

## **UKOPA PIPELINE FAULT DATABASE**

# **UKOPA**

### **Pipeline Product Loss Incidents**

(1962 - 2006)

5<sup>th</sup> Report of the UKOPA **Fault Database Management Group**

Comprising:

National Grid

BP

Huntsman

Shell UK

E-ON UK

Wales and West Utilities

Scotia Gas Networks

Northern Gas Networks

Health and Safety Executive

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**UKOPA**



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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, BP, Huntsman and E-ON UK, covering operating experience up to the end of 2006. 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 2006 is 0.248 incidents per 1000 km.year, whilst in the previous report this figure was 0.263 incidents per 1000 km.year (covering the period from 1962 to 2004).

The failure frequency over the last 5 years is 0.028 incidents per 1000 km.year, whilst in the previous report this figure was 0.028 incidents per 1000 km.year (covering the 5 year period up to the end of 2004).

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## Contents

<b>1</b>	<b>INTRODUCTION.....</b>	<b>1</b>
1.1	BACKGROUND .....	1
1.2	PURPOSE OF THE DATABASE.....	1
1.3	KEY ADVANTAGES.....	1
<b>2</b>	<b>Database Content.....</b>	<b>3</b>
2.1	PIPELINE SYSTEM DATA .....	3
2.1.1	<i>Exposure</i> .....	3
2.1.2	<i>Transported Products</i> .....	4
2.2	PRODUCT LOSS INCIDENT DATA.....	4
2.2.1	<i>Incident Ignition</i> .....	5
2.2.2	<i>Incident Frequency</i> .....	6
2.2.3	<i>Incident Frequency by Cause</i> .....	8
2.2.4	<i>External Interference</i> .....	11
2.2.5	<i>External Corrosion</i> .....	14
2.2.6	<i>Detection</i> .....	18

## 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	Covering Incidents to end of	Report Number	Reference
2000	1998	1	R 4092
2002	2000	2	R 4798
2003	2002	3	R 6575
2005	2004	4	R 8099
2007 (this report)	2006	5	6597

### 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

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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

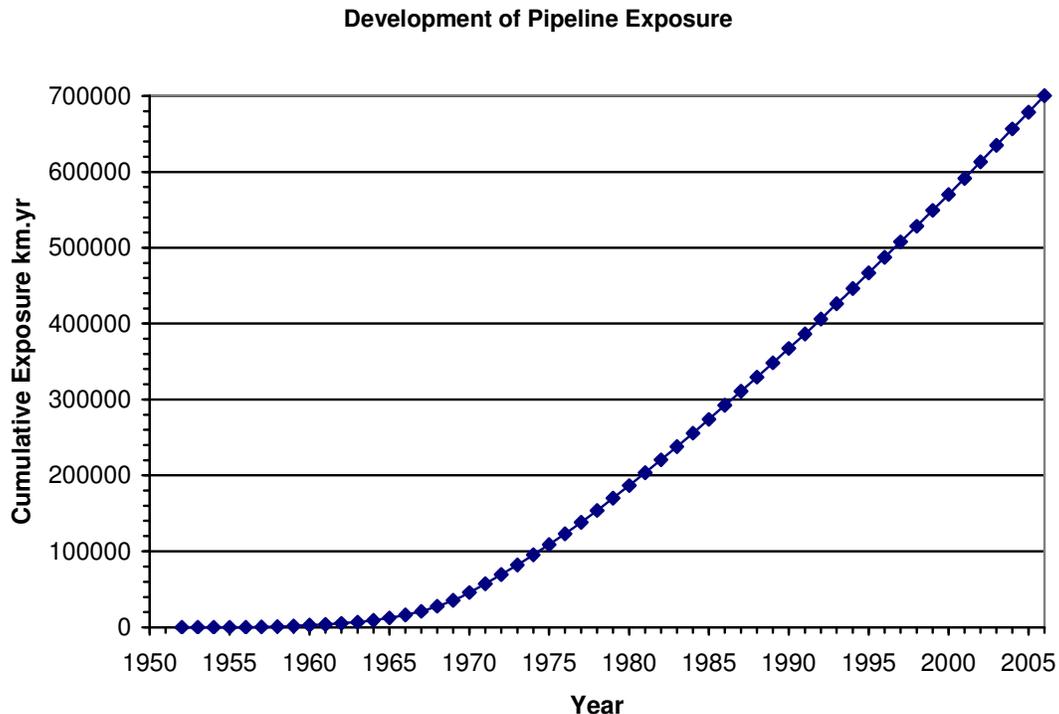
The total length of Major Accident Hazard Pipelines (MAHPs - see UK statutory legislation, The Pipelines Safety Regulations 1996 (PSR96), for their definition), above ground, below ground and elevated, in operation at the end of 2006 for all participating companies (National Grid, Scotia Gas Network, Northern Gas Network, Wales and West Utilities, BP, Shell UK, Huntsman and E-ON UK) is 21,882 km. The total exposure in the period 1952 to the end of 2006 is 700463.16 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 2006 of Elevated Pipeline = 25.8.0 km.yr (included in totals)*

*Exposure to end 2006 of Above Ground Pipeline = 142.0 km.yr (included in totals)*



**Figure 1**

## 2.1.2 Transported Products

The lengths of pipeline in operation at the end of 2006, by transported product, are (in km):

