ADVANTICA

UKOPA PIPELINE FAULT DATABASE

Pipeline Product Loss Incidents

(1961 - 2000)

2nd Report of the UKOPA **F**ault **D**atabase **M**anagement **G**roup

Comprising:

Transco
BP
Huntsman
Shell UK
Powergen UK
Health and Safety Executive

Report prepared by R. Greenwood, Advantica, for FDMG

Advantica Report Reference: R 4798
June 2002

Comments, questions and enquiries about this publication should be directed to the UKOPA Pipeline Fault Database Project Manager:

Bob Greenwood
Pipeline Transportation
Advantica
Norgas House
Killingworth
Newcastle upon Tyne NE99 1GB

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 2000. 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 1961 to 2000 is 0.289 incidents per 1000 km.year.

The failure frequency over the last 5 years is 0.093 incidents per 1000 km.year.

A further report will cover predicted failure frequencies based on models of the growth of part-wall defects where no product loss has occurred, in order to provide failure frequencies for pipeline groups where historical failure data are sparse.

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. This second biennial report is an update of the previous data, covering product loss incidents up to the end of 2000.

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 new 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 million km.yr exposure to end of 1998).

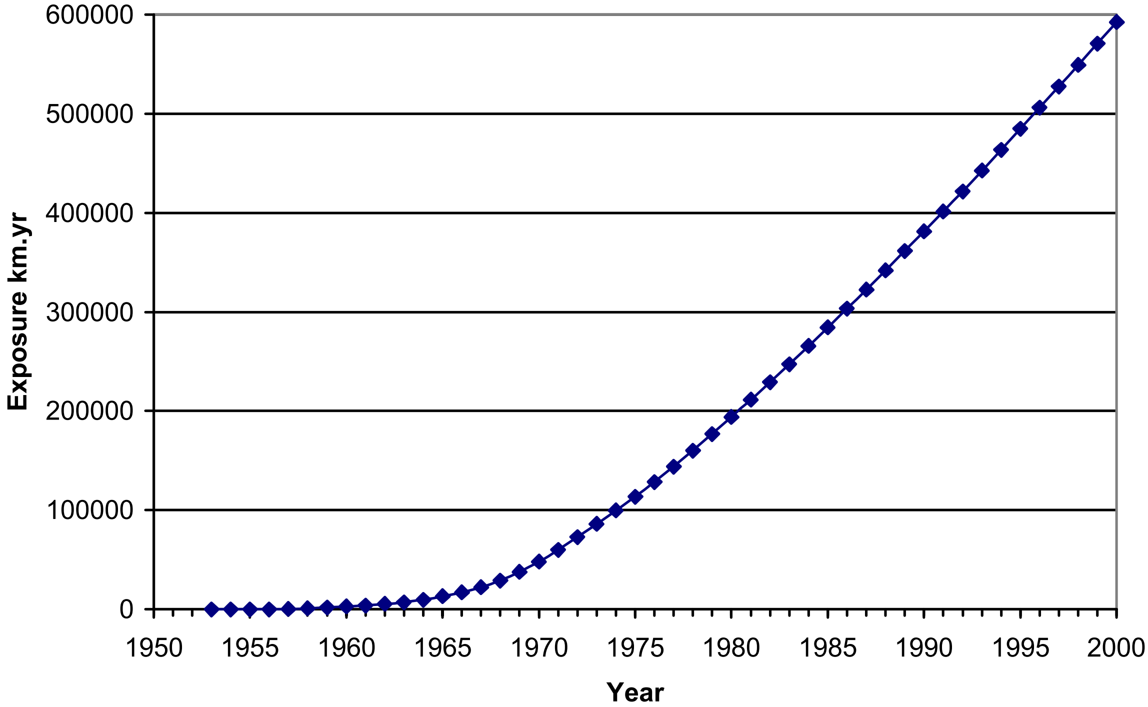
2 DATABASE CONTENT

2.1 Pipeline System Data

2.1.1 Exposure

The total length of Major Accident Hazard Pipelines (MAHPs), above ground, below ground and elevated, up to the end of 2000 for all participating companies (Transco, BP, Shell UK, Huntsman and Powergen) is 21,860 km. The total exposure in the period 1952 to the end of 2000 is 592,326 km.yr; the development of this exposure is illustrated in Figure 1.

Development of Pipeline Exposure



Length of Pipeline which has unknown commissioning date = 51.22 km. (This has been ignored in the exposure calculations)
Exposure to end 2000 of Elevated Pipeline = 21.97 km.yr (included in totals)
Exposure to end 2000 of Above Ground Pipeline = 156.75 km.yr (included in totals)

Figure 1

2.1.2 Transported Products

The transported products include (km):

Butane	19.5	Propylene	36.3
CO	36.3	LPG	9.6
Condensate	24.0	Natural Gas (Dry)	19,947.7
Crude Oil (Spiked)	212.6	Other	318.3
Ethane	38.1	Propane	19.5
Ethylene	1,198.5	**TOTAL**	**21,860**

Although the UKOPA database currently comprises only MAHPs, the intention is to include non-MAHPs in the future.

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 171 product loss incidents were recorded over the period between 1962 and 2000. 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 2000 is shown in Figure 2b.

