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Review of CONCAWE Data for Crude Oil Pipelines
Calculation of Failure Rates to end of 2003

1 Summary

This review has been carried out for Crude Oil pipelines using CONCAWE data. The methodology for assessing pipeline failures and hole sizes from reported CONCAWE data is similar to that used in an analysis carried out by W S Atkins in 1997 [Ref. 1].

2 Results and Conclusions

The failure rate of Crude Oil Pipelines for CONCAWE for the period 1971 to 2003 inclusive has been assessed as follows:-

Failure Rates per 1000 kilometre-years

Spillage Cause	Pinhole	Hole	Rupture	Total
Mechanical	0.015	0.040	0.026	0.080
Corrosion	0.036	0.047	0.007	0.091
Natural	0.000	0.007	0.007	0.015
Third Party	0.040	0.077	0.029	0.146
Total	0.091	0.171	0.069	0.332

91 relevant spillage events have been analysed for the 33-year period. These failure rates represent the average failure rates for European crude oil pipelines. The results appear to be a realistic assessment of the available data, and give 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 crude 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. 2]. In addition, spillage data for 2001, 2002 and 2003 have been obtained from later annual reports. However, some key information is not available in this report, and this further information has been obtained directly from CONCAWE.

The analysis methodology in this report, which is applied to derive the pipeline failure cases and the hole sizes is similar to that used in an analysis carried out by W S Atkins in 1997 [Ref. 1]. All results have been tabulated and fully described so that they can be replicated if required

4 Assumptions in this Analysis

Crude oil pipeline failures are categorised into 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 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 crude oil pipeline failures recorded between 1971 and 2003 is 124, but 33 of these involve other equipment, so 91 failures are included in this analysis. Appendix 1 shows the annual number of pipeline failures and those excluded.

The criteria for assigning hole sizes 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	l10 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. 2] reports that of the 379 pipeline spillages recorded for European pipelines for both crude and clean product oils in the period 1971 to 2002, 176 have the hole size recorded. The CONCAWE analysis shows that the relationship between and amount spilled and recorded hole size is broadly as expected, so the analysis method described above is used.

5 Pipeline Exposure

Data obtained from CONCAWE:- Average annual kilometres of clean product pipeline in Europe for the period 1971 to 2003 is 8,316 kilometres.

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

33 x 8,316 = 274,428 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
>30 inch	10	11%
24-30 inches	9	9.9%
16-24 inches	26	28.6%
12-16 inches	11	12.1%
8-12 inches	24	26.4%
less than 8 inches	11	12.1%

Table 2 – Spillages by Cause

Spillage Cause	Number of spillages	Percentage
Mechanical	22	24.2%
Corrosion	25	27.5%
Natural	4	4.4%
Third Party	40	44.0%
Total	91	100%

Table 3 – Spillages by Cause and Hole Size

Spillage Cause	Pinhole	Hole	Rupture	Total
Mechanical	4	11	7	22
Corrosion	10	13	2	25
Natural	0	2	2	4
Third Party	11	21	8	40
Total	25	47	19	91

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

Spillage Cause	Pinhole	Hole	Rupture	Total
Mechanical	0.015	0.040	0.026	0.080
Corrosion	0.036	0.047	0.007	0.091
Natural	0.000	0.007	0.007	0.015
Third Party	0.040	0.077	0.029	0.146
Total	0.091	0.171	0.069	0.332

Table 5 – Failure Rates as Percentage of Total

Spillage Cause	Pinhole	Hole	Rupture	Total
Mechanical	4.4%	12.1%	7.7%	24.2%
Corrosion	11.0%	14.3%	2.2%	27.5%
Natural	0%	2.2%	2.2%	4.4%
Third Party	12.1%	23.1%	8.8%	44.0%
Total	27.5%	51.6%	20.9%	100%

The overall failure rate is therefore 0.332 per 1000 kilometre-years.

