UKOPA

United Kingdom Onshore Pipeline Operators' Association

Pipeline
Maintenance Centre
Ripley Road
Ambergate
Derbyshire
DE56 2FZ

Telephone: 01773 852003
Facsimile: 01773 856456

12 April 2005

Review of CONCAWE Data for Product Pipelines
Part 2 – Calculation of Failure Rates to end of 2003

1 Summary

This review has been carried out following use of pipeline failure rate data by the UK Health & Safety Executive (HSE) during 2004 to assess the risks from gasoline pipelines. The data was based on an analysis carried out by W S Atkins in 1997 [Ref.1}. Part 1 of this study examined the Atkins analysis, but found several aspects which require updating. A study has therefore been commissioned to examine the following aspects to enable an up-to-date failure rate to be applied to product oil pipelines in the UK.

The study is in three parts:-

- Part 1 reviews the original W S Atkins work based on published CONCAWE data.
- Part 2 carries out a detailed analysis of failure rates based on CONCAWE data, extending the analysis to cover years 1971 through to 2003.
- Part 3 examines the UK pipeline failures to assess significance of the data and possible adjustments that could be applied to UK product oil pipeline failure rates.

This part of the study calculates the failure rate for clean product pipelines based on CONCAWE data collected over the past 33 years, for the years 1971 to 2003 inclusive.

2 Results and Conclusions

The failure rate of clean oil Product Pipelines for CONCAWE for the period 1971 to 2003 inclusive has been re-assessed as follows:-

Failure Rates per 1000 kilometre-years

Spillage Cause	Pinhole	Hole	Rupture	Total
Mechanical	0.025	0.022	0.012	0.059
Corrosion	0.012	0.049	0.002	0.063
Natural	0.002	0.008	0.004	0.014
Third Party	0.051	0.108	0.045	0.204
Total	0.090	0.188	0.063	0.341

For the 167spillage events that have been analysed for the 33-year period, 116 of these, representing 69.5%, occurred in the pipeline diameter range 8 to 12 inches diameter.

These failure rates represent the average failure rates for European clean Product oil pipelines, predominantly in the 8-12 inch diameter pipeline size.

The results appear to be a realistic assessment of the available data, and give plausible failure rates that are similar to other international databases for pipeline failure such as the EGIG database.

3 Introduction

CONCAWE Oil Pipelines Management Group's Special Task Force on Oil Pipeline Spillages publishes an annual report reviewing the performance of cross-country pipelines in Western Europe. Based on the statistics given in these reports it has been possible to synthesise the characteristic pipeline failure rate for product oil pipelines in Europe.

Most of the data used in this analysis has been derived using the full CONCAWE listing of failures published in the CONCAWE publication "Western Europe cross-country oil pipelines 30-year performance statistics", [Ref. 3]. However, some key information is not available in this report, and this further information has been obtained directly from CONCAWE.

Part 1 of this study considered the analysis carried out by W S Atkins as part of an HSE contract to carry out a detailed review of pipeline failures recorded in the annual CONCAWE reports in order to synthesise a failure rate. This was carried out and a report "Pipeline Failure Model" Issue 01 [Ref.1], was delivered to HSE in August 1997. Several aspects of the Atkins analysis were not clearly described, so this further review re-examines all the product pipeline failures recorded during the period 1971-1994, and extend the analysis to include years 1995-2003.

The analysis methodology in this report, which is applied to derive the pipeline failure cases and the hole sizes, is the same as for the Atkins analysis. However all results have been tabulated and fully described so that they can be replicated if required.

4 Assumptions in this Analysis

In this analysis, product oils include:- kerosene, gas oil, petrol, aviation fuel, light fuel oil, naphtha, diesel, light petroleum products, and gasoline. Hot fuel oil and crude oil are excluded.

Failures are categorised in four main types

Mechanical – covering construction and material defects

Corrosion – covering internal and external corrosion

Natural - covering ground movement, land movement and floods

Third Party – covering accidental, deliberate and incidental 3rd party damage

For the few cases of operational failure, an alternative (usually mechanical or third party) is assigned as the secondary cause.

Several product failure events are not included because they do not apply to line pipe. Failures excluded from the CONCAWE data-sets are:- Valve equipment, Flanges, bolts etc, Gaskets / O-ring materials, Instrument fittings, Couplings / branches, and Pumping stations etc. The total number of product pipeline failures recorded between 1971 and 2003 is 220, but 53 of these involve other equipment, so 167 failures are included in this analysis. Appendix 1 shows the annual number of product failures and numbers excluded.

The criteria for assigning hole sizes used by Atkins [Ref. 1] was as follows:-

Failure Mechanism	Rupture	Puncture	Pinhole
Third party activity	> 250 m3	11 to 250 m3	10 m3 or less
Corrosion	> 500 m3	11 to 500 m3	10 m3 or less
Mechanical	> 200 m3	11 to 200 m3	10 m3 or less
Natural	> 200 m3	11 to 200 m3	10 m3 or less

CONCAWE [Ref. 3] reports that of the 379 pipeline spillages recorded for European pipelines for both crude and product oils in the period 1971 to 2002, 176 have the hole size recorded. Their analysis shows that the relationship between and amount spilled and recorded hole size is broadly as expected, so the same analysis method as Atkins [Ref. 1] is used in this part of the study.