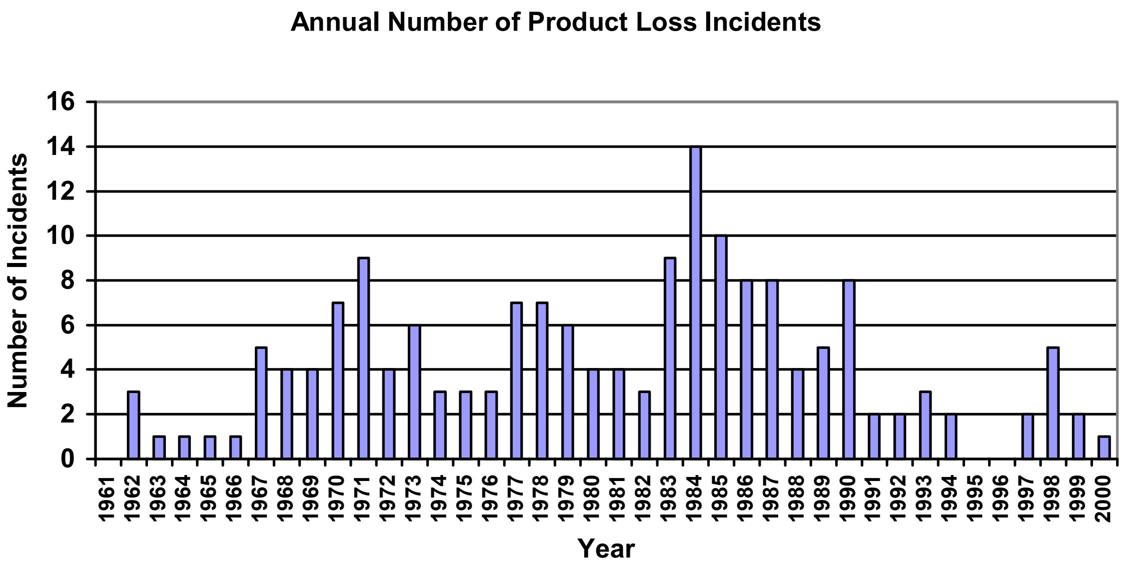


Figure 2a

Differences between 1998 and 2000 product loss statistics

Three external corrosion incidents have been recorded (2 in 1999 and 1 in 2000). As a result of audits of individual company fault databases, 2 incidents have been removed (1 flange leak in 1983 and 1 external corrosion in a compound in 1987), and 9 added (4 external interference in 1972(2),1978 and 1990, 2 external corrosion in 1976 and 1983, 2 girth weld leaks in 1973 and 1978, and 1 cause unrecorded in 1972). A number of incidents have been re-classified, the most significant change being identification of 25 old internal stress corrosion cracking faults (associated with transmission of wet town gas prior to 1970) previously classified as internal corrosion, which have been re-classified as 'other'. See table 4 for details.

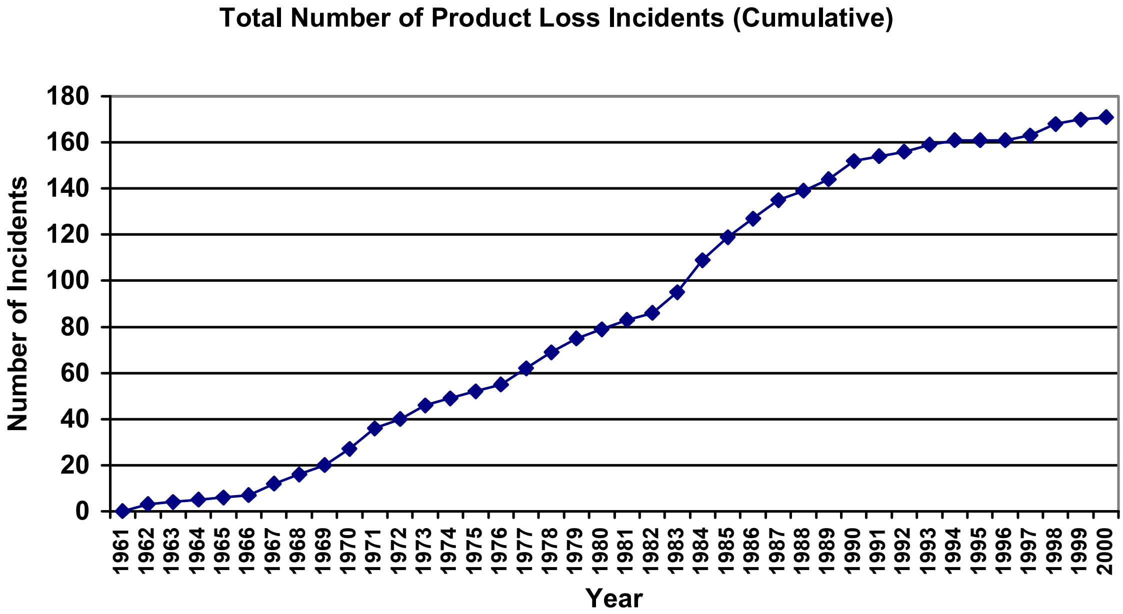


Figure 2b

2.2.1 Incident Ignition

There were 8 out of 171 (4.7%) 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	Pipe Defect	0-6 mm
Pipe	Unknown	>50 mm
Pipe	Lightning Strike	0-6 mm
Bend	Internal Corrosion	0-6 mm
Bend	Unknown	6-20 mm

Table 1 – Incidents that Resulted in Ignition

2.2.2 Incident Frequency

The incident frequency over consecutive 5-year periods is shown in Table 2.

Period	Number of Incidents	Total Exposure [km.yr]	Frequency [Incidents per 1000 km.yr]
1961 - 1965	6	10,261	0.585
1966 - 1970	21	35,115	0.598
1971 - 1975	25	65,411	0.382
1976 - 1980	27	80,322	0.336
1981 - 1985	40	90,497	0.442
1986 - 1990	33	96,728	0.341
1991 - 1995	9	103,672	0.087
1996 - 2000	**10**	**107,508**	**0.093**

Table 2

The overall incident frequency by hole size over the period 1960 – 2000 is shown in Table 3.

Hole Size Class	Number of Incidents	Frequency [Incidents per 1000 km.yr]
Full Bore*	7	0.012
≥ 50mm	16	0.027
≥ 20mm	36	0.061
≥ 6mm	63	0.106
0 – Full Bore	171	0.289

Table 3

* Full Bore ≡ diameter of pipeline

The failure frequency over the last 5 years (1996-2000) is 0.093 incidents per 1000 km.yr as compared to the failure frequency during the period 1960-2000 which is 0.289 incidents per year per 1000 km.yr. An overview of the development of this failure frequency over the period 1960 to 2000 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 (1996-2000,1995-1999,1994-1998 etc).

