The oil companies' European association for Environment, Health and Safety in refining and distribution

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Performance of European cross-country oil pipelines

Detailed description of reported spillages 1984 - 1993

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report no. 9/85

performance of oil industry cross-country pipelines in western europe

statistical summary of reported spillages – 1984

Prepared by CONCAWE's Special Task Force on Oil Pipeline Spillages

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2. PIPELINE PERFORMANCE

2.1 GENERAL DATA

The total length of oil industry cross-country pipelines in Western Europe in operation at the end of 1984 was reported by the respondents to be 17,300 km. The network consists of some two hundred separate pipeline systems. New pipelines brought into service accounted for 200 km, and a combined length of about 250 km became non-operational during 1984; another 750 km were excluded from this report as they are not operated by the oil industry. In total 495 million m^3 of crude oil and refined products were transported through these systems. This resulted in a total traffic volume of 84×10^9 m^3 km, of which products amounted to 20×10^9 m^3 km.

2.2 DETAILS OF SPILLAGE INCIDENTS

Thirteen separate incidents were reported in which oil spillage occurred. For the sake of consistency with previous reports, causes have been categorised as shown in the footnote to Table 1 and further tabulated by category and volume in Table 2. In total, 5198 m^3 of oil were spilled and the combined cost of pipeline repair and clean-up was reported to be £ 2.7 million.

Total net loss to the environment was 4427 m^3. In five of the incidents all oil spilled was recovered. In four cases clean-up time took more than one month; no potable water sources were affected.

No human injuries resulted from the pipeline incidents in 1984.

Resultant net losses

All spillage recovered	5 incidents
less than 1 m^3	1 incident
1 - 10 m^3	3 incidents
11 - 100 m^3	1 incident
over - 100 m^3	3 incidents

Clean-up time

One day	1 incident
Two days up to one week	4 incidents
Over one week up to one month	4 incidents
Longer than one month	4 incidents

2.3 CAUSES

2.3.1 Mechanical failure

Three of the thirteen incidents were caused by mechanical failure and resulted in a total gross spillage of 160 m^3, representing 3% of the 1984 gross spillage. Only 3 m^3 of the volume spilled could not be recovered.

The incident reporting the highest gross loss in this category (i.e. 141 m^3) resulted from material failure, which was caused by incorrect hot field bending. An elbow was modified by a technique involving heating and immediate cooling, whereby an embrittlement of the material was caused, which twenty years later resulted in the fracture of the elbow. The crude oil leaked into a channel and a lake. The area affected was protected by boom barriers, and the spilled volume was entirely recovered by means of floating absorbent materials.

Of the two other cases, one involved the rupture of a rubber hose connecting the pipeline to a pressure transmitting device, and the other was a spillage resulting from using an end flange of too low classification.

2.3.2 Operational error

Three failures were reported in this category, resulting in a gross loss of 18 m^3, i.e. 0.3% of the gross spillage. In the first case a ball valve, which did not seal properly in one direction, allowed the filling of a scraper trap. It was assumed that due to solar radiation an overpressure developed, which resulted in the spillage from the scraper trap.

In the second case the line was emptied and had to be cut in order to modify an operating station. As this line section had been out of operation for a long period, a plug of wax, sediments and high pour point crude oil had been formed, preventing complete line emptying. Hence, a spillage occurred after cutting the line.

The third case was due to the malfunction of a surge relief valve.

2.3.3 Corrosion

Four spillages resulted from corrosion defects, and caused a gross loss of 263 m^3 i.e. 5% of the gross volume spilled. One defect was due to internal and three to external corrosion.

The incident due to internal corrosion occurred in a pipeline transporting a semi-finished product; it resulted in a gross loss of 236 m^3, of which all was lost. The spill was first detected by a third party. The corrosion was caused by a small amount of hydrofluoric acid in the commodity transported. This, together with water, collected and formed an interface at the lowest point of the pipeline.

Two of the failures due to external corrosion occurred on coated lines where no cathodic protection was applied and pitting corrosions could form. The first one occurred on a buried line within a pump-station. The leak was too small to be detected by flow monitoring, but was confirmed by pressure loss after shutdown of the line and isolation of the various pipe sections. After repair, the line was reinstalled overground within the station. The second failure occurred at a road crossing, and was detected by pipeline staff when carrying out right-of-way surveillance.

The third incident occurred on a cathodically protected line just beyond a river crossing, where an unfavourable corrosive environment existed due to the tidal effects, whereby the coating had decomposed.

2.3.4 Natural hazards

No spillages were reported in this category during 1984.

2.3.5 Third party activities

Two incidents were caused by third party activities and contributed 394 m^3, i.e. 8% of the gross volume spilled.

One case resulted from vandalism: at a road crossing in rural surroundings two valves were blown-up. The spillage was immediately identified by the automatic leak detection system, the pumps were stopped and the valves were closed 5 minutes later. Nevertheless, 244 m^3 gasoline escaped, of which only 4 m^3 could be recovered.

In the other case the line was damaged by trenching activities. The pipeline company was not aware of any equipment activity near the line. 27 days had expired since the last monthly right-of-way surveillance was performed. The equipment operator was not aware of the pipeline though its route was identified by permanent markers.

The bulldozer damaged the line and caused a hole of about 15 cm x 20 cm. The driver himself informed the next pumping station. It took 75 minutes until the pumps were stopped and the valves were closed. During this time 150 m^3 of crude oil spilled, of which 149 m^3 finally was recovered.

2.3.6 Spillages not yet categorised

One spillage, involving the highest gross loss (4363 m^3 or 84%), can not yet be reported due to an inpending inquiry. 435 m^3 or about 10% of the gross volume spilled was recovered in this case.

Table 1 Details of spillage incidents, 1984

No.	Pipeline or Pump-stn.	Pipe specification mm (inches in brackets)	Commodity	Volumes (m^3)			How discovered	Cause		Damage			Clean-up period (days)
				Spilled	Recovered	Net loss		Category	Origin	Water pollution type	Soil pollution: area affected (m^2)	Estimated total cost (£)	
1	P/Stn	406 x 9.52 (16 x 0.375) 5L Grade B	Products	5	4	1	Third party	Corrosion C (a)	Pitting corrosion due to damaged coating	water course affected	yes (14)	34000	10
2	P/L	406 x 5.56 (16 x 0.219) 5LX-X52	Crude oil	10	10	-	R/W surveillance	Oper. error B (a)	A ball valve, which did not seal properly in one direction, allowed the filling of the scraper trap. Overpressure resulting from solar radiation, caused the spillage	no	yes (50)	12000	1
3	P/L	914 x 9.5 (36 x 0.375) St53-7	Crude oil	3	3	-	Pipel. operator	Oper. error B (b)	Incomplete emptying of a pipe section during modification of an operating station	no	yes (2)	1300	2
4	P/L	711 x 7.93 (28 x 0.313) 5LX-X53	Crude oil	3	3	-	Autom. detect. system	Mechanical A (b)	Rupture of a rubber hose connection to a pressure transmetting device	ditch affected	yes (120)	34300	4
5	P/L	219 x 6.35 (8.6 x 0.25) 5LX-X52	semi-fin. products	236	-	236	Third party	Corrosion C (b)	Corrosion at lowest point where water and hydrofluoric acid collected	water course affected	yes (200)	35000	3
6	P/Stn	864 x 7.94 (34 x 0.313) 5LX-X60	Crude oil	5	3	2	Pipel. operator	Oper. error B (a)	surge relief valve malfunction	no	yes (1000)	2000	60
7	P/L	711 x 6.35 (28 x 0.25) 5LX-X42	Crude Condens. Mixture	4363	435	3928			Not yet categorised; subject to an inquiry	no	yes (6500)	190000	22
8	P/L	610 x 9.52 (24 x 0.375) 5LX-X42	Crude oil	141	141	-	Third party	Mechanical A (a)	Material failure due to incorrect hot field bending	lake, channel affected	yes (4500)	1630000	45
9	P/L	152 x 4.5 (6 x 0.177) 5LS-Grade A	Crude oil	20	4	16	Third party	Corrosion C (a)	Decomposed coating	water course affected	yes (250)	340000	60
10	P/L	254 x 7.09 (10 x 0.28) 5LX-X42	Crude oil	150	149	1	Third party	Third party E (a)	Damage caused by trenching activities	no	yes (100)	11500	80
11	P/L	203 x 4.8 (8 x 0.188) 5LX-X46	Products	16	13	3	Third party	Mechanical A (b)	Flange classification too low for service	no	yes (720)	34000	20
12	P/L	305 x 6.35 (12 x 0.25) 5LS-X42	Fuel Oil	2	2	-	R/W surveillance	Corrosion C (a)	Pitting corrosion at road crossing	no	yes	30000	2
13	P/L	273 x 5.56 (10.75 x 0.219) 5LX-X42	Products	244	4	240	Autom. detect. system	Third party E (b)	Blow-up of two valves	no	yes	325000	13