5 Pipeline Exposure

Data obtained from CONCAWE:- Average annual kilometres of clean product pipeline in Europe for the period 1971 to 2003 is 14,832 kilometres.

Therefore, the total exposure for the 33-year period 1971-2003 inclusive is

33 x 14,832 = 489,456 kilometre-years

6 Results

Detailed tables showing the year-by-year failures are attached in Appendix 2.

The main Results are as follows:-

Table 1 - Spillages from Various Pipeline Diameters

Pipeline Diameter	Number of spillages	Percentage
24-30 inches	3	1.8%
16-24 inches	14	8.4%
12-16 inches	11	6.6%
8-12 inches	116	69.5%
less than 8 inches	23	13.8%

Table 2 – Spillages by Cause

Spillage Cause	Number of spillages	Percentage
Mechanical	29	17.4%
Corrosion	31	18.6%
Natural	7	4.2%
Third Party	100	59.9%

Table 3 – Spillages by Cause and Hole Size

Spillage Cause	Pinhole	Hole	Rupture	Total
Mechanical	12	11	6	29
Corrosion	6	24	1	31
Natural	1	4	2	7
Third Party	25	53	22	100
Total	44	92	31	167

Table 4 – Failure Rate per 1000 kilometre-years – by Hole Size and Cause

Spillage Cause	Pinhole	Hole	Rupture	Total
Mechanical	0.025	0.022	0.012	0.059
Corrosion	0.012	0.049	0.002	0.063
Natural	0.002	0.008	0.004	0.014
Third Party	0.051	0.108	0.045	0.204
Total	0.090	0.188	0.063	0.341

Table 5 – Failure Rates as Percentage of Total

Spillage Cause	Pinhole	Hole	Rupture	Total
Mechanical	7.2%	6.6%	3.6%	17.4%
Corrosion	3.6%	14.4%	0.6%	18.6%
Natural	0.6%	2.4%	1.2%	4.2%
Third Party	15.0%	31.7%	13.2%	59.9%
Total	26.3%	55.1%	18.6%	100%

The overall failure rate is therefore 0.341 per 1000 kilometre-years, which is significantly lower than the result obtained by WS Atkins in their 1997 report [Ref. 1], which was 0.586 per 1000 km-years. However, the result is higher than the 0.29 per 1000 km-years presented in the later W S Atkins report in July 1998 called "Assessing the Risk from Gasoline Pipelines in the UK Based on a Review of Historical Experience" [Ref. 2] which contains a summary of CONCAWE data for the period 1971-1996.

R A McConnell

12 April 2005

References

1 "Pipeline Failure Model", A Report prepared by W S Atkins Safety & Reliability for and on behalf of The Health & Safety Executive, Report Number AM5099 /430 / R8000 / WP1.00, Issue 01, dated August 1997

2 "Assessing the Risk from Gasoline Pipelines in the UK Based on a Review of Historical Experience", A Report Prepared by W S Atkins Safety & reliability for and on behalf of The Health & Safety Executive, Report Number AM5121, Issue No 01, dated July 1998.

3 "Western European Cross-Country Oil Pipelines 30-year Performance Statistics", prepared on behalf of CONCAWE oil pipelines Management Group (OPMG) by D. Lyons (Consultant), CONCAWE Report No 1/02

Appendix 1 - CONCAWE Product Pipeline Failures

Year	Total	Line Pipe	Pumping	Valves	Fittings	Above Ground
1971	4	4				
1971	6	5			1	
1973	2	2				
1974	6	5			1	
1975	4	1	2		1	
1976	6	4			2	
1977	10	8	2			
1978	6	5		1		
1979	4	4				
1980	4	3	1			
1981	5	5				
1982	2	1				1
1983	3	2		1		
1984	4	2	1	1		
1985	4	1	3			
1986	7	5	1		1	
1987	5	5				
1988	10	9	1			
1989	10	8				2
1990	6	3		1	2	
1991	17	12	5			
1992	13	6	3	2	2	
1993	11	8	1	1	1	
1994	6	5	1			
1995	9	7			2	
1996	5	4	1			
1997	4	4				
1998	6	6				
1999	8	7			1	
2000	5	4			1	
2001	11	10	1			
2002	8	5	1		2	
2003	9	7			2	
Total	220	167	24	7	19	3