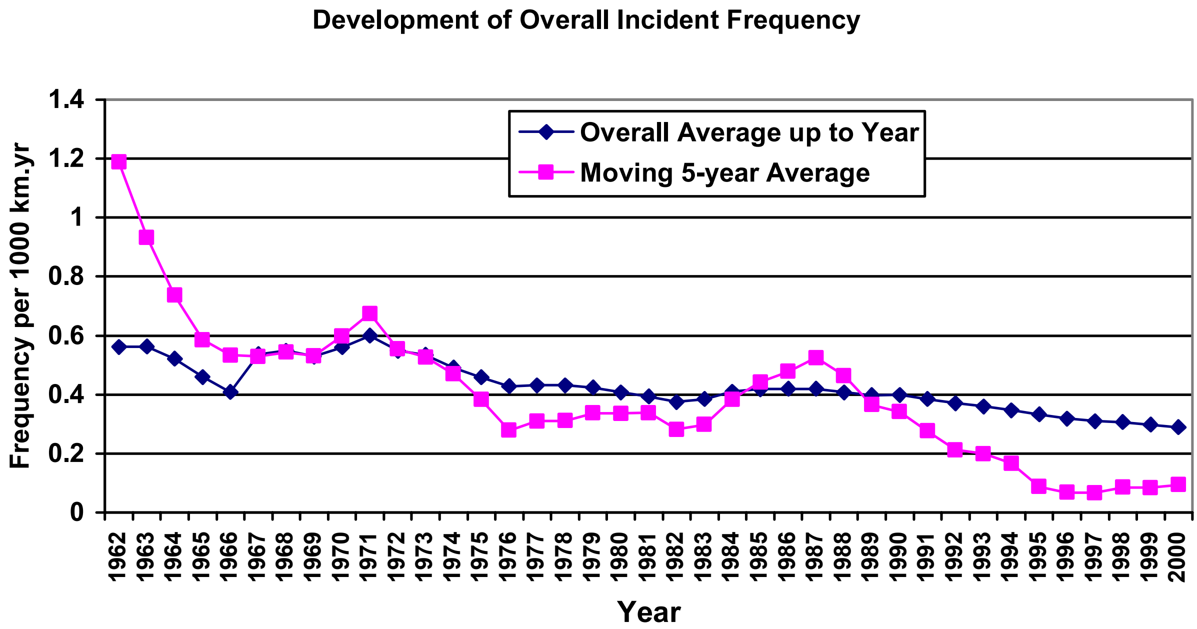

Development of Overall Incident Frequency
Frequency per 1000 km.yr
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Overall Average up to Year
Moving 5-year Average
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
Year

Figure 3

2.2.3 Incident Frequency by Cause

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

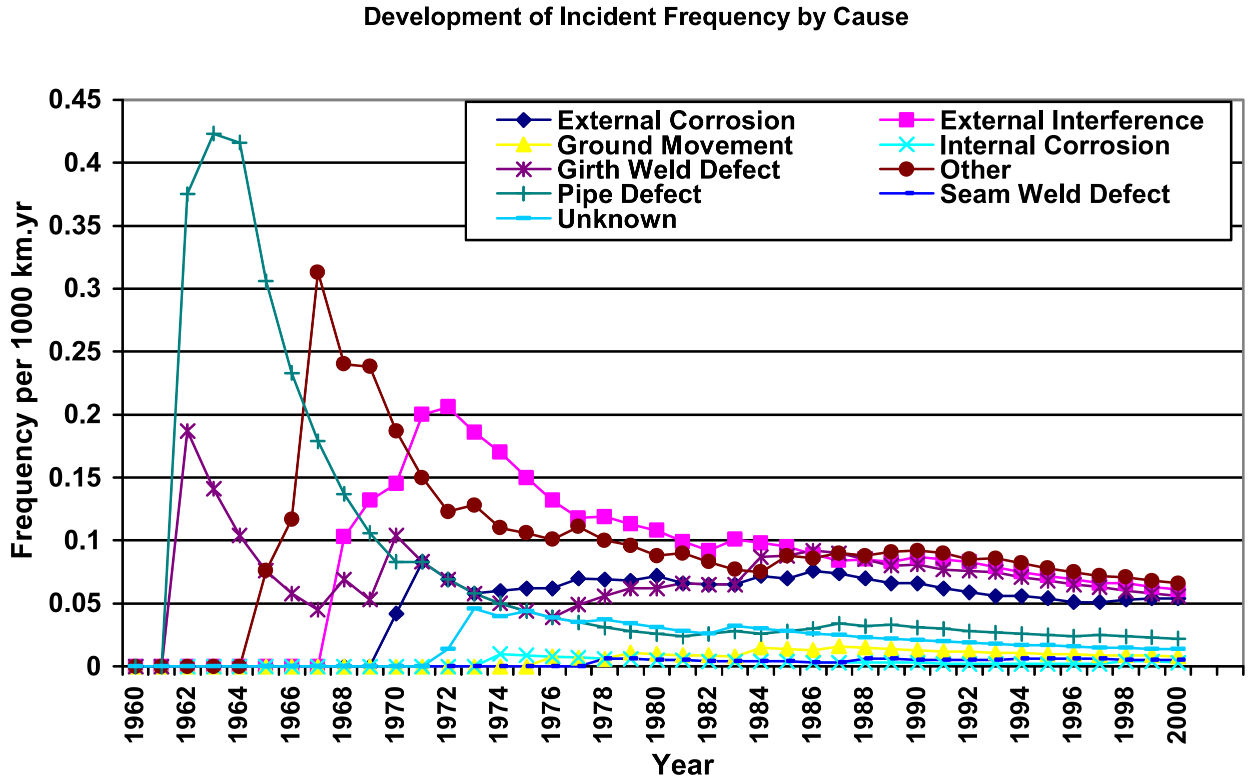


Figure 4

Product Loss Cause	No. of Incidents
Girth Weld Defect	33
External Interference	36
Internal Corrosion	2
External Corrosion	32
Unknown	8
Other	39
Pipe Defect	13
Ground Movement	5
Seam Weld Defect	3
Total	**171**

Cause = 'Other':

Other Cause	Incidents
Internal SCC due to wet town gas	29
Pipe-Fitting Welds	4
Leaking Clamps	2
Lightning	1
Soil stress	1
Threaded Joint	1
Electric Cable Arc Strike	1
Total	**39**

Table 4 – Product Loss Incidents by Cause

Figure 5 shows the product loss incident frequency by cause over the period 1960-2000 compared with the frequency over only the last 5 years (1996-2000).