Cause/category: A - Mechanical failure B - Operational error C - Corrosion D - Natural hazard E - Third party

(a) Construction fault
(b) Materials fault

(a) System malfunction
(b) Human error

(a) External
(b) Internal

(a) Landslide or subsidence
(b) Flooding
(c) Other

(a) Direct damage -accidental
(b) Direct damage - malicious
(c) Incidental damage

Table 2 Analysis of 1984 incidents

Main category	Number of incidents		Spillage in cubic metres (m^3)			Average volume per incident	
	Pipeline	Pump-station	Gross	Recovered	Net	Gross	Net
Mechanical failure	3	-	160	157	3	53	1
Operational error	2	1	18	16	2	6	1
Corrosion	3	1	263	10	253	66	63
Natural hazard	-	-	-	-	-	-	-
Third party activity	2	-	394	153	241	197	121
Not yet categorised	1	-	4363	435	3928	4363	3928
Total	11	2	5198	771	4427	400	341

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performance of oil industry cross-country pipelines in western europe

statistical summary of reported spillages – 1985

Prepared by the CONCAWE Oil Pipelines Management Group's Special Task Force on Oil Pipeline Spillages (OP/STF-1)

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2. PIPELINE PERFORMANCE

2.1 GENERAL DATA

The total length of oil industry cross-country pipelines in Western Europe in operation at the end of 1985 was reported by the respondents to be 17,400 km. The network consists of some two hundred separate lines. New pipelines brought into service accounted for 140 km, and a combined length of about 90 km became non-operational during 1985. In total 496 million m^3 of crude oil and refined products were transported through these system. This resulted in a total traffic volume of 85 x 10^9 m^3 km, of which products amounted to 20 x 10^9 m^3 km.

2.2 DETAILS OF SPILLAGE INCIDENTS

Seven separate incidents were recorded in which oil spillage occurred. For the sake of consistency with previous reports, causes have been categorised as shown in the footnote to Table 1 and further tabulated by category and volume in Table 2. Total net loss to the environment was 956 m^3. The volume recovered amounted to 408 m^3, equivalent to 30% of the gross volume spilled (1364m^3). The combined cost of pipeline repair and clean-up was reported to be £ UK 810,000.

No potable water sources were affected. No human injuries resulted from the pipeline incidents in 1985. The effectiveness of clean-up efforts and the clean-up time are summarised in the following tables:

Effectiveness of clean-up efforts

Spillage recovery (%)

100 % recovered:	3 incidents
75 - 99 % " :	1 incident
50 - 74 % " :	0 "
25 - 49 % " :	1 "
0 - 24 % " :	2 incidents

Clean-up time

One day:	3 incidents
Two days up to one week:	1 incident
Over one week up to one month:	1 "
Longer than one month:	2 incidents

2.3 CAUSES

2.3.1 Mechanical failure

One of the seven incidents was caused by mechanical failure and resulted in a gross spillage of 1 m^3. The spillage occurred in rural surroundings and was detected by the pipeline staff during the right-of-way surveillance. The incident was traced back to a construction fault: after 14 years of operation a crack of 80 mm length had developed at a dent, the dimensions of which were 140 mm x 4 mm, which originated from poorly prepared pipe bedding materials.

2.3.2 Operational errors

Four of the seven incidents are in this category. Three of these spillages occurred within pump stations and one in the manifold piping. These amounted to 52 m^3 (4% of 1985 total) gross spillage of which 48 m^3 were recovered.

One failure (gross spillage 25 m^3, net loss 4 m^3) was detected by an outside party. A pump gasket leaked, and the alarm device of the station did not work properly, due to a defect in the remote control system. The spillage started when the drain tank overflowed. The clean-up was carried out with absorbents and detergents, and crude oil was recovered from a river using floating booms.

The three other incidents in this category were all detected by automatic detection systems.

In one case the pumps were stopped and the suction and discharge valves did not close due to a breakdown of the power supply; the drain system opened up, however, as it was connected to an emergency power supply circuit. The fault was spotted by the automatic detection system and the valves were closed on the restoration of power. All the spilled volume was contained within the bund and the interceptor. In order to prevent a recurrence the pump control sequence was modified.

In another case the incident was caused by a software fault: the suction valve opened too early and the product flowed out via the venting system, which was detected by the automatic detection system. Here also the spillage was contained within the bund and all recovered. Meanwhile the pump fill control sequence has been modified to prevent a recurrence.

The last case happened within a terminal compound. The body relief of the manifold valve remained open when the valve was opened to come on line. The product then flowed through the body relief line to the sumptank, which overflowed. However all the escaped product

was contained within the site bund and the interceptor. The spillage was detected by a valve relief alarm, after the sump tank high level alarm failed.

2.3.3 Corrosion

One incident was due to external corrosion, causing 756 m^3 net loss and 1,100 m^3 gross spillage, (80% of 1985 total) and thus the largest spillage of the incidents reported.

Although the pipeline was cathodically protected by an impressed current system, this is not effective where stress corrosion is present as in this particular case. This stress corrosion condition caused a crack 200 mm long by 4 mm wide.

The leak occurred in rural surroundings and was detected by routine monitoring carried out by the pipeline operators. The pumps were stopped immediately and the valves closed on the pipeline section where the leak was detected. Due to the mountainous terrain the gross spillage was higher than would normally take place on level ground. The leakage point occurred at 430 m altitude whereas the pipeline peaked at 1000 m nearby, causing the pipeline contents to drain down. Due to the porous ground in that area, only 344 m^3 were recovered.

2.3.4 Natural hazards

No spillages were reported in this category during 1985.

2.3.5 Third party activities

One spillage was caused by accidental third party damage resulting in a net loss of 195 m^3 (20% of 1985 total) and a gross spillage of 211 m^3 (15% of 1985 total).

The damage was at first indicated by a sudden pressure drop and pumping was stopped immediately. Shortly afterwards the spillage and its location was notified by a third party. This enabled the pipeline valves in the sections concerned to be closed. The spillage occurred in a hilly rural area and as a result, the line continued to drain down for about two hours. Due to the pipeline contents being gasoline, the activities of the emergency crew were mainly addressed to isolate the endangered area and to minimise the risk of fire and explosion. Most of the loss either evaporated or sank into the ground, while about 5 m^3 escaped onto a creek and a river. There were no injuries to personnel.

When the damaged portion of pipe was excavated, there were signs of teeth marks of a bucket digger. The local land owner reported that

the pipeline was clearly identified by permanent markers when previous excavation works were conducted to bury some elm stubs.

2.3.6 Spillages not yet categorised

In the previous report one spillage (3928 m^3 net loss, 4363 m^3 gross spillage) could not be categorised pending completion of the inquiry. CONCAWE has now been informed by the operator concerned that the rupture of the pipeline had its origin in superficial mechanical damage of the pipewall caused by heavy equipment used during the laying of the pipeline (Category: A(a)). The operational conditions of the pipeline - i.e. the daily pressure cycles - caused small cracks to develop at this weakened spot of the pipewall. One of these cracks became critical during a pressure test and resulted in the rupture of the line.