Appendix 2 – Analysis of Data

Revised Assessment of Product Lines Based on CONCAWE 2002 Lyons Report

	Diameter					Cause				Gross	Hole size		
Year	< 8	8-12	12-16	16-24	24-30	Corr	Mech	Nat	3rd Party	Spill m3	Rupture	Hole	Pinhole
71													
		1					1			0			1
		1					1			1			1
		1				1				6			1
		1							1	2			1
72													
		1					1			70		1	
		1				1				150		1	
		1							1	400	1		
		1							1	30		1	
		1							1	99		1	
73													
	1						1			12		1	
				1			1			25		1	
74													
		1							1	668	1		
	1								1	1			1
		1							1	30		1	
		1							1	200		1	
		1							1	489	1		
75													
		1							1	60		1	
76													
	1					1				90		1	
		1							1	153		1	
		1							1	14		1	
			1						1	358	1		
77													
				1			1			2			1
		1				1				350		1	
		1						1		103		1	
		1							1	3			1
		1							1	3			1
		1							1	191		1	
		1							1	269	1		
				1					1	2530	1		
78													
	1					1				12		1	
		1				1				100		1	
				1				1		400	1		
		1							1	3			1
		1							1	58		1	
79													
		1				1				300		1	
		1				1				50		1	
		1							1	90		1	
		1							1	950	1		

Revised Assessment of Product Lines Based on CONCAWE 2002 Lyons Report (Cont)

Year	Diameter					Cause				Gross	Hole size		
	< 8	8-12	12-16	16-24	24-30	Corr	Mech	Nat	3rd Party	Spill m3	Rupture	Hole	Pinhole
80													
		1							1	270	1		
		1							1	313	1		
		1							1	762	1		
81													
		1					1			600	1		
		1				1				92		1	
		1				1				10			1
					1			1		125		1	
		1							1	322	1		
82													
		1							1	7		1	
83													
	1					1				12		1	
		1							1	213		1	
84													
		1					1			16		1	
		1				1				236		1	
85													
		1							1	211		1	
86													
				1		1				2			1
			1						1	280	1		
		1							1	192		1	
	1								1	52		1	
		1							1	11		1	
87													
				1			1			1000	1		
					1		1			2			1
		1						1		12		1	
				1					1	3			1
			1						1	300	1		
88													
		1					1			90		1	
		1				1				80		1	
		1						1		305	1		
			1						1	3			1
		1							1	3			1
	1								1	2			1
	1								1	63		1	
	1								1	18		1	
				1					1	40		1	
89													
		1					1			66		1	
		1				1				400		1	
		1							1	186		1	
		1							1	3			1
		1							1	298	1		
			1						1	660	1		
	1								1	52		1	
			1						1	253	1		

Revised Assessment of Product Lines Based on CONCAWE 2002 Lyons Report (Cont)

Year	Diameter					Cause				Gross	Hole size		
	< 8	8-12	12-16	16-24	24-30	Corr	Mech	Nat	3rd Party	Spill m3	Rupture	Hole	Pinhole
90													
		1							1	189		1	
		1							1	225		1	
	1								1	3			1
91													
				1			1			275	1		
		1					1			5			1
		1					1			50		1	
		1					1			29		1	
		1					1			2			1
		1				1				80		1	
		1				1				15		1	
		1				1				100		1	
		1							1	4			1
	1								1	21		1	
	1								1	1			1
		1							1	10			1
92													
		1					1			1000	1		
		1					1			5			1
	1					1				3			1
		1						1		75		1	
		1							1	50		1	
		1							1	25		1	
93													
				1		1				14		1	
					1			1		10			1
		1							1	8			1
				1					1	49		1	
		1							1	3			1
		1							1	101		1	
	1								1	3			1
				1					1	3050	1		
94													
		1					1			5			1
	1						1			1			1
		1							1	285	1		
		1							1	195		1	
		1							1	46		1	
95													
		1					1			30		1	
	1						1			115		1	
		1				1				1000	1		
		1							1	48		1	
		1							1	20		1	
	1								1	12		1	
		1							1	139		1	
96													
			1				1			292	1		
	1								1	19		1	
		1							1	437	1		
		1							1	500	1		

Revised Assessment of Product Lines Based on CONCAWE 2002 Lyons Report (Cont)

Year	Diameter					Cause				Gross	Hole size		
	< 8	8-12	12-16	16-24	24-30	Corr	Mech	Nat	3rd Party	Spill m3	Rupture	Hole	Pinhole
97													
		1				1				19		1	
		1				1				435		1	
		1				1				422		1	
		1							1	40		1	
98													
		1					1			486	1		
			1			1				250		1	
		1							1	176		1	
		1							1	0			1
		1							1	15		1	
		1							1	340	1		
99													
		1				1				167		1	
	1					1				1			1
		1							1	80		1	
		1							1	84		1	
	1								1	29		1	
		1							1	80		1	
		1							1	1			1
2000													
		1							1	7			1
		1							1	8			1
		1							1	159		1	
				1					1	1			1
2001													
		1					1			1			1
	1								1	5			1
		1							1	10			1
			1						1	2			1
		1				1				4			1
		1							1	55		1	
		1					1			5			1
		1							1	85		1	
		1					1			10			1
	1						1			37		1	
2002													
		1				1				225		1	
		1							1	190		1	
		1							1	170		1	
		1				1				80		1	
		1				1				70		1	
2003													
				1					1	2500	1		
		1							1	83		1	
		1							1	74		1	
			1						1	52		1	
		1							1	45		1	
			1						1	28		1	
		1							1	11		1	