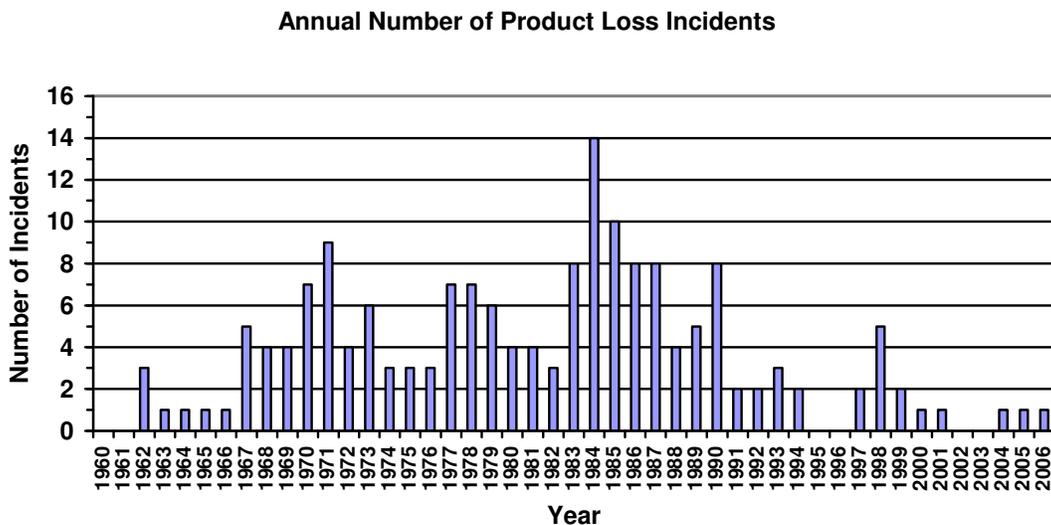
Butane	19.5	Hydrogen	14.14
Condensate	24.0	LPG	9.94
Crude Oil (Spiked)	212.6	Natural Gas (Dry)	20134.53
Ethane	38.1	Other	225.8
Ethylene	1141	Propane	19.5
Gasoline	6.5	Propylene	36.3
<b>TOTAL PIPELINE LENGTH</b>		<b>21881.85</b>	

## 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

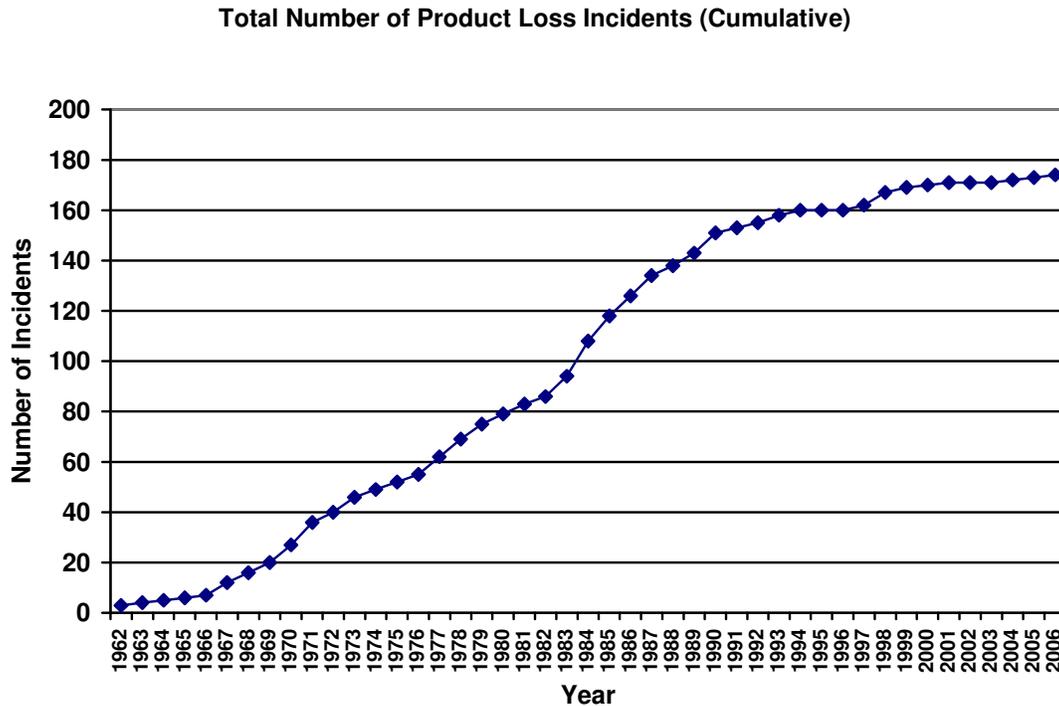
A total of 174 product loss incidents were recorded over the period between 1962 and 2006. No product loss incidents were recorded prior to 1962. An annual breakdown of incidents is illustrated in Figure 2a. The cumulative number of incidents over the period 1962 to 2006 is shown in Figure 2b.



**Figure 2a**

**Differences between 2004 and 2006 product loss statistics**

There was one product loss incident recorded during the year 2006.



**Figure 2b**

**2.2.1 Incident Ignition**

There were 9 out of 174 (5.2%) product loss incidents that resulted in ignition. Table 1 below provides more detail:

<b>Affected Component</b>	<b>Cause Of Fault</b>	<b>Hole Diameter Class</b>
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 2006 is shown in Table 2.

Period	Number of Incidents	Total Exposure [km.yr]	Frequency [Incidents per 1000 km.yr]
1967 - 1971	29	41.104	0.706
1972 - 1976	19	66.139	0.287
1977 - 1981	28	80.241	0.349
1982 - 1986	43	88.883	0.484
1987 - 1991	27	94.150	0.287
1992 - 1996	7	100.878	0.069
1997 - 2001	11	104.195	0.106
2002 - 2006	3	108.836	0.028

**Table 2**

The overall incident frequency by hole size over the period 1962 - 2006 is shown in Table 3.

Hole Size Class	Number of Incidents	Frequency [Incidents per 1000 km.yr]
Full Bore* and Above	7	0.010
110mm – Full Bore*	3	0.004
40mm – 110mm	7	0.010
20mm – 40mm	21	0.031
6mm – 20mm	27	0.040
0 – 6mm	107	0.158

**Table 3**

\* Full Bore ≡ 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 (2002-2006) is 0.028 incidents per 1000 km.yr as compared to the failure frequency during the period 1962-2006 which is 0.248 incidents per year per 1000 km.yr. An overview of the development of this failure frequency over the period 1962 to 2006 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 (2002-2006, 2001-2005, 2000-2004 etc).