Table 1 Details of spillage incidents 1985

No.	Pipeline or Pumpstn.	Pipe specification mm (inches in brackets)	Commodity	Spillage (m^3)			How discovered	Cause		Damage			Clean-up period (days)
				gross	Recovered	net		Category	Origin	Water pollution type	Soil area affected (m^2)	Estimated total cost (£)	
1	P/L	054D 203 x 5.56 (8 x 0.219)	Gasoline	211	16	195	Pipel. Operat.	Third Party E(c)	A mechanical digger damaged the line during a shut-down period.	water course affected	yes 1,000	80,000	90
2	P/STN	5LX - X52 152 x 4.78 (6 x 0.188)	Gasoil	4	4	0	Autom. Detect. System	Oper. error B(a)	Valve malfunction.	no	no	700	1
3	P/STN	5LX - X52 245 x 6.35 (10 x 0.25)	Kerosene	7	7	0	Autom. Detect. System	Oper. error B(a)	Software fault for pump fill sequence	no	no	400	1
4	P/STN	5LX - X52 254 x 5.56 (10 x 0.219)	Gasoline	16	16	0	Autom. Detect. System	Oper. error B(a)	Due to a power breakdown suction and discharge valves stopped whilst drain system, which is supplied by an emergency power supply, opened.	no	no	1,500	1
5	P/L	5LX - X60 610 x 6.25 (24 x 0.246)	Crude	1	0	1	R/W Surveillance	Mech. Fail. A(a)	Crack at a dent; the latter was caused by a construction fault	no	yes 18	22,000	25
6	P/L	5LX x X60 406 x 7.92 (16 x 0.312)	Crude	1100	344	756	Pipel. Operator	Corrosion C(a)	Stress corrosion.	no	yes 13,000	440,000	not completed at year end
7	P/STN	5LX x X60 508 x 6.35 (20 x 0.25)	Crude	25	21	4	Third party	Oper. error B(a)	Pump gasket failure.	water course affected	yes	265,000	6

Cause/category: A - Mechanical failure
(a) Construction fault
(b) Materials' fault

B - Operational error
(a) System malfunction
(b) Human error

C - Corrosion
(a) External
(b) Internal

D - Natural hazard
(a) Landslide or subsidence
(b) Flooding
(c) Other

E - Third party activity
(a) Direct damage -accidental
(b) Direct damage - malicious
(c) Incidental damage

Table 2 Analysis of 1985 incidents

Main category	Number of incidents		Spillage in cubic metres (m^3)		Average volume per incident		
	Pipeline	Pump-station	gross	recovered	net	gross	net
Mechanical failure	1	-	1	0	1	1	1
Operational error	-	4	52	48	4	13	1
Corrosion	1	-	1100	344	756	1100	756
Natural hazard	-	-	-	-	-	-	-
Third party activity	1	-	211	16	195	211	195
Total	3	4	1364	408	956	195	137

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November 1987

2. PIPELINE PERFORMANCE

2.1 GENERAL DATA

The total length of oil industry cross-country pipelines in Western Europe in operation at the end of 1986 was reported by the respondents to be about 17,400 km. The network consists of some two hundred separate lines. New and reactivated pipelines brought into service accounted for 140 km, and a combined length of about 184 km became non-operational during 1986. In total, 517 million m^3 of crude oil and refined products was transported through these systems. This resulted in a total traffic volume of 88×10^9 m^3 km, of which products amounted to 21×10^9 m^3 km.

2.2 DETAILS OF SPILLAGE INCIDENTS

Twelve separate incidents were recorded in which oil spillages occurred. For the sake of consistency with previous reports, causes have been categorised as shown in the footnote to Table 1 and further tabulated by category and volume in Table 2. Total net loss to the environment was 238 m^3. The volume recovered amounted to 851 m^3, equivalent to 78% of the gross volume spilled (1089 m^3). The combined cost of pipeline repair and clean-up was reported to be about £ 1,340,000.

No potable water sources were affected. No human injuries resulted from the pipeline incidents in 1986. The effectiveness of clean-up efforts and the clean-up time are summarised in the following tables:

Effectiveness of clean-up efforts

Spillage recovery (%)

100 % recovered:	1 incident
75 - 99 % " :	5 incidents
50 - 74 % " :	1 incident
25 - 49 % " :	1 incident
0 - 24 % " :	4 incidents

Clean-up time

Less than one day:	1 incident
Two days up to one week:	4 incidents
Over one week up to one month:	5 incidents
Longer than one month:	2 incidents

2.3 CAUSES

2.3.1 Mechanical failure

Three of the twelve incidents were caused by mechanical failure and resulted in a gross spillage of 505 m^3 of which 489 m^3 were recovered thus resulting in a net loss of 16 m^3 to the environment.

The incident with the highest gross loss (292 m^3) in this category was caused by a broken gasket between insulating flanges near a valve in a 24" product line. It is assumed that settlement of the line caused a 1 mm gap to open up between the flanges. The leak was first discovered by a mechanic performing maintenance work in that rural location. About 2000 m^3 of contaminated soil had to be removed.

Another gasket failure occurred in a pump-station of a product pipeline on a 1½" valve and was indicated by an automatic detection system. 160 m^3 escaped of which 154 m^3 was recovered or safely disposed.

The last case in this category happened on a 20" crude line in a rural area. Spillage occurred during the line-packing phase about 20 minutes after completion of a crude delivery. The line split 90 mm wide over a length of 900 mm thereby releasing 53 m^3 into an irrigation ditch and onto a farm road. The incident was detected by control room operators watching the pressure build up. Pipe-wall lamination is regarded as the primary cause of the failure and the secondary cause is fatigue resulting from the stresses due to pressure variations between pumping conditions and line-packing phases ranging from 3 to 50 bars.

2.3.2 Operational errors

No spillages were reported in this category in 1986.

2.3.3 Corrosion

There were two internal and three external corrosion incidents in this category. These resulted in 49 m^3 (4% of 1986 total) gross spillage of which 25 m^3 was recovered.

A pipe rupture occurred on an 8" heavy fuel oil line during the annually requested pressure test. This test is carried out with product at 130 % of max. operating pressure. Due to external corrosion, the pipe split 20 mm wide over a length of 200 mm. 10 m^3 escaped and was fully recovered. The failure was traced back to pitting corrosion which developed under wet glass wool heat insulation.

A third party detected a spillage due to external corrosion on a 20" product line adjacent to a rain water sewer in a residential area. The spillage occurred in a pipe section which was not covered with soil. Therefore the cathodic protection became ineffective. The bitumen coating had been damaged by the sewer construction thus exposing the metal to the corrosive influence of air and changing water levels.

Another spillage caused by external corrosion developed in a sleeved road crossing of a 16" product line. The bitumen coating was decomposed and the cathodic protection system was ineffective inside the sleeve. The incident caused a 1.5 months shutdown of the pipeline. 5 m^3 of the estimated 20 m^3 gross spilled was recovered.

Internal corrosion of an 8" crude pipeline system led to a spillage in a rural environment which was detected by the landowner. 10 m^3 of spilled crude affected an area of about 180 m^2. The clean-up efforts were completed within two days.

An insulating coupling installed at the deepest point of a 34" crude line in a delivery station suffered severe internal corrosion in the presence of water. It was found that anodic currents would have accelerated the corrosion process. The incident was detected by pipeline operators at a routine inspection. 270 metric tons of contaminated soil had to be removed. 10 days were needed for cleaning up.

2.3.4 Natural hazards

No spillages were reported in this category in 1986.

2.3.5 Third party activities

This category is by far the largest contributor to the oil spillages in 1986. In four incidents, a gross volume of 535 m^3 was spilled of which 337 m^3 was recovered. The net loss to the environment amounted to 198 m^3 which is 83% of the total net volume lost in 1986.

In two cases, the causes of the spillages were very similar: a trenching machine and a chain excavator operated by third parties damaged the pipelines. The equipment operators were aware of the pipelines in their vicinity. There were neither personnel injuries nor accidental fires.

In one incident, the pipeline was perforated when digging the trench for a new water main. 52 m^3 gross was spilled of which 11 m^3 was recovered from inside the new water main the contractor was laying. The recovery of the oil from the water main took place on the day of the incident.