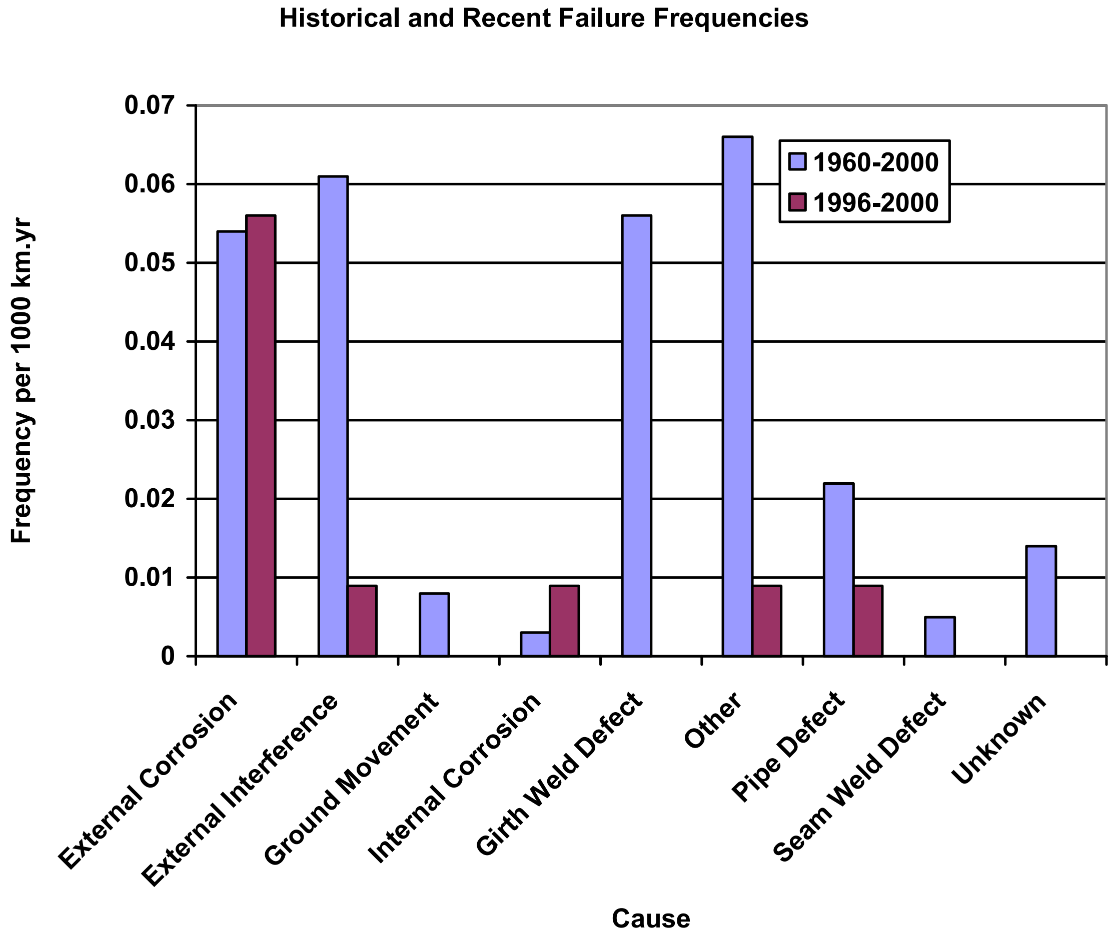
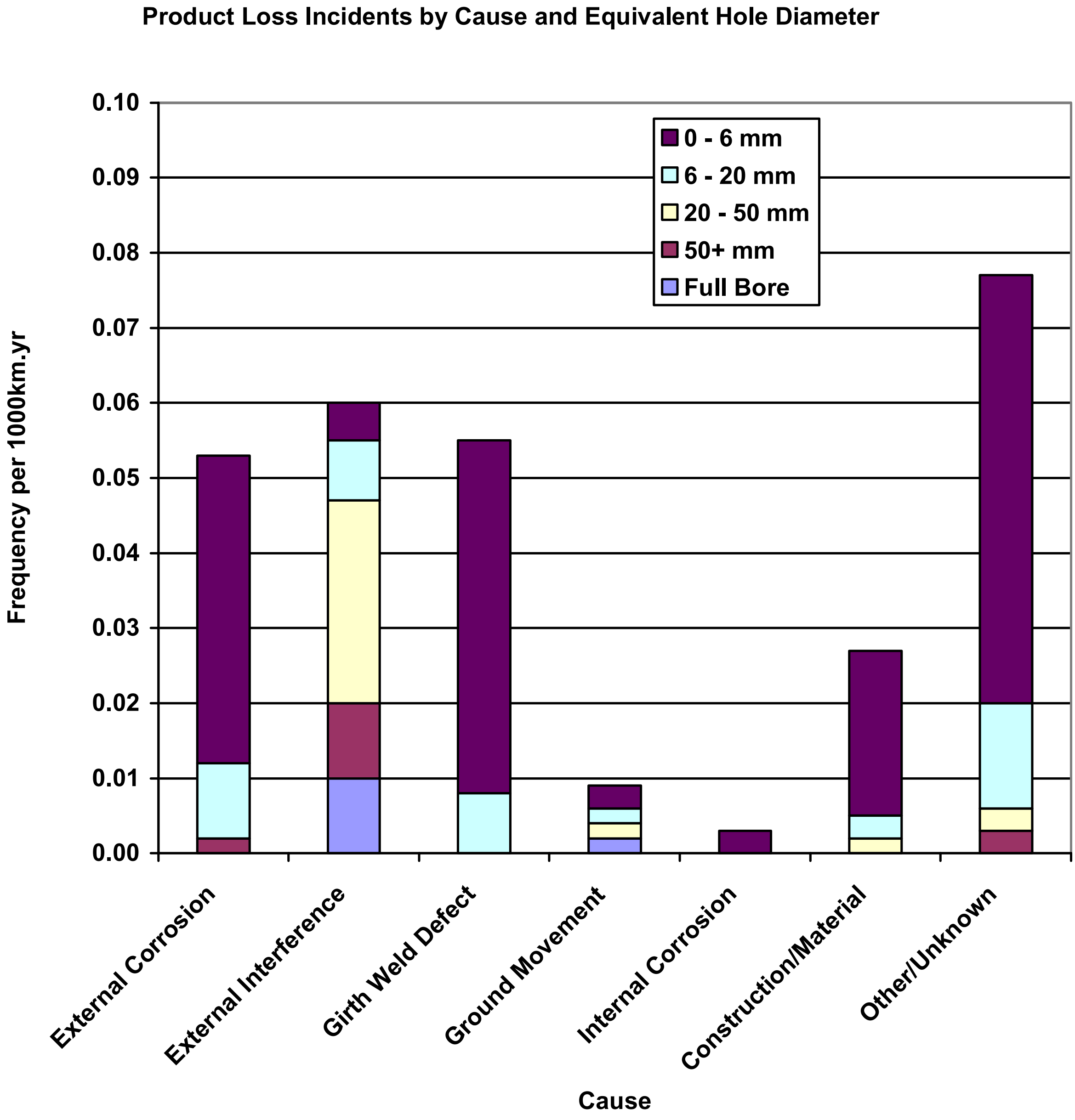


Figure 5

An overview of the product loss incident frequency by cause and size of leak in the period 1952 to 2000 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.