R A McConnell
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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 "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 Crude Oil Pipeline Failures

Year	Total	Line Pipe	Pumping	Valves	Fittings
1971	6	2	4		
1972	10	7	1		2
1973	6	2	4		
1974	6	4	2		
1975	7	5	2		
1976	5	4			1
1977	8	5	3		
1978	4	3		1	
1979	4	4			
1980	2	1	1		
1981	6	4		1	1
1982	6	5	1		
1983	3	3			
1984	8	5	2	1	
1985	3	2	1		
1986	3	3			
1987	2	2			
1988	6	5			1
1989	5	5			
1990	0				
1991	2	2			
1992	0				
1993	2	2			
1994	4	2	1		1
1995	1	1			
1996	0				
1997	1	1			
1998	1	1			
1999	2		2		
2000	1	1			
2001	4	4			
2002	5	5			
2003	1	1			
Total	124	91	24	3	6

Appendix 2 – Analysis of Data

Assessment of Crude Oil Lines Based on CONCAWE 2002 Lyons Report

	Diameter						Cause				Gross	Hole size		
Year	< 8	8-12	12-16	16-24	24-30	>30	Mech	Corr	Nat	3rd Party	Spill m3	Pinhole	Hole	Rupture
71														
				1						1	300			1
						1				1	2000			1
72														
		1						1			10	1		
		1						1			40		1	
		1								1	90		1	
				1						1	200		1	
				1						1	250		1	
		1								1	7	1		
					1					1	60		1	
73														
		1						1			12		1	
					1				1		100		1	
74														
	1						1				20		1	
		1						1			10	1		
	1									1	1	1		
				1						1	500			1
75														
						1	1				30		1	
		1								1	120		1	
	1									1	15		1	
				1						1	5	1		
	1									1	15		1	
76														
				1			1				1322			1
				1					1		200		1	
		1								1	40		1	
				1						1	802			1
77														
						1	1				0	1		
				1					1		550			1
				1					1		600			1
		1								1	160		1	
				1						1	80		1	
78														
						1	1				2000			1
				1			1				19		1	
				1						1	255			1
79														
				1			1				100		1	
				1			1				100		1	
		1								1	245		1	
			1							1	50		1	
80														
						1	1				4800			1

Assessment of Crude Oil Lines Based on CONCAWE 2002 Lyons Report (Cont)

Year	Diameter						Cause				Gross	Hole size		
	< 8	8-12	12-16	16-24	24-30	>30	Mech	Corr	Nat	3rd Party	Spill m3	Pinhole	Hole	Rupture
81														
				1				1			19		1	
	1									1	132		1	
	1									1	96		1	
					1					1	5	1		
82														
				1			1				9	1		
		1						1			2	1		
					1			1			15		1	
	1							1			140		1	
	1									1	31		1	
83														
	1							1			182		1	
	1									1	148		1	
		1								1	1	1		
84														
				1			1				141		1	
					1		1				4363			1
		1								1	10	1		
	1							1			20		1	
		1								1	150		1	
85														
				1			1				1	1		
			1					1			1100			1
86														
				1			1				53		1	
		1						1			10	1		
						1		1			7	1		
87														
		1					1				25		1	
		1						1			8	1		
88														
					1			1			5	1		
						1		1			81		1	
			1							1	14		1	
		1								1	2	1		
				1						1	650			1
89														
					1		1				3	1		
					1		1				155		1	
		1						1			25		1	
		1								1	2	1		
						1				1	40		1	
90														
91														
				1			1				20		1	
		1						1			20		1	
92														

Assessment of Crude Oil Lines Based on CONCAWE 2002 Lyons Report (Cont)

Year	Diameter						Cause				Gross	Hole size		
	< 8	8-12	12-16	16-24	24-30	>30	Mech	Corr	Nat	3rd Party	Spill m3	Pinhole	Hole	Rupture
93														
						1	1				248			1
				1				1			2000			1
94														
			1				1				1350			1
			1				1				200		1	
95														
			1					1			132		1	
96														
97														
		1						1			2	1		
98														
			1					1			250		1	
99														
2000														
		1						1			10	1		
2001														
						1		1			6	1		
				1			1				800			1
			1							1	17		1	
			1							1	10	1		
2002														
			1							1	750			1
				1				1			100		1	
		1								1	40		1	
					1					1	2	1		
				1						1	280			1
2003														
			1							1	5	1		