In another case, the dismantling of an electricity pylon led to the perforation of an 8" product line when part of the steel structure punched a hole 100 x 50 mm into the line which at this location has a soil coverage of 1.40 metres. 192 m^3 of gasoline was spilled of which 97 m^3 was recovered. The cleaning up was completed within 6 days. Nobody was hurt in this accident.

The last spillage to be reported in this category is a case of vandalism on an 8" product line. After the disconnection of an instrument line in a valve station at a river crossing, the escaping gasoil was set on fire. The blaze destroyed the instrumentation of the valve station and also badly damaged the wire cables of the bridge which carries the pipeline across the nearby river. 80 firemen succeeded in extinguishing the fire after five hours. Since it was feared that oil could pollute the river, preventive barriers were installed but finally were not needed. The gross volume spilled amounted to 11 m^3 of which 6 m^3 was burnt and 5 m^3 was recovered from the valve station and from a retention basin. Only 2 days were needed for cleaning up.

Table 1 Details of spillage incidents 1986

No.	Pipeline or Pump-stn.	Pipe specification mm (inches in brackets)	Commodity	Spillage (m^3)			How discovered	Cause		Damage			Clean-up Period (Days)
				Gross Spilled	Recovered	Net Loss		Category	Origin	Water Pollution: Type	Soil Pollution: Area Affected (m^2)	Estimated Total Cost (English Pounds)	
1	STN	X52 406 x 6.35 (16 x 0.250)	Gasoline Kerosina Gasoil	160	154	6	Autom. Detect. System	Mech. Fail. A (b)	Gasket failure	no	yes 200 m^2	50,000	78
2	P/L	5LX - X52 508 x 7.14 (20 x 0.281)	Crude	53	47	6	Pipe-line Oper-ator	Mech. Fail. A (b)	Line rupture due to lamination and fatigue stresses	water course affected	yes 3000 m^2	145,000	15
3	P/L	5LX - X52 203 x 5.1 (8 x 0.200)	Heavy Fuel Oil	10	10	0	Pres-sure Test	Corro-sion C (a)	Line rupture during annual pressure test	no	yes 20 m^2	1,200	3
4	P/L	5LX - 46 610 x 12.7 (24 x 0.500)	Gasoil	292	288	4	Pipe-line Mecha-nic	Mech. Fail. A (a)	Failure of gasket at insulating flanges	no	yes 3000 m^2	480,000	350
5	P/L	5LX - X56 864 x 8.8 (34 x 0.344)	Crude	7	0	7	Pipe-line Oper-ator	Corro-sion C (b)	Presence of water caused corrosion of insulating coupling	no	yes 84 m^2	85,000	10
6	P/L	5LX - X52 356 x 7.14 (14 x 0.281)	Kero-sene	280	224	56	Autom. Detect. System	Third Party E (a)	Trenching machine cut hole in the line	Sewage works affected	yes 100 m^2	46,000	17
7	P/L	ST 53.7/ ST 43.7 203 x 9.52 (8 x 0.375)	Gasoil	11	5	6	Pipe-line Oper-ator	Third Party E (b)	Instrument line disconnected and fire set by vandal	no	yes 3 m^2	188,000	2
8	P/L	5LB 152 x 5.6 (6 x 0.220)	Gasoil	52	11	41	Autom. Detect. System	Third Party E (a)	Trenching machine pierced line	no	yes 10 m^2	7,800	less than 1
9	P/L	5LX 45 508 x 6.35 (20 x 0.250)	Naphtha Gasoil	2	0	2	Third Party	Corro-sion C (a)	Damaged bitumen coating	Sewage works affected	yes under-ground	30,000	15
10	P/L	5LB 406 x 9.52 (16 x 0.375)	Gasoil	20	15	5	Third Party	Corro-sion C (a)	Severe corrosion in sleeved road crossing	no	yes under-ground	265,000	30
11	P/L	5LA 219 x 6.35 (8 x 0.250)	Crude	10	0	10	Third Party	Corro-sion C (b)	Severe corrosion	no	yes 180 m^2	3,600	2
12	P/L	5LX-X52 203 x 5.56 (8 x 0.219)	Gaso-line	192	97	95	Third Party	Third Party E (a)	Dismantling of steel structures caused perfora-tion of line	no	yes 1500 m^2	35,000	6
		T o t a l		1089	851	238							

Cause/category: A - Mechanical failure
- (a) Construction fault
- (b) Materials' fault

B - Operational error
- (a) System malfunction
- (b) Human error

C - Corrosion
- (a) External
- (b) Internal

D - Natural hazard
- (a) Landslide or subsidence
- (b) Flooding
- (c) Other

E - Third party activity
- (a) Direct damage -accidental
- (b) Direct damage - malicious
- (c) Incidental damage

Table 2 Analysis of 1986 incidents

Main category	Number of incidents		Spillage in cubic metres (m^3)			Average volume per incident (m^3)	
	Pipeline	Pump-station	gross	recovered	net	gross	net
Mechanical failure	2	1	505	489	16	168	5
Operational error	-	-	-	-	-	-	-
Corrosion	5	-	49	25	24	10	5
Natural hazard	-	-	-	-	-	-	-
Third party activity	4	-	535	337	198	134	50
Total	11	1	1089	851	238	91	20

performance of oil industry cross-country pipelines in western europe

statistical summary of reported spillages — 1987

Prepared by the CONCAWE Oil Pipelines Management Group's Special Task Force on Oil Pipeline Spillages (OP/STF-1)

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2. PIPELINE PERFORMANCE

2.1 GENERAL DATA

The total length of oil industry cross-country pipelines in Western Europe in operation at the end of 1987 was reported by the respondents to be about 17 400 km. The network remained essentially unchanged during the year and consists of some two hundred separate lines. In total, 527 million m^3 of crude oil and refined products was transported through these systems. This resulted in a total traffic volume of 89 x 10^9 m^3km, of which products amounted to about 20 x 10^9 m^3km.

2.2 DETAILS OF SPILLAGE INCIDENTS

Eight incidents were recorded in which reportable oil spillages occurred. For the sake of consistency with previous reports, causes have been categorized as shown in the footnote to Table 1 and further tabulated by category and volume in Table 2. Total net loss to the environment was 400 m^3. The volume recovered amounted to 1500 m^3, equivalent to 79% of the gross volume spilled (1900 m^3). The combined cost of pipeline repair and clean-up was reported to be about £2.9 million.

In three cases ground water was affected for a time and one case involved a river but actions taken protected drinking water supplies. No human injuries resulted from any of the pipeline incidents in 1987. The effectiveness of clean-up efforts and the clean-up time are summarized in the following tables:

Effectiveness of clean-up efforts

Spillage recovery (%)	No. of incidents
100	0
75 - 100	3
50 - 75	4
25 - 50	0
0 - 25	1
0	0

Clean-up time

Time taken	No. of incidents
Less than one day:	1
Two days up to one week:	1
Over one week up to one month:	2
Longer than one month:	4

2.3 CAUSES

2.3.1 Mechanical failure

Three of the eight incidents were caused by mechanical failure and resulted in a total gross spillage of 1027 m^3 of which 904 m^3 was recovered thus resulting in a net loss of 123 m^3 (31% of 1987 total net spillage) into the environment.

The incident with the largest gross loss (1000 m^3) in this category was also the largest spillage of the year. It occurred in a 20" underground multi-product pipeline within the boundaries of an oil refinery. The spillage was discovered when the pipeline operator noted pressure losses during short operational pumping stoppages and carried out a pressure test. The location was discovered by a bi-directional test using an ultrasonic leak detection pig. It transpired that the leakage had occurred over a period of 20 days. It took this time to discover the problem because the rate of leakage was only roughly 0.2% of the pipeline flowrate which is below the detection limits of the short-term volume comparisons and nothing was visible from the surface as winter weather had frozen the topsoil. The failure originated from a crack in the root of a butt weld which had occurred during construction some 20 years ago at a difficult construction area obstructed by other underground lines. The x-ray of the original weld showed a crack in the root and a repair weld had been made and accepted after being x-ray tested. Recent re-examination of this x-ray picture following the spillage showed some lack of clarity and it is now evident that the repair had not removed the crack. The evidence shows that this weakness did not deteriorate over the years but that the weld failed suddenly after oil was pumped into the pipeline from cold above-ground connections at a temperature as cold as - 12°C. This coldness (the weak weld was only 280 m downstream of the pumpstation) placed abnormal longitudinal stress on the pipeline due to thermal contraction and at the same time decreased the brittle strength of the pipe metal resulting in a crack 130 mm long. The pipeline was quickly repaired by re-welding and brought back into service after a total outage of just six days. However, clean-up of the oil from the ground water table in the vicinity has taken more than 300 days using pumps to lower the water table to form a sink to collect spilled oil and allow it to be skimmed off. By this means, 880 m^3 of oil was recovered.