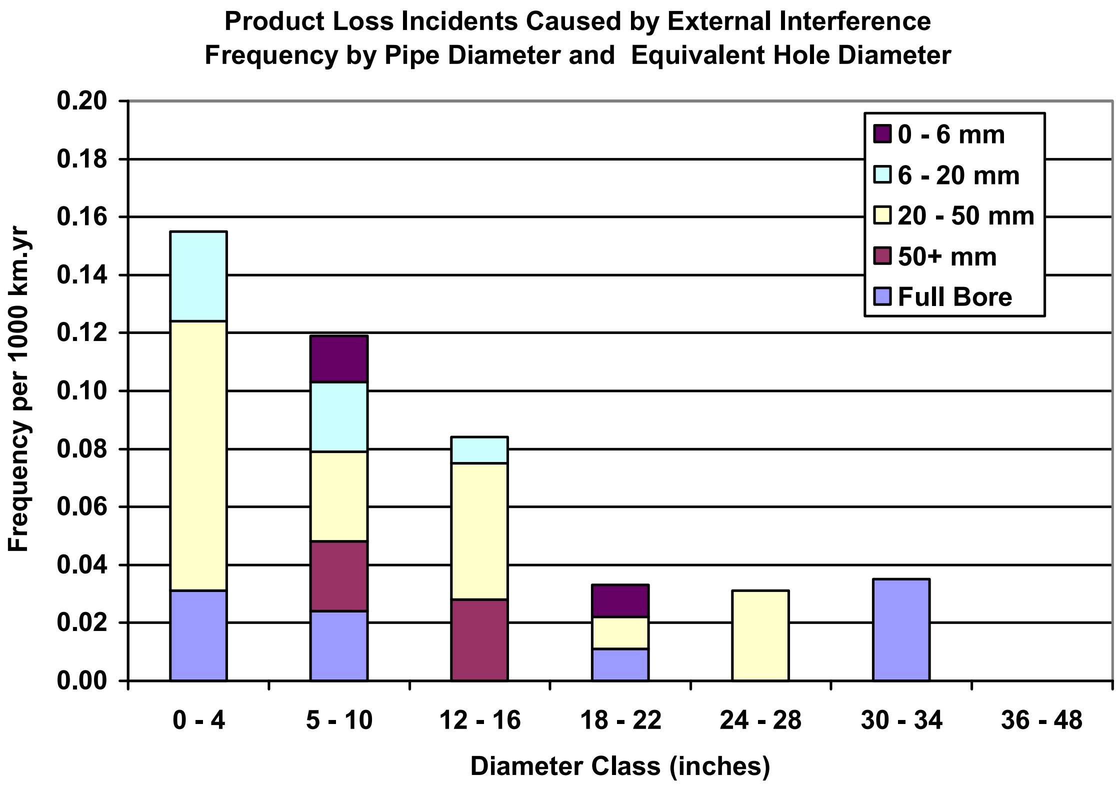


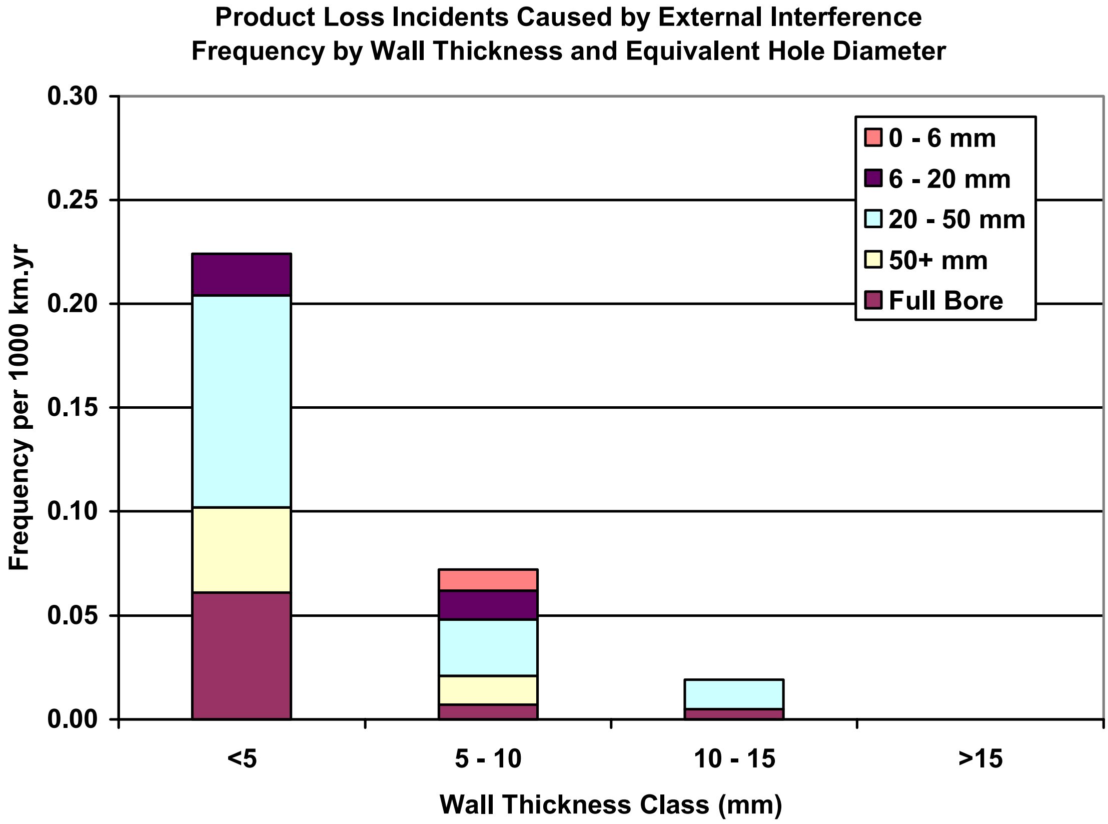
Figure 7

Diameter inches	Exposure km.yr	Incidents	Frequency /1000km.yr
0-4	32171	5	0.155
5-10	127108	15	0.118
12-16	106084	9	0.085
18-22	91708	3	0.033
24-28	96294	3	0.031
30-34	28598	1	0.035
36-48	109319	0	0.000
Total	**591282**	**36**	**0.061**

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: Maximum wall thickness for loss of product incident caused by external interference is 12.7mm.

