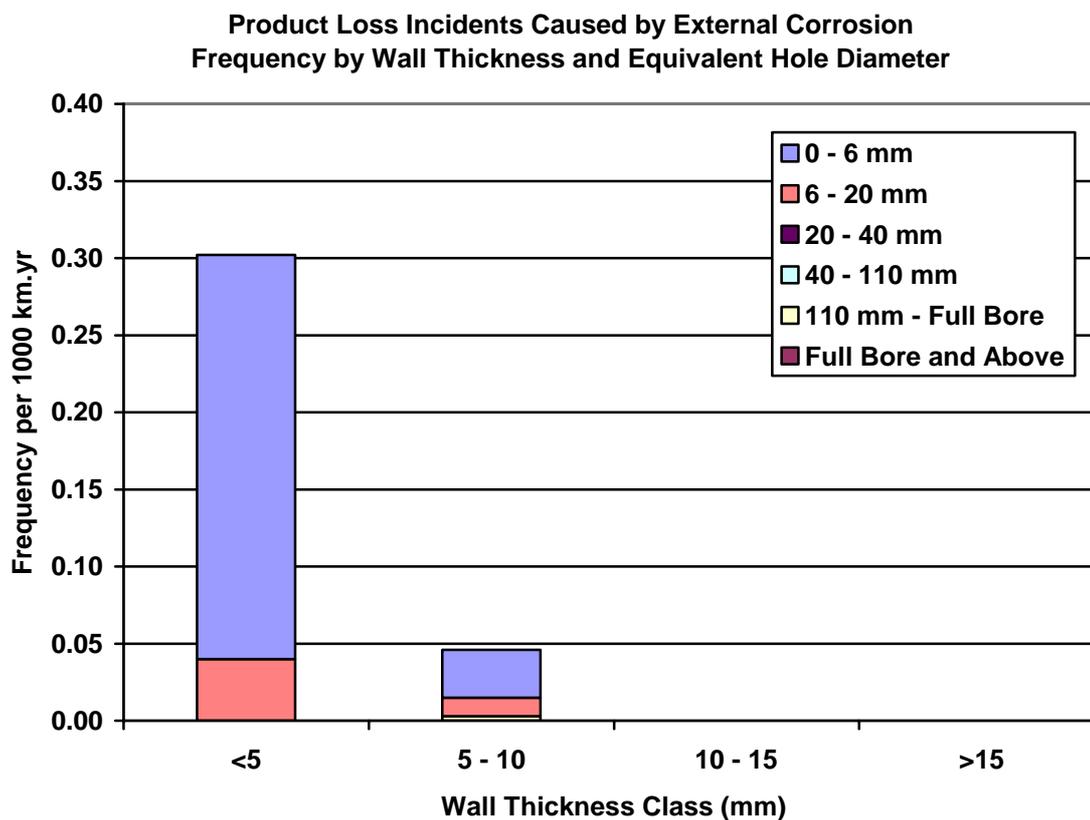
2.2.5.1 External Corrosion by Wall Thickness Class

**Product Loss Incidents Caused by External Corrosion
Frequency by Wall Thickness and Equivalent Hole Diameter**

Legend:
- 0 - 6 mm
- 6 - 20 mm
- 20 - 40 mm
- 40 - 110 mm
- 110 mm - Full Bore
- Full Bore and Above

Figure 10

Wall Thickness mm	Exposure km.yr	Incidents	Frequency /1000 km.yr
<5	49537	15	0.303
5-10	320504	16	0.050
10-15	242744	0	0.000
>15	41947	0	0.000
Total	**654732**	**31**	**0.047**