A spillage (25 m^3 gross) from an 8" crude oil pipeline happened when a crack developed at a faulty manufactured pipe bend which had been installed some 40 years ago. The presence of a spillage was reported by a third party and the pipeline was almost immediately shut down. Repair by welding took only a few hours. Effective clean-up operations recovered some 23 m^3 of oil.

The last incident in this category was the smallest reportable gross spillage of the year and resulted in a 2 m^3 gross spillage from a 26" crude oil pipeline. A third party reported the appearance of oil from the ground in a mountainous location. It was found to come from a 170 mm long hairline crack in the pipe wall. This had originated from a hard spot caused by faulty heat treatment in the vicinity of a butt weld made during construction of the pipeline 25 years ago. Spilled oil reached a river which required detailed clean-up action. About half of the spilled oil was recovered from the site.

2.3.2 Operational error

No spillages were reported in this category.

2.3.3 Corrosion

There were one external and one internal corrosion occurrances. These resulted in 558 m^3 gross spillage of which 407 m^3 was recovered leaving 151 m^3 (38% of the 1987 total) net loss into the environment.

The spillage (550 m^3 gross) due to external corrosion, the second largest spillage of the year, occurred from a 16" fuel oil pipeline at a road crossing. It was discovered by pipeline personnel alerted by an abnormal decrease in discharge pressure from the pipeline pumps. External corrosion caused a fissure in the pipe wall 600 mm in length at a point at which disbonding of the 40 years old asphalt coating had occurred. Cathodic protection was in operation but could not be expected to give protection in this circumstance. To stop the spillage a sleeve was installed around the leak and the pipeline was cleared using water. Subsequent inspection using an intelligence pig identified several areas of substantially decreased thickness and confirmed general external corrosion. The pipeline remained shut down pending construction of a replacement section. Clean-up required removal of contaminated soil and some 400 m^3 of oil were removed and safely disposed of.

The internal corrosion incident caused an 8 m^3 gross spillage which was the only spillage which occurred in a residential area, and was discovered by a third party. This occurred from a 40 year old 8" crude oil pipeline carrying uninhibited crude oil from a production field. Inspection revealed localized internal corrosion which was repaired by installing a sleeve, and later by replacing a section of pipe. Careful clean-up reinstated the affected area and removed most (7 m^3) of the spilled oil.

2.3.4 Natural hazard

The spillage in this category resulted in a gross spillage of 12 m^3 of which 2 m^3 was recovered.

This occurred where a 12" naphtha pipeline traverses a steeply sloping field in hilly countryside. A third party reported smelling light hydrocarbons and an immediate investigation discovered a 20 l/hr leak. Downhill slippage of the ground had overstressed the pipeline causing a hairline crack 70 mm long in the pipe wall. The spillage contaminated a patch of agricultural land for a period and local ground water was also affected. Oil recovery was hampered by the lightness of the product and only some 2 m^3 was collected.

2.3.5 Third party activity

The two incidents in this category contributed 303 m^3 gross spillage of which 187 m^3 was recovered giving a net loss of 116 m^3 (29% of the 1987 total).

The third largest spillage (300 m^3 gross) of the year occurred during normal operation of a 16" multi-product pipeline running through an industrial area. A third party reported oily ground and pipeline operations were immediately suspended to investigate. A small crack in the pipe wall was discovered within a dent (1 cm deep with an area of 150 cm^2) in the pipeline. The dent was believed to have occurred some time after completion of the construction of the pipeline some 18 years previously and had been caused by the pipe being struck by an excavator or similar piece of machinery. The crack itself was caused by the stress reversals from normal operating pressure fluctuations over the years focussed at the out of the round section of the pipe at the dented location. The pipeline was out of service for investigation and repair for four days. The spillage seeped into the local ground water table. Oil recovery was carried out using scavenger pumps to collect oil skimmed off from the ground water. Some 185 m^3 of oil was recovered during one and a half months of intensive clean-up operation. This greatly diminished the pollution and the site was kept under observation in case further quantities of oil should become recoverable.

A small spillage (3 m^3 gross) occurred when a contractor carrying out work at the pipeline owner's industrial site inadequately controlled his mobile bush cutting equipment and damaged a vent pipe on an above ground section of 22" pipeline. The vent was repaired and the ground in the vicinity cleaned up (removing 2 m^3 of oil) within the same day as the incident.

Table 1 Details of spillage incidents 1987

No.	Pipeline or Pump-stn.	Pipe specification mm (inches in brackets)	Commodity	Spillage (m^3)			How discovered	Cause		Damage			Clean-up period (days)
				Spilled	Recovered	Net Loss		Category	Origin	Water pollution /type	Soil pollution /area affected (m^2)	Estimated total cost (£)	
1	P/L	5LA 216 x 8 (8 x 0.315)	Crude	25	23	2	Third Party	Mechanical A (b)	Failure of faulty pipebend	no	yes 200 m^2	55 000	< 30
2	P/L	5LA 216 x 8 (8 x 0.315)	Crude	8	7	1	Third Party	Corrosion C (b)	Internal corrosion	no	yes 280 m^2	80 000	< 30
3	P/L	5LB 406 x 9.52 (16 x 0.375)	Fuel Oil	550	400	150	Pipeline Operator	Corrosion C (a)	Severe corrosion in road crossing	no	yes 200 m^2	150 000	6
4	P/L	5LX - X52 406 x 8.74 (16 x 0.344)	Products	300	185	115	Third Party	Third Party E (c)	Crack in dented pipe	ground water affected	yes underground	90 000	45 +
5	P/L	St 53.7 508 x 10 (20 x 0.40)	Products	1000	880	120	Pressure test, Ultra S. Leak D.	Mechanical A (a)	Butt weld failure caused by defective construction	ground water affected	yes underground	1 600 000	300 +
6	P/L	5LX - X52 305 x 6.35 (12 x 0.250)	Naphtha	12	2	10	Third Party	Natural D (a)	Exessive pipe stresses due to landslide	ground water affected	yes 2000 m^2	325 000	40
7	P/L	5LX - X52 660 x 12.7 (26 x 0.500)	Crude	2	1	1	Third Party	Mechanical A (a)	Hard spot caused by heat treatment	river affected	yes 1000 m^2	560 000	70
8	P/L	5L 560 x 9.5 (22 x 0.375)	Gasoil	3	2	1	Third Party	Third Party E (a)	Mobile bush cutter damaged ventpipe	no	yes 10 m^2	2 000	< 1
		T o t a l		1900	1500	400							

Cause/category: A - Mechanical failure
- (a) Construction fault
- (b) Materials fault

B - Operational error
- (a) System malfunction
- (b) Human error

C - Corrosion
- (a) External
- (b) Internal

D - Natural hazard
- (a) Landslide or subsidence
- (b) Flooding
- (c) Other

E - Third party activity
- (a) Direct damage -accidental
- (b) Direct damage - malicious
- (c) Incidental damage

Table 2 Analysis of 1987 incidents

Main category	Number of incidents		Spillage in cubic metres (m^3)			Average volume per incident	
	Pipeline	Pump-station	gross	recovered	net	gross	net
Mechanical failure	3	-	1027	904	123	342	41
Operational error	-	-	-	-	-	-	-
Corrosion	2	-	558	407	151	279	75
Natural hazard	1	-	12	2	10	12	10
Third party activity	2	-	303	187	116	151	58
Total	8	-	1900	1500	400	237	50

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report no. 9/89

performance of oil industry cross-country pipelines in western europe

statistical summary of reported spillages — 1988

Prepared by the CONCAWE Oil Pipelines Management Group's Special Task Force on Oil Pipeline Spillages (OP/STF-1)

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The Hague
December 1989

2. PIPELINE PERFORMANCE

2.1 GENERAL DATA

The total length of oil industry cross-country pipelines in Western Europe in operation at the end of 1988 was reported by the 65 respondents to be about 17 700 km. This is 270 km greater than last year due to changes reported to the CONCAWE database, mainly the inclusion of one additional respondent. The pipeline network itself remained essentially unchanged during the year and consists of some two hundred separate lines. In total, 538 million m^3 of crude oil and refined products was transported through these systems. This resulted in a total traffic volume of 91 x 10^9 m^3 km, of which products amounted to about 20 x 10^9 m^3 km.