### Development of Overall Incident Frequency

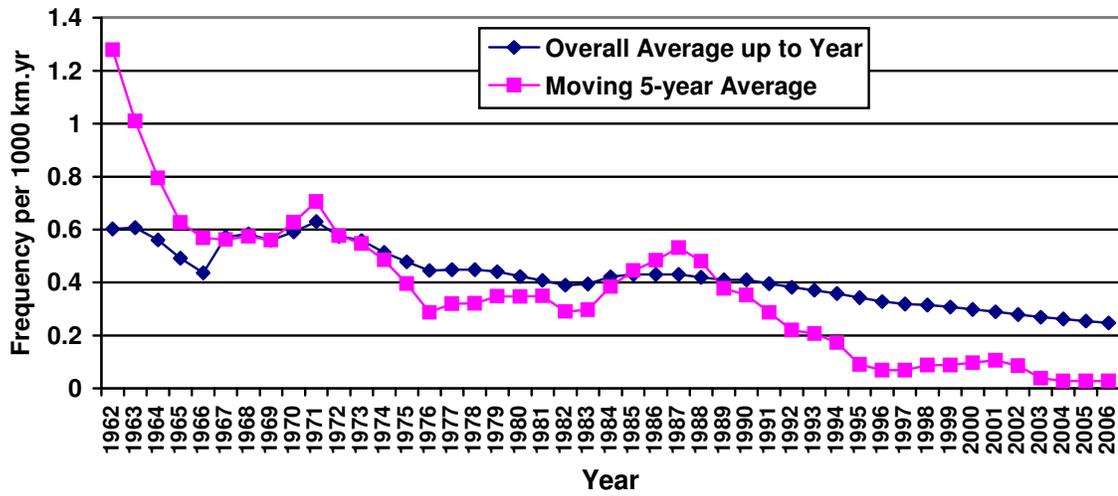
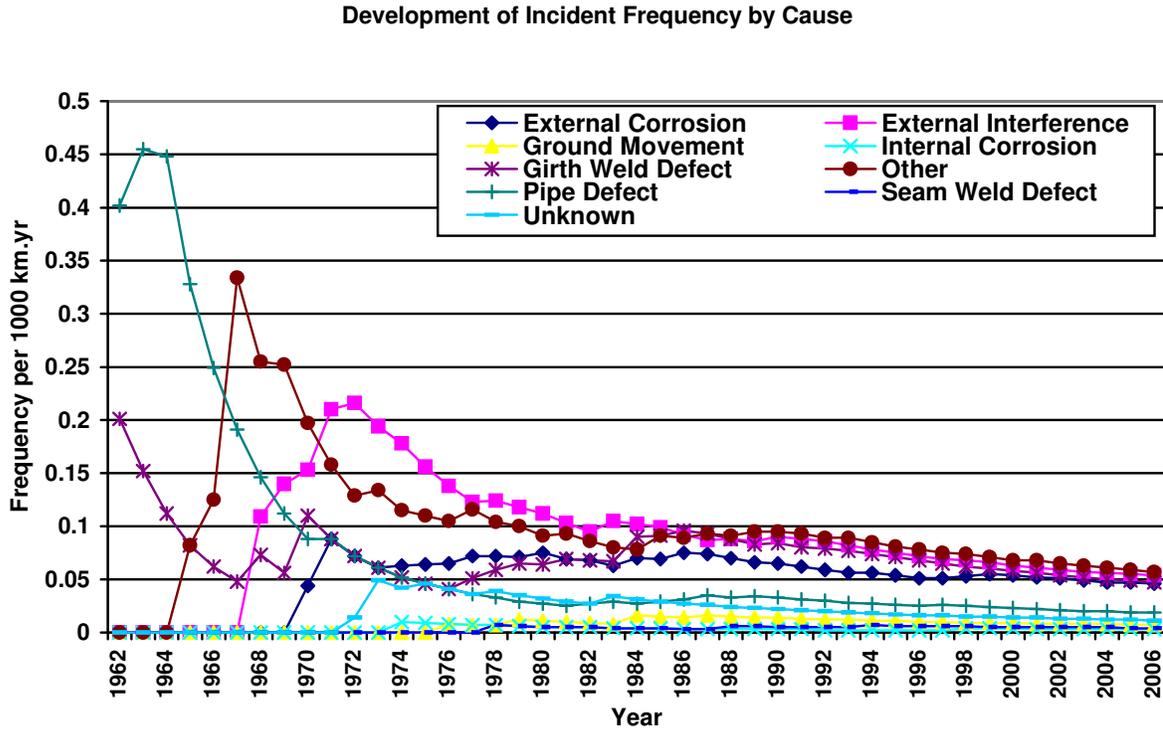


Figure 3

### 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	32
Unknown	8
Other	40
Pipe Defect	13
Ground Movement	5
Seam Weld Defect	3
<b>Total</b>	<b>174</b>

**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
<b>Total</b>	<b>40</b>

**Table 4 – Product Loss Incidents by Cause**

Figure 5 shows the product loss incident frequency by cause over the period 1962-2006 compared with the frequency over only the last 5 years (2002-2006).