Table 8 – Exposure by Wall Thickness Class

2.2.5.2 External Corrosion by Year of Construction

**Product Loss Incidents Caused by External Corrosion
Frequency by Year of Construction and Equivalent Hole Diameter**
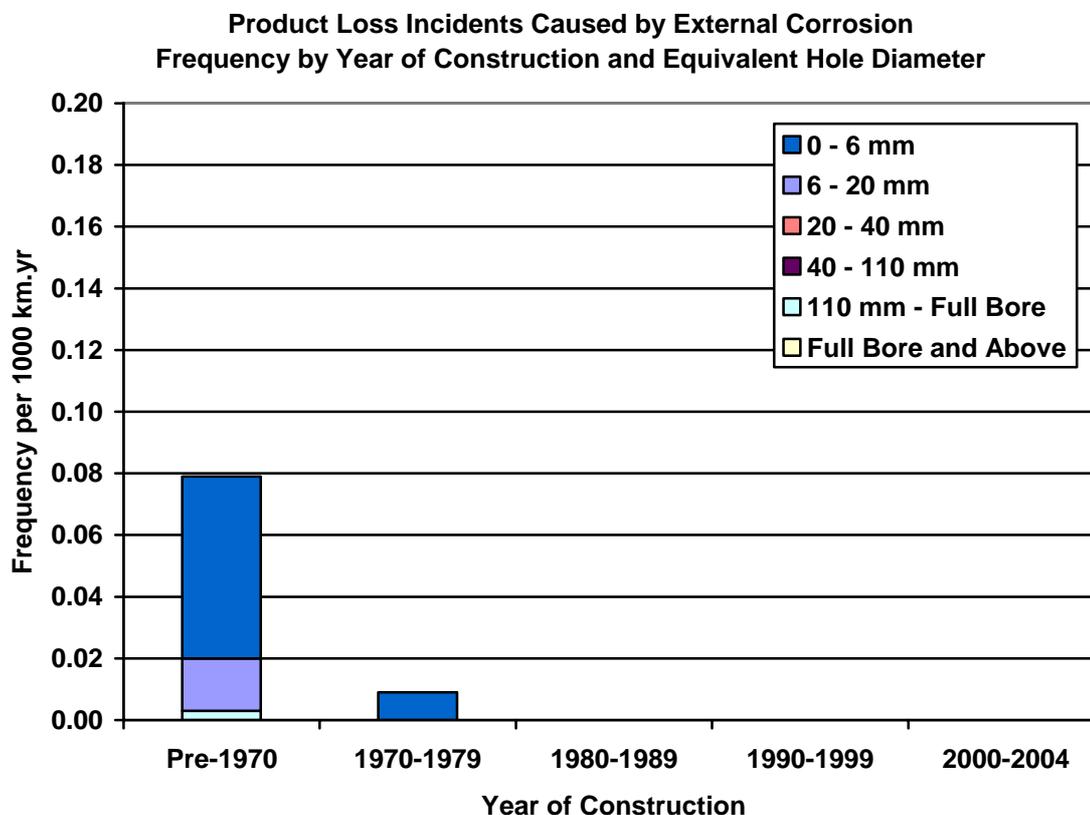
Figure 11

Construction Year	Exposure km.yr	Incidents	Frequency /1000 km.yr
Pre-1970	353153	28	0.079
1970-1979	225176	3	0.013
1980-1989	52752	0	0.000
1990-1999	20932	0	0.000
2000-2004	2720	0	0.000
Total	**654732**	**31**	**0.047**