Figure 8

Wall Thickness mm	Exposure km.yr	Incidents	Frequency /1000 km.yr
<5	49222	11	0.223
5-10	295500	21	0.071
10-15	211057	4	0.019
>15	36546	0	0.000
Total	**592325**	**36**	**0.061**

Table 6 – Exposure by Wall Thickness Class

2.2.4.3 External Interference by Area Classification

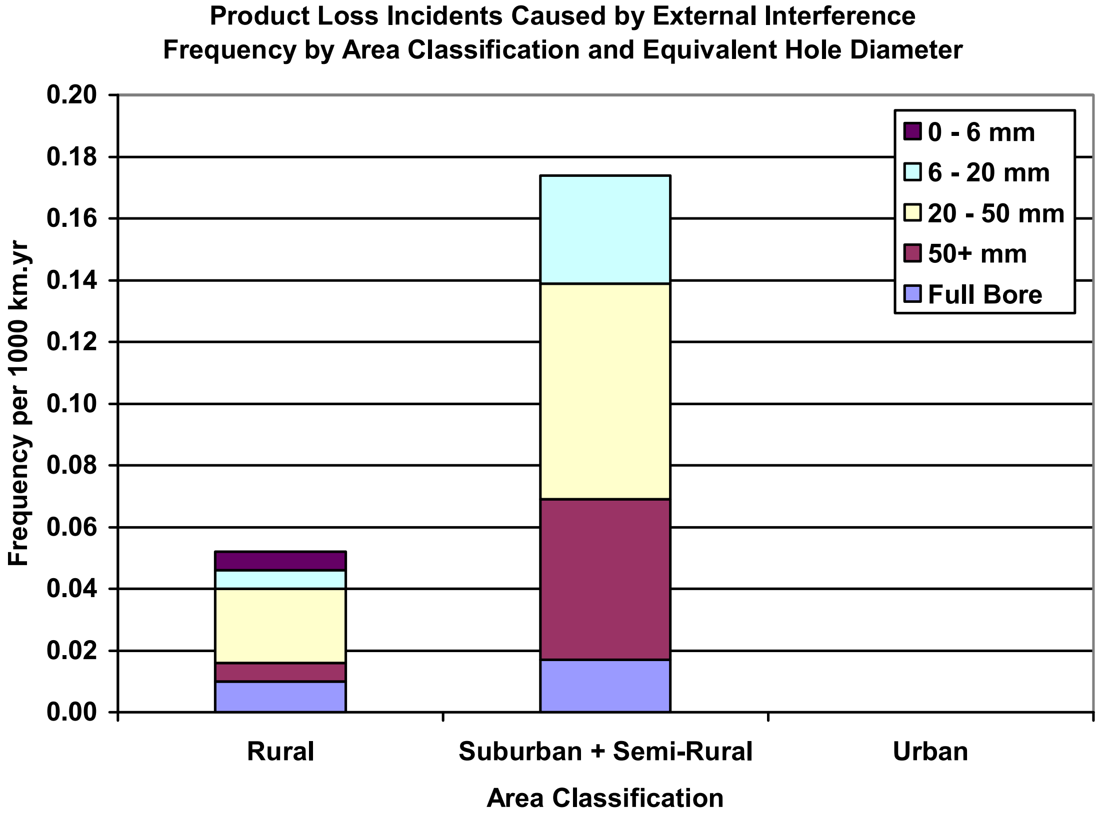


Figure 9

Area Classification	Exposure km.yr	Incidents	Frequency /1000 km.yr
Rural	498016	26	0.052
Suburban + Semi-Rural	57187	10	0.175
Urban	792	0	0.000
Total	**555995**	**36**	**0.065**

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

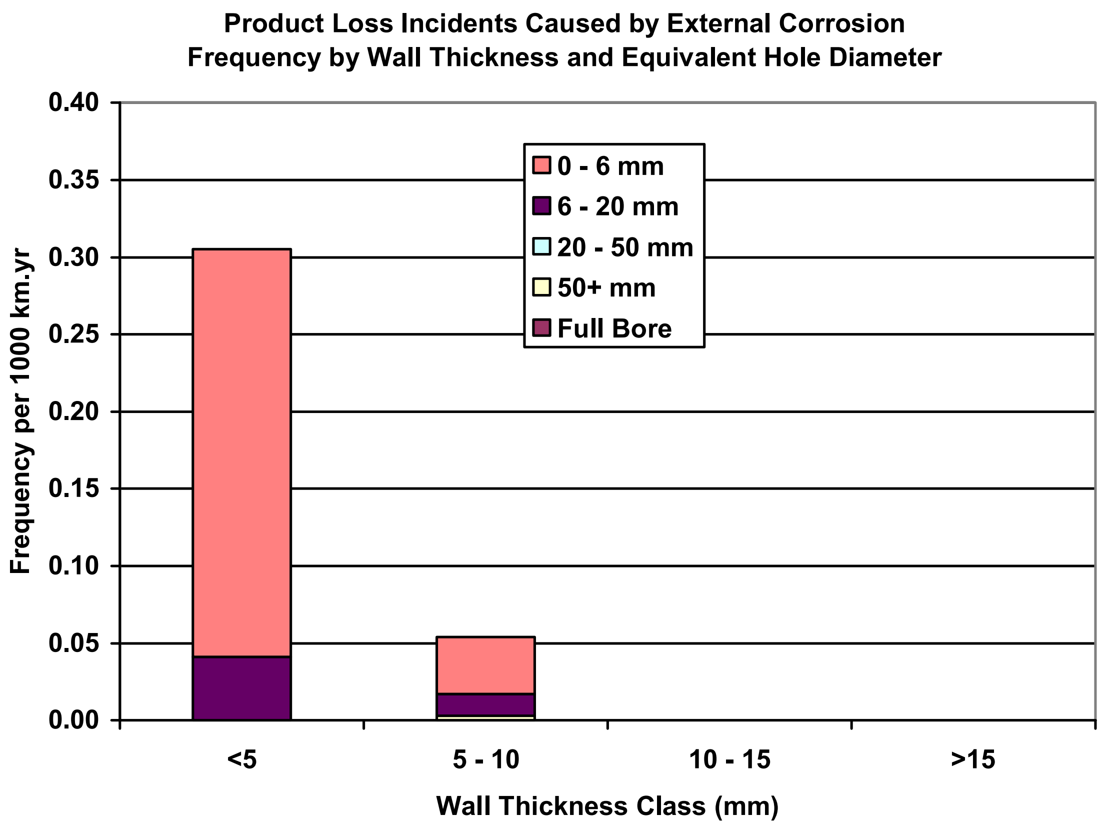


Figure 10

Wall Thickness mm	Exposure km.yr	Incidents	Frequency /1000 km.yr
<5	49222	15	0.305
5-10	295500	17	0.058
10-15	211057	0	0.000
>15	36546	0	0.000
Total	**592325**	**32**	**0.054**