2.2 DETAILS OF SPILLAGE INCIDENTS

Eleven incidents were recorded in which reportable oil spillages occurred. For the sake of consistency with previous reports, causes have been categorized as shown in the footnote to Table 1 and further tabulated by category and volume in Table 2. Total net loss to the environment was 752 m^3. The volume recovered amounted to 441 m^3, equivalent to 37% of the gross volume spilled (1193 m^3). The combined cost of pipeline repair and clean-up was reported to be about £2.7 million.

In one case ground water was affected for a time, two cases involved rivers and another a tidal estuary but actions taken protected drinking water supplies and prevented damage to amenity areas. One human injury resulted from one of the pipeline incidents in 1988. The effectiveness of clean-up efforts and the clean-up time are summarized in the following tables:

Effectiveness of clean-up efforts

Spillage recovery (%)	No. of incidents
100	0
75 - 100	6
50 - 75	3
25 - 50	0
0 - 25	0
0	2

Clean-up time

Time taken	No. of incidents
Less than one day:	2
Two days up to one week:	4
Over one week up to one month:	2
Longer than one month:	3

2.3 CAUSES

2.3.1 Mechanical failure

There was one incident caused by mechanical failure which resulted in gross spillage of 10 m^3, of which 9 m^3 was recovered resulting in a net loss of 1 m^3.

The incident occurred in a 34" crude oil pipeline due to the failure of a gasket between the flanges of an electrical insulating joint. The gasket was replaced by one of a better quality for the service and the pipeline was back in service within two days. The location was an industrial area accessible for effective clean-up, which took 45 days to complete.

2.3.2 Operational error

No spillages were reported in this category.

2.3.3 Corrosion

There were three spillages due to corrosion, all of which were due to external corrosion. These resulted in gross losses of 166 m^3 of which 84 m^3 was recovered and the net loss was 82 m^3.

A spillage of 81 m^3 gross occurred where a 34" crude oil pipeline passes under a road. The asbestos-cement casing of the duct through which the pipeline passes had become displaced and was contacting the pipe causing damage to the coating. The exposed pipe became a focus for corrosion. Within the exposed area, there was a small dent and a nearby magnesium anode of the cathodic protection system was in contact with the pipeline. Both of these dated from the original construction. This combination of circumstances led to a hydrogen induced stress corrosion crack mechanism that caused a 140 mm tear in the pipewall. A large area of ground was affected by

oil, and the extensive clean-up operation required the removal of a substantial quantity of top-soil. Free oil was also recovered from the site using vacuum trucks to skim oil out of drain pits dug locally. The removed soil was cleaned with steam and heat and partially re-used together with fresh top-soil to reinstate the area. Altogether some 80 m^3 of the spillage was recovered or safely disposed of leaving a net loss of about 1 m^3 indicating the very effective outcome of the clean-up. This took 165 days to complete although it was only necessary to have the pipeline out of service for 6 days for repairs.

A similar sized spillage (80 m^3 gross) occurred from a 10 $^3/_4$" product pipeline in a residential area. In this case the focus of the external corrosion site was the point of contact between the pipeline and a piece of metal guttering left in the soil of the pipe trench. This caused damage to the pipeline's coal-tar coating and a subsequent corrosion patch of about 2.5 cm diameter developed eventually resulting in a pin-hole perforation of the pipe-wall. The location of the leak was determined using intelligent noise detecting pigs. Due to the sandy soil and the light nature of the product spilled, the oil was not recoverable. Clean-up was not possible and no environmental damage could be detected. The pipeline was out of service for 10 days, while repairs were completed.

The third spillage (5 m^3 gross) in this category was from a 28" crude oil pipeline on the foreshore of a tidal estuary. A discontinuity in the pipeline's coating around a non-standard fitting and a less than perfect weld, both dating from the original construction, exposed the fitting to the corrosive salt-water environment. A pin-hole perforation of the weld resulted. Oil leakage was noticed almost immediately by a passer-by and absorbent material booms were quickly deployed to contain the spillage. Vacuum tank road vehicles were used to keep the site free of oil while the pipeline was excavated to allow capping of the fitting. Over 4 m^3 of the spilled oil was recovered, hence the estimated net loss amount is under 1 m^3. The clean-up took 2 days and the pipeline repair outage was 3 days.

2.3.4 Natural hazard

One spillage was in this category, 305 m^3 gross spillage of which 300 m^3 was recovered and net loss 5 m^3. This was the second largest gross spillage in 1988.

This occurred where a 10" products pipeline in a rural area crosses under a river onto a tongue of land bordered by another river. In the region of one of the river banks, the ground containing the pipeline was subject to movement due to creep flow of the land. The pipeline under the river itself remained as a fixed point and the

change in direction of the pipeline at the angle of ascent from the river crossing became deformed and overstressed. A 160 mm rupture occurred which was detected not long after by pressure discrepancies noted by the pipeline operators who initiated shut down and isolation. The leakage of light fuel oil was initially stemmed by installing a collar over the rupture. Some of the released oil reached the river and another river downstream. Temporary barriers were set up on the rivers and a large scale effort was mounted to trap and collect the free oil. At the same time clean-up of the riverside was attended to, and when this was completed, residual oil bloom formation on the rivers was dealt with over a period of time using a series of barriers and absorbent materials. The 300 m^3 of oil recovered altogether was safely disposed of at controlled disposal and incineration sites. The overall clean-up time was 54 days and the pipeline shut-down for reallignment and repair was 5 days.

2.3.5 Third party activity

There were six spillage incidents due to pipelines being damaged by the activities of third parties. In all cases the damage was caused by accident and no malicious incidents occurred. The total gross spillage was 712 m^3 of which 48 m^3 was recovered giving a net loss of 664 m^3 (88% if the 1988 grand total net spillage loss).

The largest spillage incident (650 m^3 gross) in this category was the largest spillage of the year. It occurred in a remote open country area where a 16" crude oil pipeline crosses under a rural road. The pipeline operator was aware of trenching activity in the locality and those involved in the work knew about the existence of the pipeline and had been notified to restrict the use of mechanical equipment. A bulldozer driver carrying out the trenching work hit the pipeline with ditch digging equipment. This resulted in a 165 mm gash in the pipeline and released a powerful spray of crude oil. The bulldozer operator inhaled crude oil spray and suffered nervous shock but recovered sufficiently to be released from hospital within two days. The spillage is classified as a total loss. However, the surface condition of the road and agricultural land affected was reinstated and the pipeline was repaired and back in service within two days.

Also caused by trenching activities during excavation of drainage ditches was a 40 m^3 gross spillage from a 20" products pipeline. In this case the excavation contractor knew of the location of the pipeline from markers in the area and was in possession of a marked-up map, but the pipeline operator was unaware of any work being done. Clean-up recovered 30 m^3 resulting in a remainder of 10 m^3 net loss. The clean-up and pipeline repairs were both completed within 4 days.

A spillage of 14 m^3 gross of crude oil from a 10" pipeline was caused by it being pierced by a drainage plough. This was being used during agricultural work to improve land drains. The pipeline company was unaware of the work, but the machine operator knew about the existence of the pipeline and its identification markers. Thorough clean-up taking 17 days recovered 13 m^3 of oil for a net loss of 1 m^3. It took 6 days to repair and re-start pipeline operations.