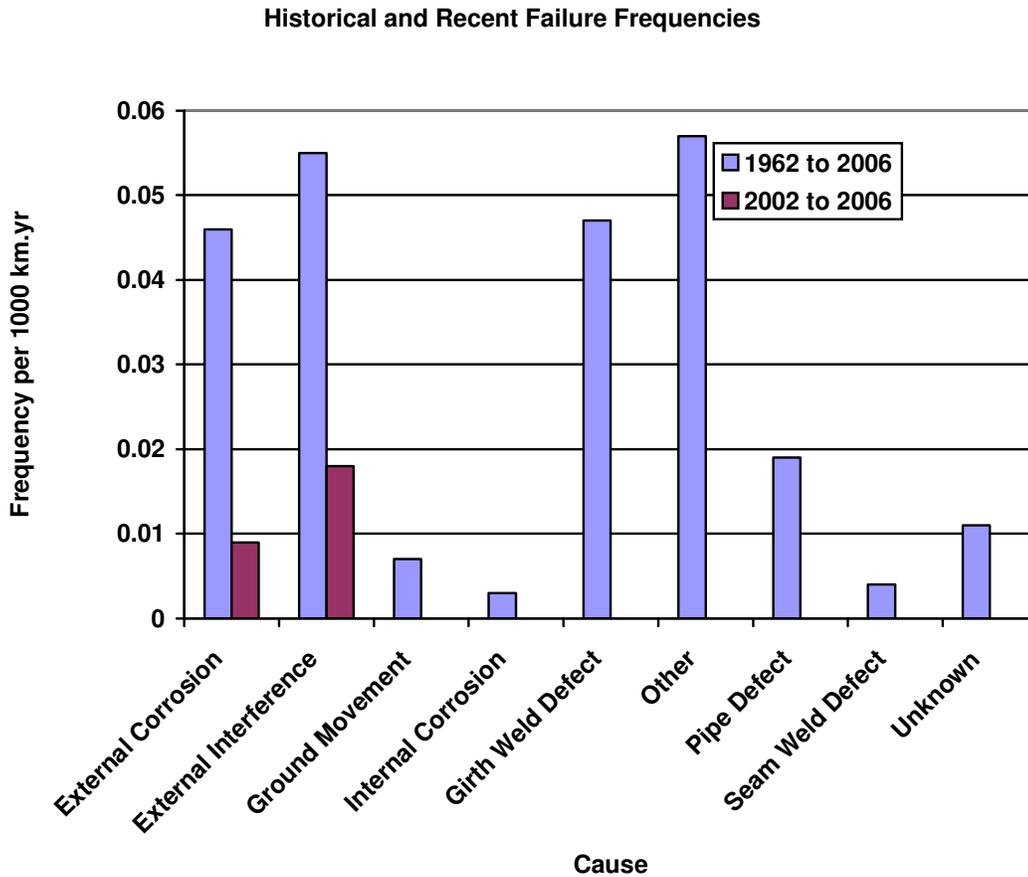
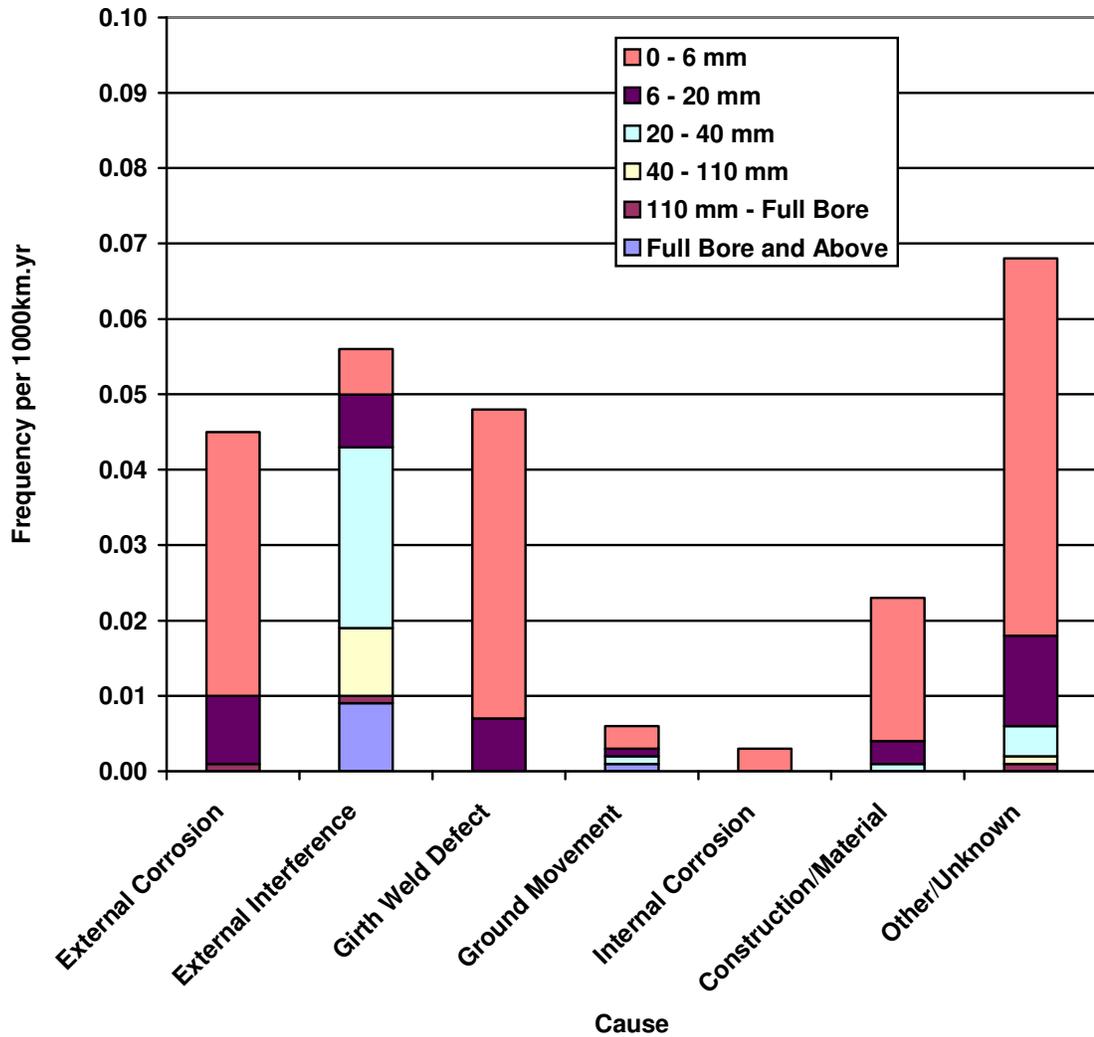