Table 8 – Exposure by Wall Thickness Class

2.2.5.2 External Corrosion by Year of Construction

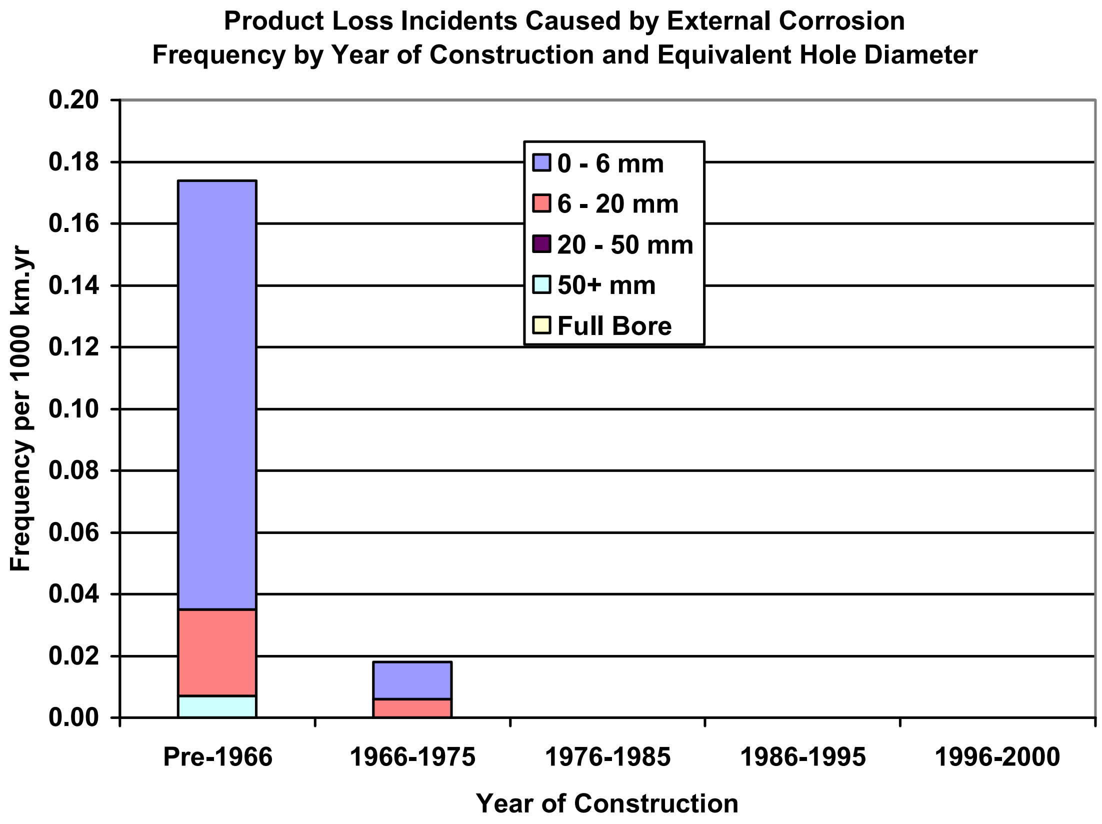


Figure 11

Construction Year	Exposure km.yr	Incidents	Frequency /1000 km.yr
Pre-1966	143482	25	0.174
1966-1975	327325	7	0.021
1976-1985	98234	0	0.000
1986-1995	22020	0	0.000
1996-2000	1264	0	0.000
Total	**591062**	**32**	**0.054**

Table 9 – Exposure by Year of Construction

2.2.5.3 *External Corrosion by External Coating Type*

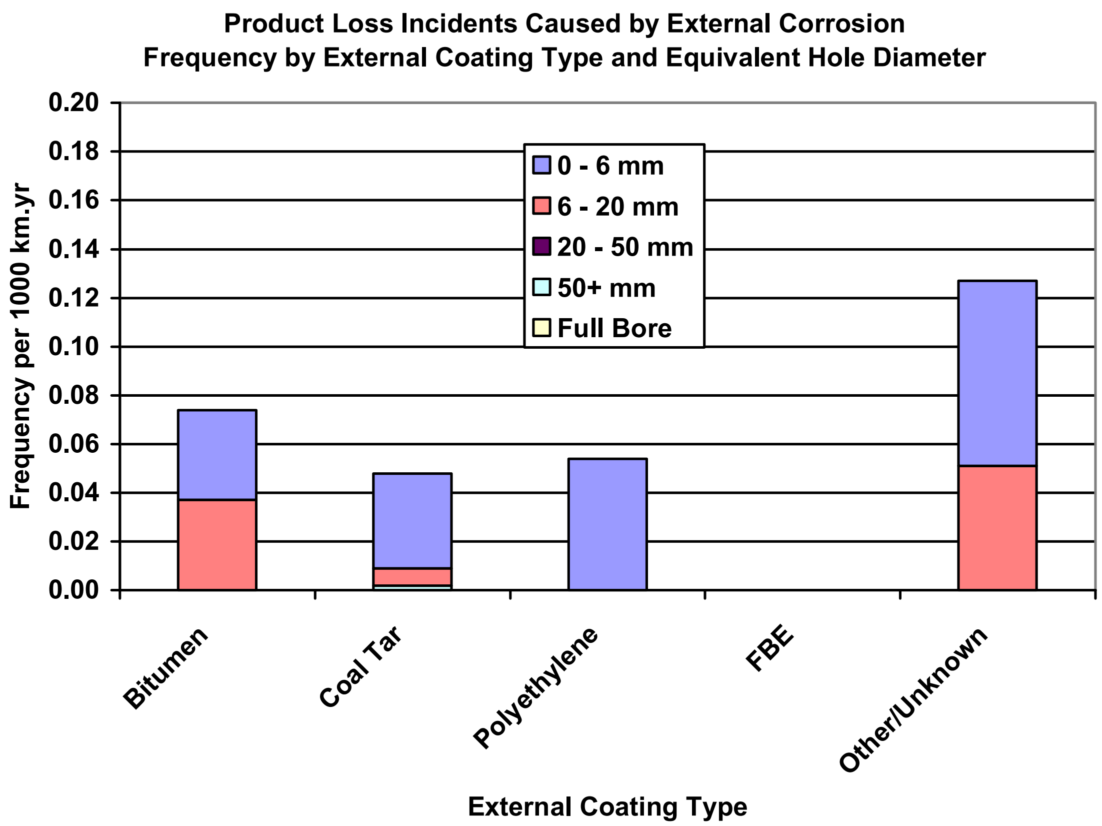


Figure 12

External Coating	Exposure km.yr	Incidents	Frequency /1000 km.yr
Bitumen	27327	3	0.110
Coal Tar	461236	22	0.048
Polyethylene	37011	2	0.054
FBE	36186	0	0.000
Other/Unknown	39298	5	0.127
Total	**561760**	**27**	**0.048**