A drill being used during geological surveying in a rural area drilled into and pierced a 16" products pipeline. A 3 m^3 gross spillage resulted. The driller knew there was a pipeline in the general vicinity but there were no line markers locally and the surveyors did not ascertain the exact pipeline position. The pipeline company was unaware of the geological survey taking place. A day was spent cleaning up during which 2 m^3 of oil was picked up. It took 9 days to repair and reinstate pipeline operations.

Also 3 m^3 gross was the spillage caused when about 1 m of an 8" products pipeline was damaged by a third party carrying out sewer installations in a residential area in the vicinity of a pipeline road crossing. No other details of the circumstances of this incident were received. Clean-up was thorough, taking 6 days, and recovered well over 2 m^3 of the spillage leaving less than 1 m^3 net loss.

Lastly, and at 2 m^3 gross the smallest reportable spillage of the year, was that caused when farm workers engaged in machine laying of soil drainage pipe hit a 3" crude oil pipeline. The pipeline operator was unaware of the work but the machine operator knew the location of the pipeline and local line markers are in place. Care was taken during the clean-up operation to protect two rivers with a total of five booms and some skimming of oil from surface water was carried out. Oil soaked soil was removed and incinerated. It is estimated that over 1 m^3 of the spillage was recovered during the 13 days recovery operation and the net loss was below 1 m^3. The pipeline was out of service for repairs for 12 days.

Table 1 Details of spillage incidents 1988

No.	Pipeline or Pumpstation	Pipe Specification mm (inches in brackets)	Commodity	Spillage (m^3)			How Discovered	Cause		Water Pollution /Type	Soil Pollution /Area Affected (m^2)	Estimated Total Cost (£)	Clean-up Period (days)
				Spilled	Recovered	Net Loss		Category	Origin				
1.	P/L	5L - B 275 x 6.5 (10 3/4 x 0.256)	Products	80	0	80	Pipeline Operator	Corrosion C (a)	Galvanic contact with scrap metal left in pipe trench	No	No	10 000	Nil
2.	P/L	5L - B 865 x 7.9 (34 x 0.312)	Crude	10	9	1	Third Party	Mechanical A (b)	Gasket failure at insulating flange	No	Yes (200)	135 000	45
3.	P/L	5LX - X46 508 x 6.35 (20 x 0.25)	Products	40	30	10	Third Party	Third Party E (a)	Excavator hit pipeline	No	Yes (30)	21 000	4
4.	P/L	St 35.29 83 x 3.25 (3 x 0.13)	Crude	2	1	1	Third Party	Third Party E (a)	Excavator hit pipeline	Yes Rivers Affected	Yes (100)	20 000	13
5.	P/L	5LX - X46 (254 x 6.3) (10 x 0.25)	Crude	14	13	1	Third Party	Third Party E (a)	Drainage ditch plough hit pipeline	No	Yes (100)	28 000	17
6.	P/L	Not known 203 x ? (8 x ?)	Products	3	2	1	Third Party	Third Party E (a)	Sewer works near road-crossing hit pipeline	No	Yes (20)	10 000	6
7.	P/L	5LX - X52 254 x 5.56 (10 x 0.219)	Products	305	300	5	Automatic Detection System	Natural Hazard D (a)	Ground movement near river-banks	Yes Rivers Affected	Yes (5000)	530 000	54
8.	P/L	5LX - 405 x 6.35 (16 x 0.25)	Products	3	2	1	Third Party	Third Party E (a)	Geological drill hit pipeline	No	Yes (150)	30 000	1
9.	P/L	5LS - X60 865 x 7.92 (34 x 0.312)	Crude	81	80	1	Third Party	Corrosion C (a)	Hydrogen induced stress corrosion crack	Yes Groundwater Affected	Yes (5000)	1 900 000	165
10.	P/L	5LX - X42 406 x 5.56 (16 x 0.219)	Crude	650	0	650	Automatic Detection System	Third Party E (a)	Ditch digger (bulldozer) hit pipeline	No	Yes (550)	6 000	2
11.	P/L	5LX - X52 (711 x 7.11) (28 x 0.28)	Crude	5	4	1	Third Party	Corrosion C (a)	Weld corrosion at site of defective coating/original welding	Yes Tidal Area Affected	Yes (400)	11 000	2
		Total		1193	441	752						2 701 000	

Cause category: A - Mechanical failure (a) Construction fault (b) Materials fault; B - Operational error (a) System malfunction (b) Human error; C - Corrosion (a) External (b) Internal; D - Natural hazard (a) Landslide or subsidence (b) Flooding (c) Other; E - Third party activity (a) Direct damage - accidental (b) Direct damage - malicious (c) Incidental damage

Table 2 Analysis of 1988 incidents

Main category	Number of incidents		Spillage in cubic metres (m^3)			Average volume per incident	
	Pipeline	Pump-station	gross	recovered	net	gross	net
Mechanical failure	1	-	10	9	1	10	1
Operational error	-	-	-	-	-	-	-
Corrosion	3	-	166	84	82	55	27
Natural hazard	1	-	305	300	5	305	5
Third party activity	6	-	712	48	664	119	111
Total	11	-	1193	441	752	108	68

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performance of oil industry cross-country pipelines in western europe

statistical summary of reported spillages -1989

Prepared by the CONCAWE Oil Pipelines Management Group's Special Task Force on Pipeline Spillages (OP/STF-1)

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2. PIPELINE PERFORMANCE

2.1 GENERAL DATA

The total length of oil industry cross-country pipelines in operation in Western Europe at the end of 1989 was reported by the 63 respondents to be about 18 900 km. The two fewer respondents than last year are companies associated with refineries that have permanently closed-down. The details of the status of the shutdown pipelines are not known. The pipeline network consists of nearly two hundred separate lines. The reported length is some 1200 km more than in 1988; 950 km is due to reclassification of a Spanish pipeline system from government to oil industry ownership, 400 km is new pipelines and the balance includes the shutdown of three pipeline systems. In total, 535 million m^3 of crude oil and refined products was transported through the pipeline systems. This resulted in a total traffic volume of 89.0 x 10^9 m^3 km, of which products amounted to about 22.7 x 10^9 m^3 km.

2.2 DETAILS OF SPILLAGE INCIDENTS

Thirteen incidents were recorded in which reportable oil spillages occurred. For the sake of consistency with previous reports, causes have been categorized as shown in the footnote to Table 1 and further tabulated by category and volume in Table 2. Total net loss to the environment was 1291 m^3. The volume recovered amounted to 893 m^3, equivalent to 41% of the gross volume spilled (2184 m^3). The combined cost of pipeline repair and clean-up was reported to be 8.7 million ECU.

It must be mentioned that two of the 1989 incidents had extremely serious consequences: three fatalities in one case, prosecution and a large fine in the other.

In four cases groundwater was affected and three cases involved rivers, one of which was a tidal estuary. Two of these cases resulted in drinking water abstraction being affected. The effectiveness of clean-up efforts and the clean-up time are summarized in the following tables:

Effectiveness of clean-up efforts

Spillage recovery (%)	No. of incidents
100	2
75 - 100	4
50 - 75	1
25 - 50	3
0 - 25	1
0	2

Clean-up time

Time taken	No. of incidents
One day or less:	1
Two days up to one week:	1
Over one week up to one month:	5
Longer than one month:	5

In one incident involving the spillage of light product in an arid area, there was no clean-up reported.

Seven of the incidents have been classified as severe in one or more respects of soil or water pollution or other serious consequences.

2.3 CAUSES

2.3.1 Mechanical failure

There were four incidents caused by mechanical failure which resulted in gross spillage of 184 m^3 of which 170 m^3 was recovered resulting in a net loss of 14 m^3.

A 25 m^3 gross spillage occurred after a joint blow out between flanges in above-ground, recently installed, 1" diameter instrument pipework. The joint had been poorly fitted during construction. An extensive area of ground was surveyed for traces of the gasoline which had leaked out. The pipeline was put back in service 24 hours after the spillage was detected and clean-up took 8 days.

A cracked seam (longitudinal) weld of a repair sleeve which had been fitted some time previously as a repair for external corrosion, caused a 1 m^3 gross spillage. The welding of the sleeve seam was found to be substandard. The spilled fuel oil was quickly removed taking one day and the pipeline was returned to service in 20 hours.