Figure 5

An overview of the product loss incident frequency by cause and size of leak in the period 1962 to 2006 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*

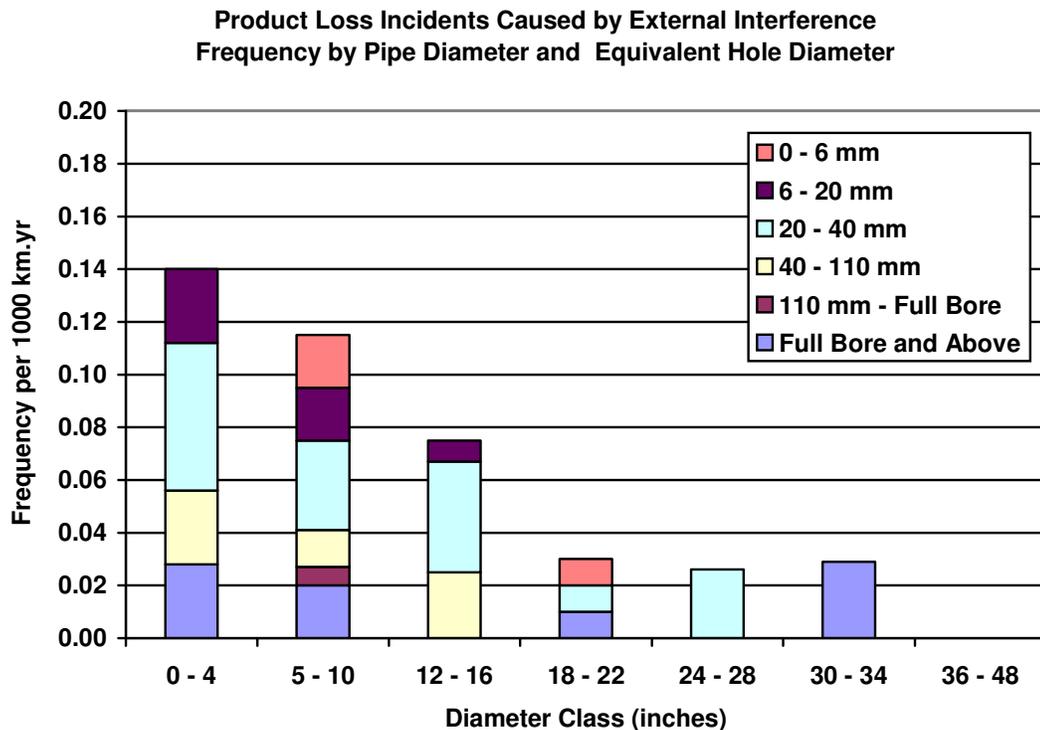
**Figure 6**

## 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.



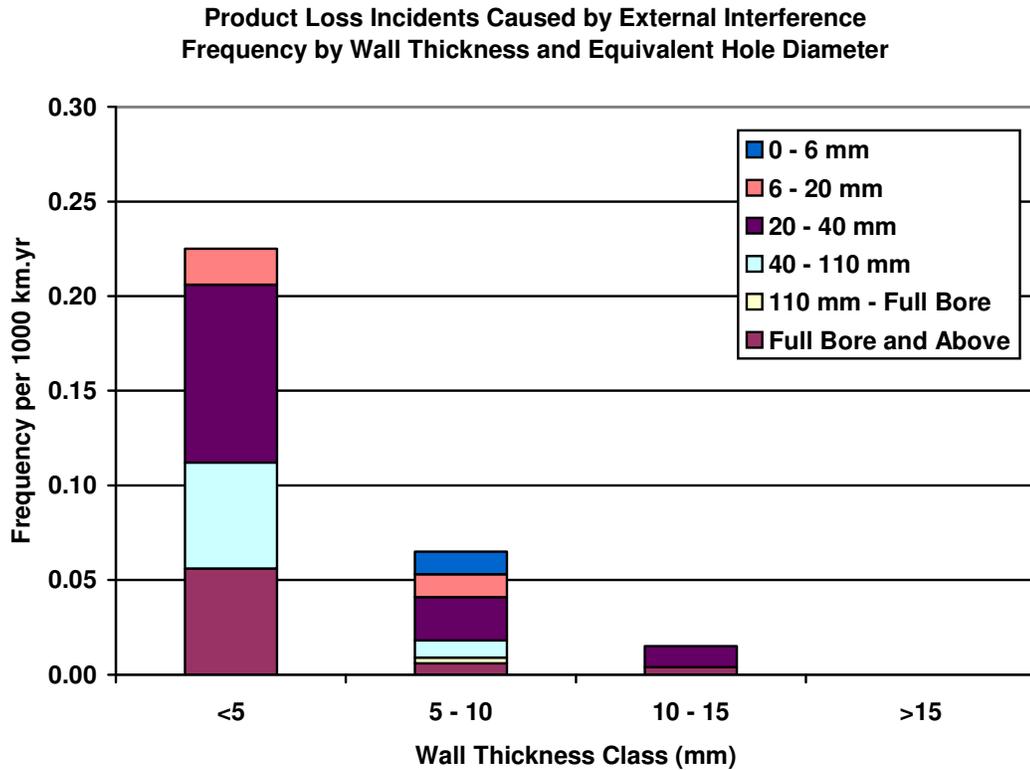
**Figure 7**

Diameter inches	Exposure km.yr	Incidents	Frequency /1000km.yr
0-4	35996	5	0.139
5-10	147342	17	0.115
12-16	120225	9	0.075
18-22	105083	3	0.029
24-28	113585	3	0.026
30-34	33948	1	0.029
36-48	144285	0	0.000
<b>Total</b>	<b>700463</b>	<b>38</b>	<b>0.054</b>