Table 10 – Exposure by External Coating Type

2.2.5.4 *External Corrosion by Type of Backfill*

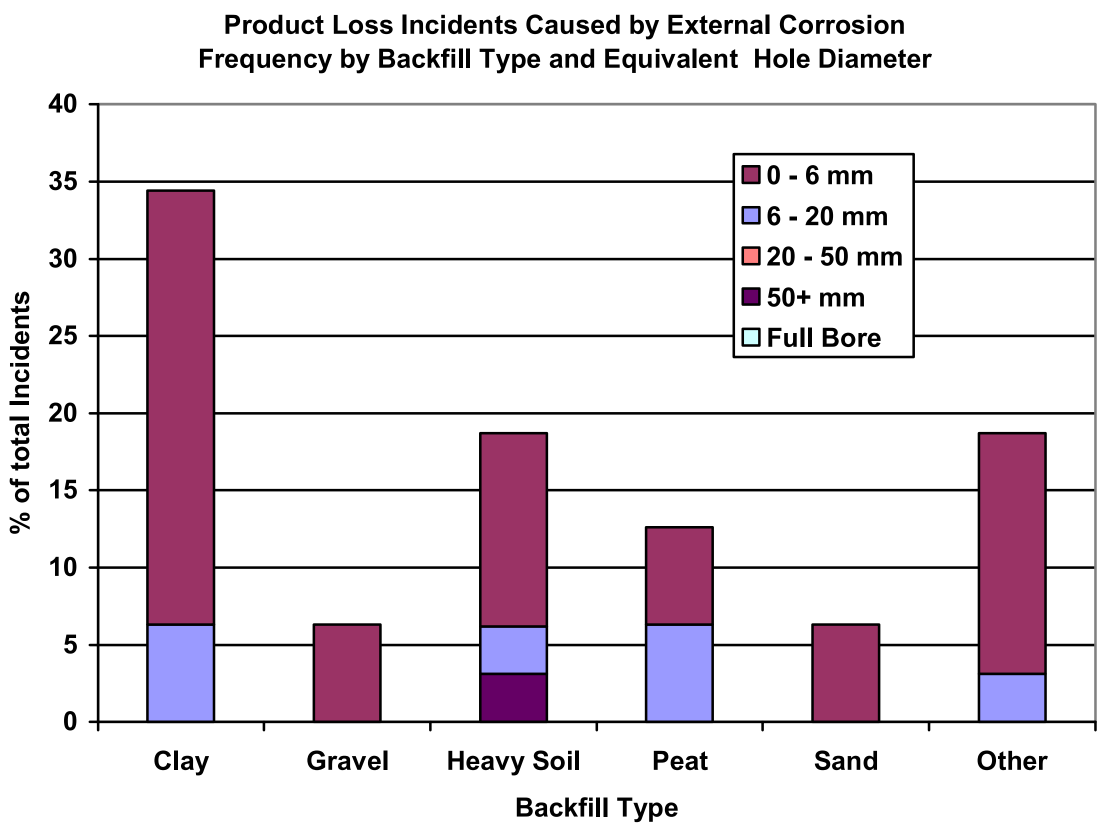


Figure 13

2.2.5 Detection

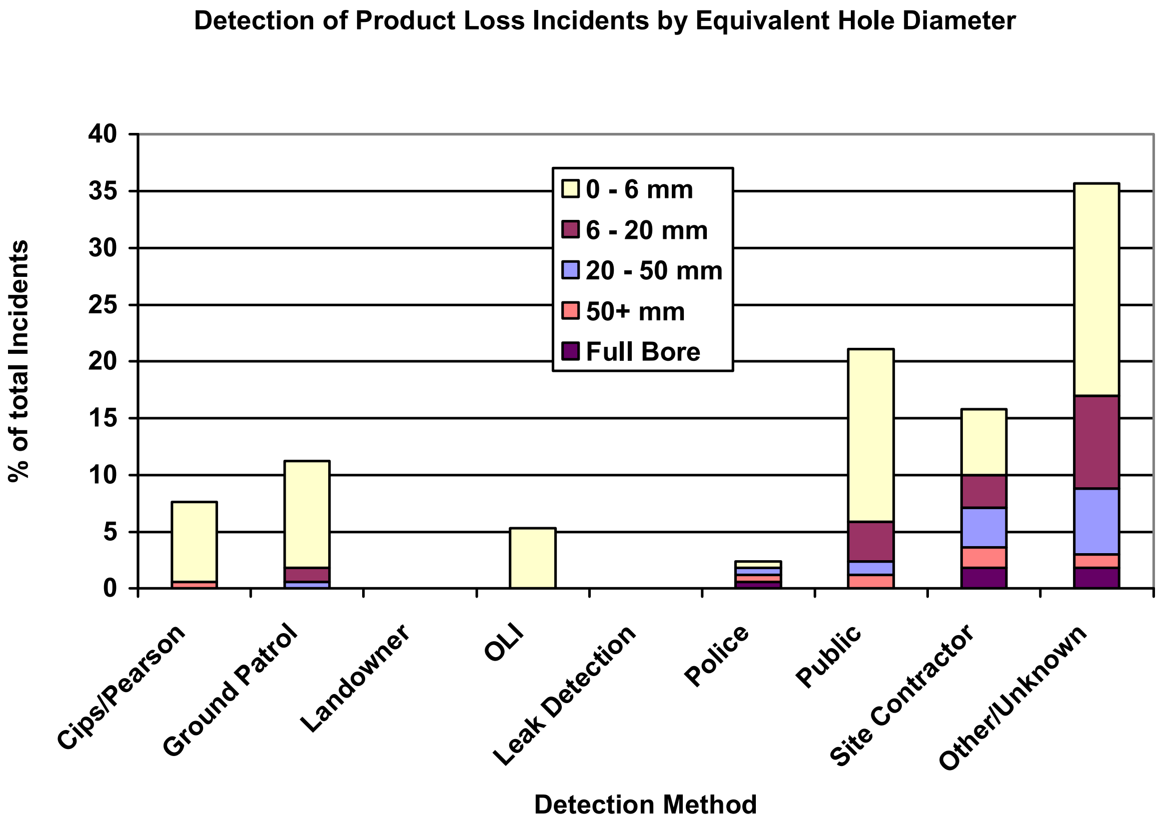


Figure 14

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