Table 9 – Exposure by Year of Construction

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2.2.5.3 External Corrosion by External Coating Type
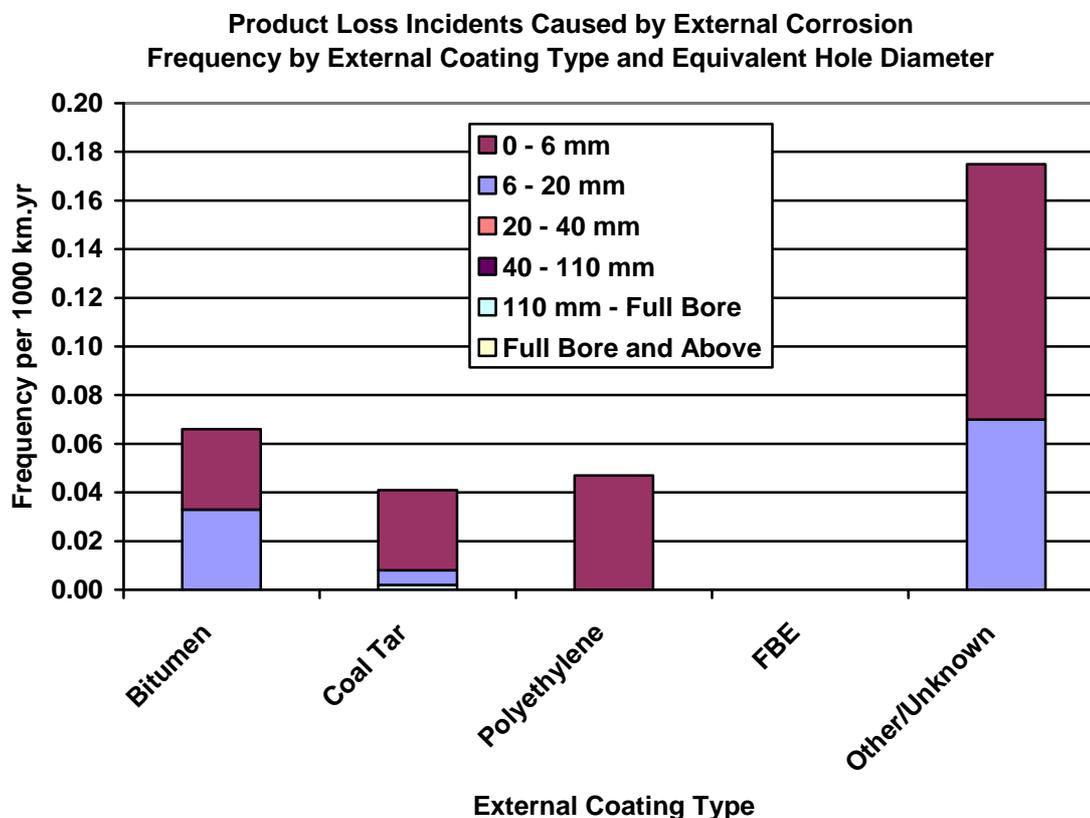
Figure 12

External Coating	Exposure km.yr	Incidents	Frequency /1000 km.yr
Bitumen	30086	3	0.100
Coal Tar	512867	21	0.041
Polyethylene	42462	2	0.047
FBE	49397	0	0.000
Other/Unknown	28674	5	0.174
Total	**663487**	**31**	**0.047**

Table 10 – Exposure by External Coating Type

2.2.5.4 External Corrosion by Type of Backfill

Product Loss Incidents Caused by External Corrosion Frequency by Backfill Type and Equivalent Hole Diameter

Legend:
- 0 - 6 mm
- 6 - 20 mm
- 20 - 40 mm
- 40 - 110 mm
- 110 mm - Full Bore
- Full Bore and Above

Y-axis: % of total Incidents
X-axis: Backfill Type (Clay, Gravel, Heavy Soil, Peat, Sand, Other)