**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.

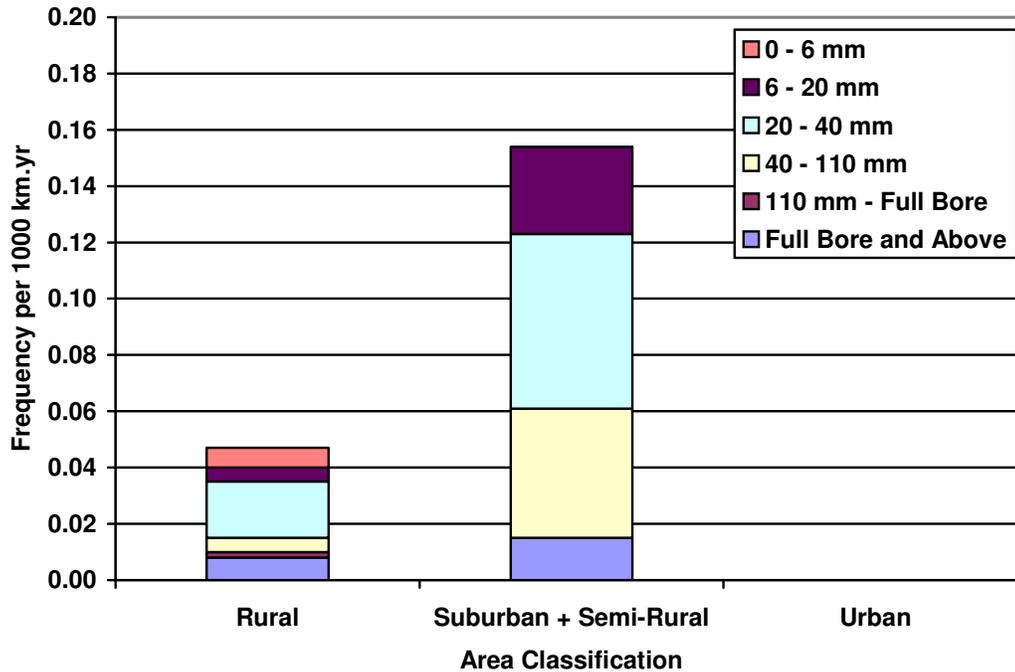
**Figure 8**

Wall Thickness mm	Exposure km.yr	Incidents	Frequency /1000 km.yr
<5	53099	12	0.226
5-10	340779	22	0.065
10-15	261400	4	0.015
>15	45185	0	0.000
<b>Total</b>	<b>700463</b>	<b>38</b>	<b>0.054</b>

**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	597744	28	0.047
Suburban + Semi-Rural	64636	10	0.155
Urban	771	0	0.000
<b>Total</b>	<b>663151</b>	<b>38</b>	<b>0.057</b>

**Table 7 – Exposure by Area Classification in km.yr**

*Note:*

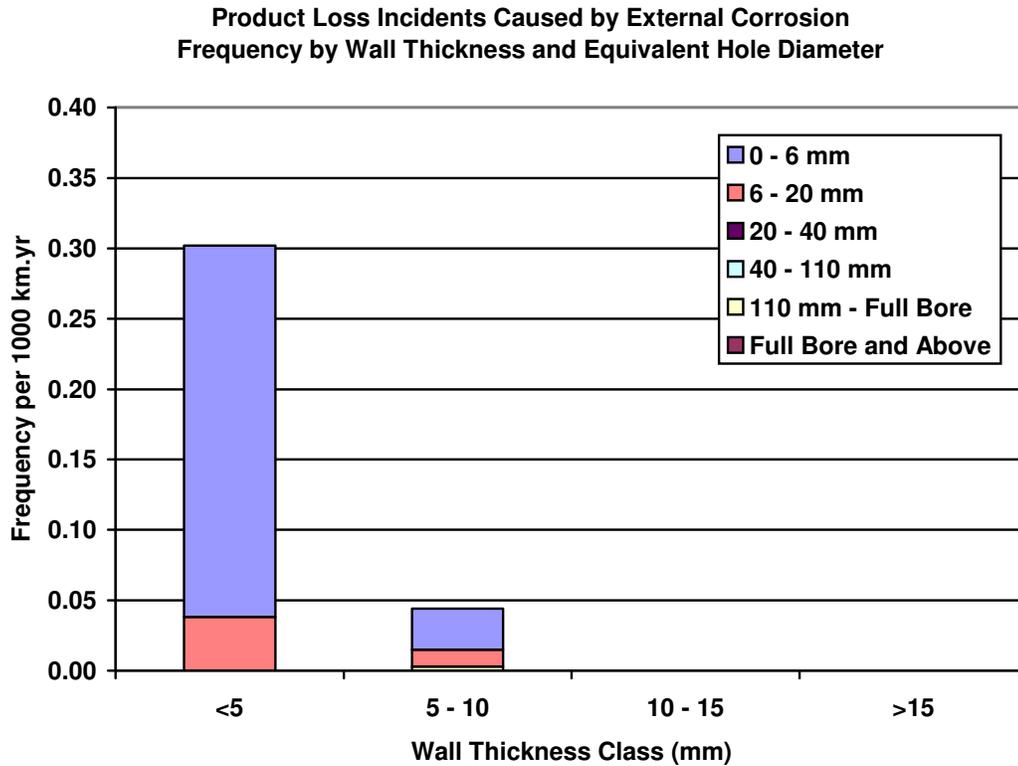
*Rural = population density < 2.5 persons per hectare*

*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

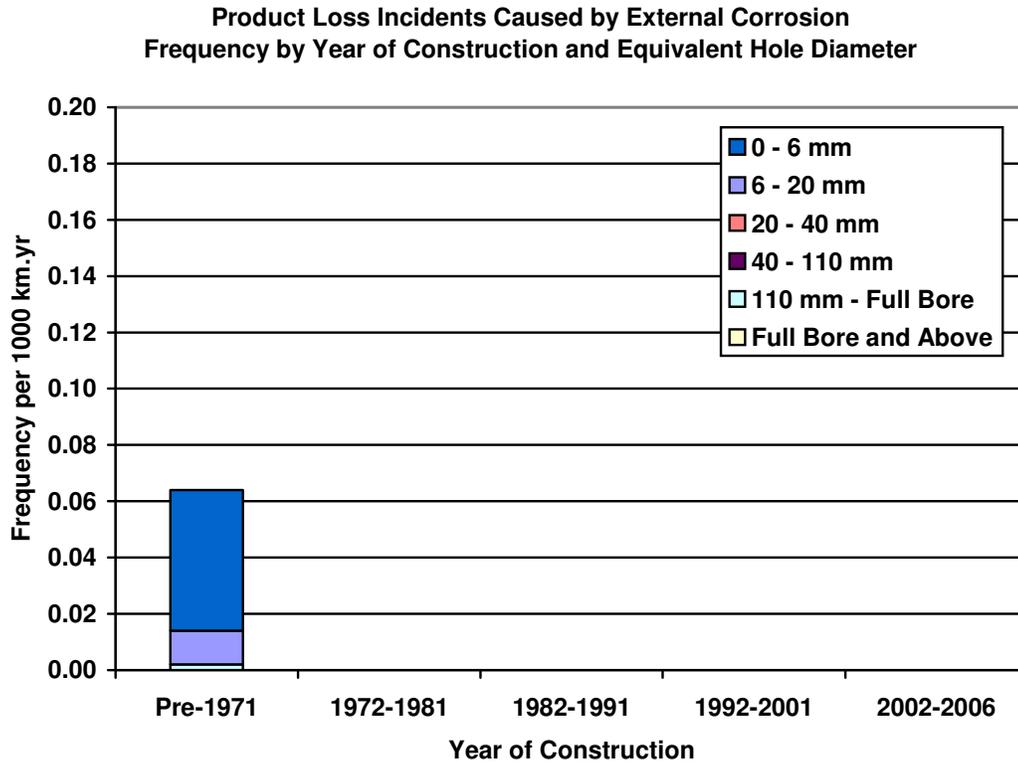


**Figure 10**

Wall Thickness (mm)	Exposure km.yr	Incidents	Frequency /1000 km.yr
<5	53099	16	0.301
5-10	340779	16	0.047
10-15	261400	0	0.000
>15	45185	0	0.000
<b>Total</b>	<b>700463</b>	<b>32</b>	<b>0.046</b>

**Table 8 – Exposure by Wall Thickness Class**

**2.2.5.2 External Corrosion by Year of Construction**

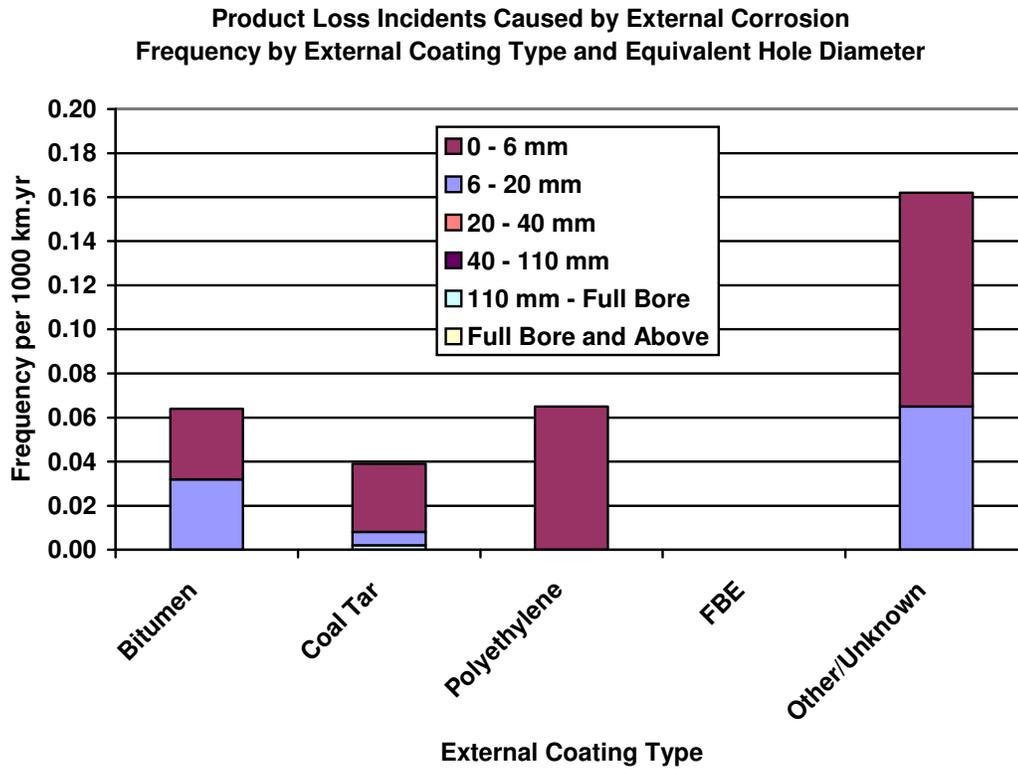


**Figure 11**

Construction Year	Exposure km.yr	Incidents	Frequency /1000 km.yr
Pre-1971	481398	31	0.064
1972-1981	149117	1	0.007
1982-1991	44535	0	0.000
1992-2001	23655	0	0.000
2002-2006	1758	0	0.000
<b>Total</b>	<b>700463</b>	<b>32</b>	<b>0.046</b>