Figure 13

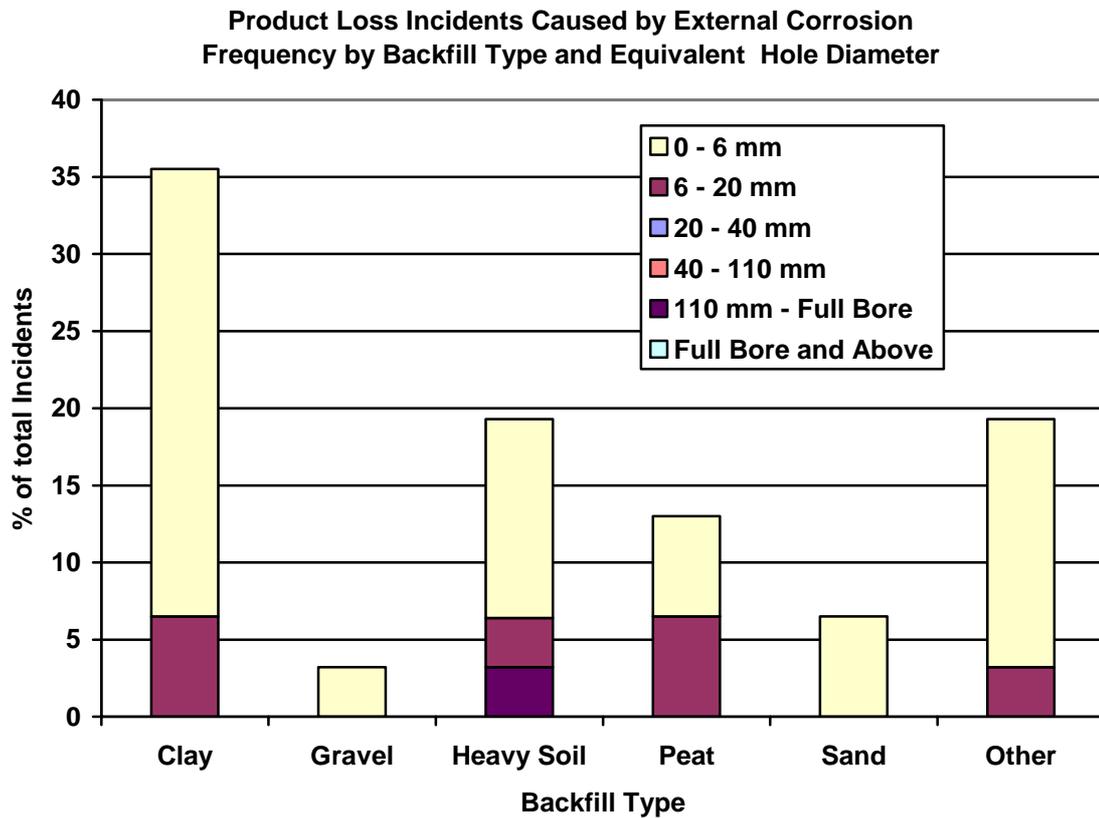# UKOPA

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2.2.6 Detection

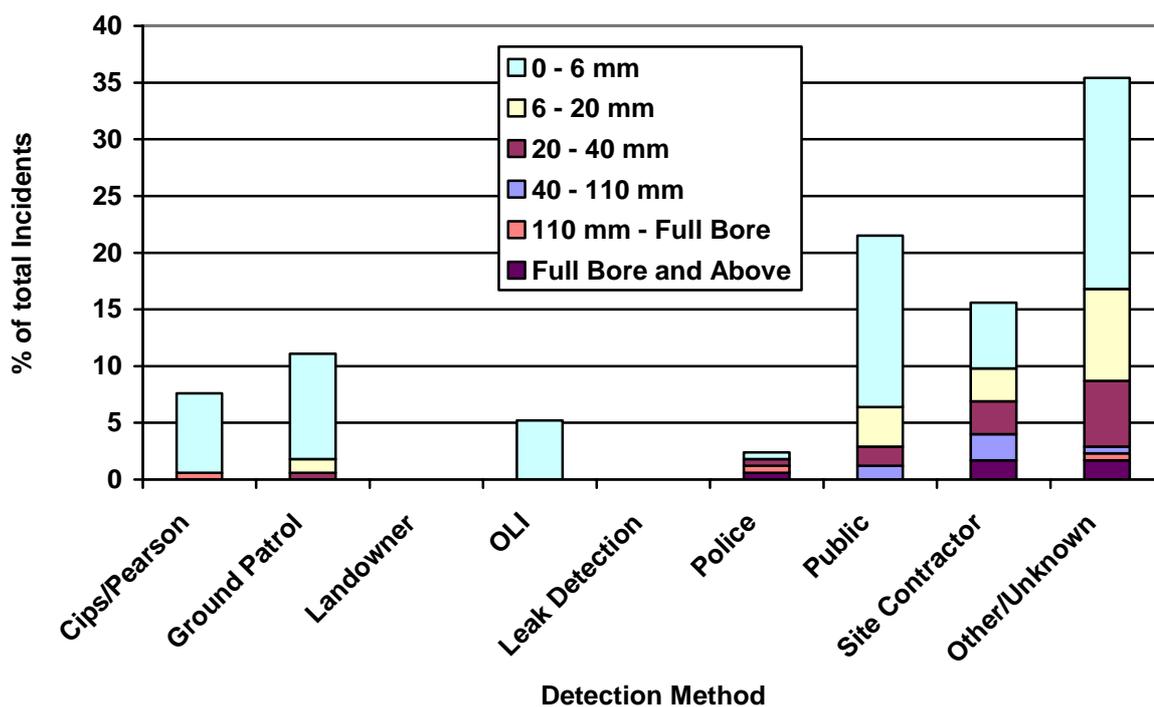**Detection of Product Loss Incidents by Equivalent Hole Diameter**

Figure 14

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