**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	31572	3	0.095
Coal Tar	543174	21	0.039
Polyethylene	46286	3	0.065
FBE	57964	0	0.000
Other/Unknown	30850	5	0.162
<b>Total</b>	<b>709846</b>	<b>32</b>	<b>0.045</b>

**Table 10 – Exposure by External Coating Type**

### 2.2.5.4 External Corrosion by Type of Backfill

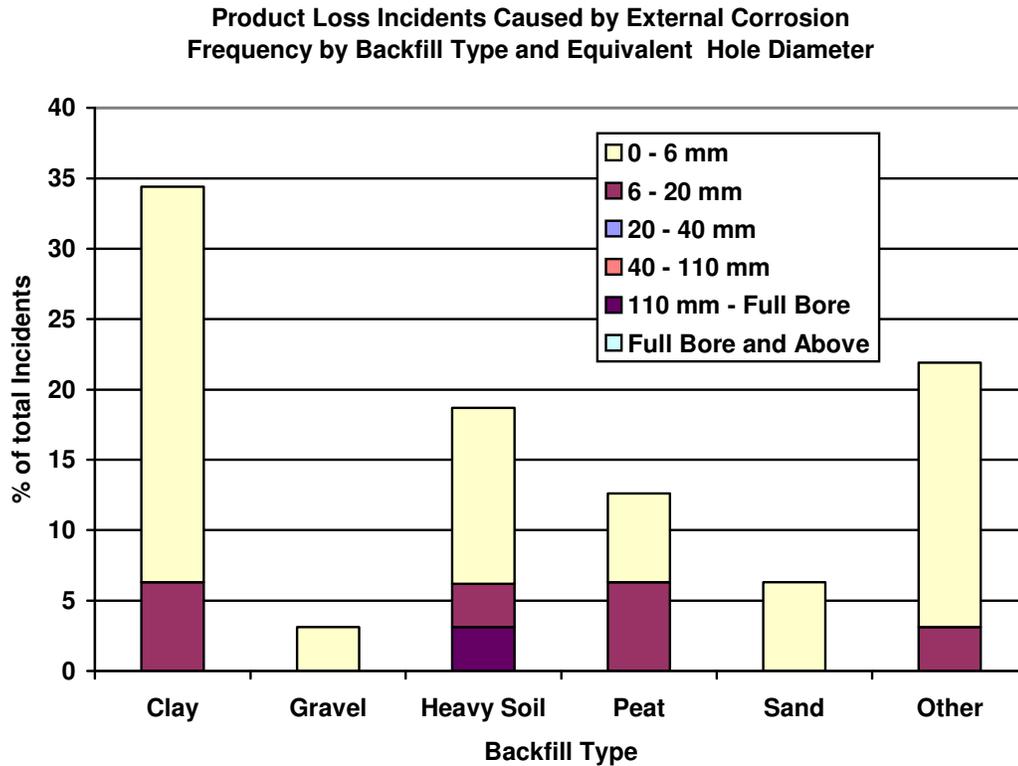
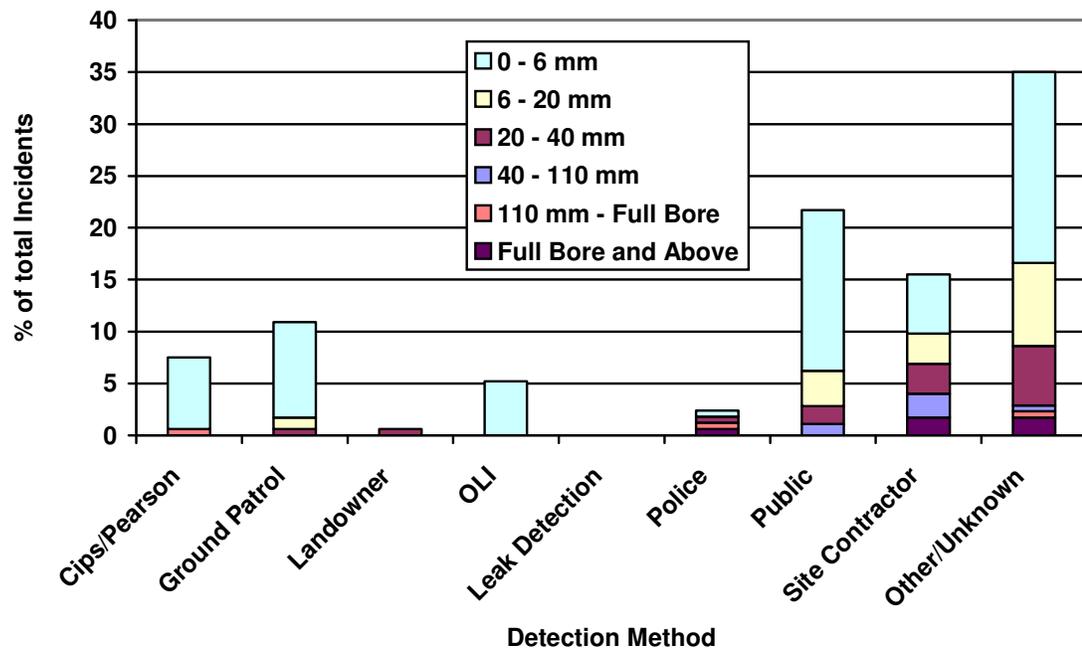


Figure 13

## 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.*