Spillage of 155 m^3 gross occurred after the failure of a defective seam weld in the pipe material supplied by the manufacturer. Factors which may have contributed to the size of the split are under investigation, but no overpressures have been registered. The pipeline was repaired and restarted in 11 days. The spillage affected sources of drinking water, preventing abstraction and requiring facilities to provide alternative supplies. It took 160 days to clean a crude oil polluted stream thoroughly in a demanding recovery operation.

A 3 m^3 gross spillage accumulated from a weeping girth weld which was defective and became porous. The weld was made manually in the field in the original construction. The pipeline was out of service for 5 days and a straightforward clean-up operation took 9 days to complete.

2.3.2 Operational error

No spillages were reported in this category.

2.3.3 Corrosion

There were three spillages due to corrosion, two of which were external corrosion and one was internal corrosion. These resulted in gross losses of 665 m^3 of which 420 m^3 was recovered and the net loss was 245 m^3.

One external corrosion incident resulted in a gross spillage of 240 m^3 of heavy high pour point crude oil, pumped in a thermally insulated pipeline at elevated temperature. An area of general external corrosion occurred at a tidal location where the pipeline coating of coal tar reinforced with glass fibre had failed. Extensive clean-up operations were required to remove the oil pollution from the foreshore of the river estuary. Subsequently as a result of legal proceedings, a large fine was imposed. The pipeline remains shut down nine months after the incident.

The other external corrosion incident involved spillage of 25 m^3 of crude oil when the pipeline failed under pressure testing. An area of general external corrosion occurred where the coal-tar coating of the pipe had decomposed. The pipeline was repaired and re-commissioned in two days and clean-up involving excavation and removal of oiled soil was completed subsequently.

The internal corrosion incident resulted in about 400 m^3 gross spillage. Following immediate shutdown of the pipeline after the automatic leak detection system indicated something irregular, an extended search took place trying to find the precise location of the leak. After a day's search, a patch of land saturated with gasoline and gas oil was discovered. The cause of the leak was a tiny fissure resulting from localized internal corrosion. From the small size of the failure, it was concluded that the leak had perhaps remained undetected for quite a period of time. Although the pipeline was repaired and put back into service within three days an extensive and extended operation was instituted to remove oil from the groundwater and subsoil. This operation was still continuing at the date of the report some 200 days after the spillage was detected.

2.3.4 Natural hazard

No spillages were reported in this category.

2.3.5 Third party activity

There were six spillage incidents due to pipelines being damaged by the activities of third parties. In all cases the damage was caused unintentionally. In one of these cases the damage was done at some time in the past and the specific individual responsible is unknown. In another case, the damage was caused by the side effects of a third party's electrical installation. The total gross spillage was 1335 m^3 of which 303 m^3 was recovered giving a net loss of 1032 m^3 (80% of the 1989 grand total net spillage loss).

In none of these cases involving machinery did the pipeline company have advance knowledge and details of the work being carried out by the third party.

A 298 m^3 gross spillage resulted when a farmer's ditch digging equipment punctured the pipeline. An emergency clamp was installed and the restart of the pipeline was made in 6 hours. The spillage was of light product in an arid area, and no clean-up was reported.

The largest spillage of the year, 660 m^3 gross, occurred when an agricultural machine equipped with a ripper gouged the pipeline. Several scratches were found on the pipe, made during previous passes of the machine. The pipeline was repaired and returned to service in less than 5 days. The spillage affected a stream and the groundwater, restricting the abstraction of drinking water. Hydrocarbon recovery systems were installed in a large-scale clean-up operation which was still underway some 450 days after the date of the spillage.

Excavation works along the banks of a stream caused a gash in a pipeline and 82 m^3 of gas oil was spilled. The pipeline was repaired in 4 days. A rapid deployment of booms and dams was successful in restricting the extent of the river pollution that occurred, and a very satisfactory clean-up operation was completed in 18 days.

A digging machine carrying out ground levelling work caused a spillage of 253 m^3 of naphtha, with tragic consequences. The machine dug into a bank in which the pipeline was buried, gashing it. The pipeline was shut-down immediately, but some time afterwards, the spillage ignited and three bystanders were killed in the fire. The pipeline was out of service for 25 days and no oil clean-up was required following the fire.

Faulty design of an earth cable installation, part of a high voltage electricity supply system, located the cable too close to the pipewall. The resulting electrical field modification caused loss of metal from the pipewall and led to a 40 m^3 gross spillage. The pipeline was not required to be returned to service straight-away. The spillage of crude oil contaminated groundwater and a difficult and extensive operation was required to protect drinking water supplies and to recover and clean-up the hydrocarbon, taking some 180 days to complete.

A 2 m^3 spillage occurred from a pipeline which showed evidence of having been dented by agricultural or construction machinery at an undetermined prior date. The dent subsequently developed a small crack due to normal operating stresses. The pipeline was out of service for 7 days and crude oil saturated subsoil was successfully removed and disposed of in an 18 day operation.

Table 1 Details of spillage incidents 1989

No	P/L or P/S	Pipe Spec.	Commodity	Spillage (m^3) Spilled	Recd.	Net	How Discovered	Category	Cause Origin	Water Pollution /Type	Soil Pollution /Area (m^2)	Estimated Cost (ECU)	Clean-up Days
1.	P/L	5LB 304x8.38 (12x0.33)	Crude Oil	240	90	150	Third Party	Corrosion C (a)	Corrosion of pipeline in hot service at tidal river estuary location	Yes Widespread coastal impact	No	2 235 000	60+
2.	P/S	1"Instrument Piping	Gasoline	25	18	7	Third Party	Mechanical A (a)	Joint blow out between flanges of poorly fitted instrument line	No	Yes 10 000	29 000	8
3.	P/L	5LX-X42 304x6.35 (12x0.25)	Products	298	0	298	Pipeline Operator	Third Party E (a)	Farm ditching equipment hit pipeline	No	Yes 250	8 000	No report
4.	P/L	5LS 304x6.35 (12x0.25)	Fuel Oil	1	1	0	Third Party	Mechanical A (a)	Crack in seam weld of previously fitted repair sleeve due to substandard welding	No	Yes 6	27 000	1
5.	P/L	5LX-X52 254x5.56 (10x0.219)	Products	400	310	90	Automatic Detection System	Corrosion C (b)	Local internal corrosion	Yes Groundwater affected	Yes 2000	1 720 000	200+
6.	P/L	5LX-X52 254x7.8 (10x0.31)	Gas Oil	82	78	4	Automatic Detection System	Third Party E (a)	Excavator engaged in trenching work struck pipeline	Yes River affected short-term	Yes 200	450 000	18
7.	P/L	5LX-X52 660x9.52 (26x0.37)	Crude Oil	155	150	5	Third Party	Mechnical A (b)	Failure of defective seam weld	Yes Drinking water contaminated	Yes 2000	1 850 000	160
8.	P/L	5LX-X52 (660x9.52) (26x0.37)	Crude Oil	3	1	2	Third Party	Mechanical A (a)	Porosity in defective girth weld	No	Yes 100	55 000	9
9.	P/L	5LX-X60 1100x8.74 (40x0.34)	Crude Oil	40	35	5	Third Party	Third Party E (c)	Damage caused by the field of a high voltage electricity cable earth installation located too close to the pipewall	Yes Groundwater affected	Yes 4000	1 300 000	180
10.	P/L	5LX-X52 406x8.74 (16x0.34)	Products	660	188	472	Automatic Detection System	Third Party E (a)	Machine with ripper attachment carrying out agricultural under soil works gouged pipeline	Yes Drinking water and stream affected	Yes Subsoil impregnated	480 000	450+
11.	P/L	5LX-X52 406x7.14 (16x0.28)	Naphtha	253	0	253	Third Party	Third Party E (a)	Digging machine doing ground levelling work dug into the pipeline	No	Yes 500 (burned)	3 fatalities 340 000	7
12.	P/L	5LX-46 273x6.35 (10.75x0.25)	Crude Oil	2	2	0	Third Party	Third Party E (c)	Pipewall damage from impact of agricultural/digging machinery subsequently developed a crack	Yes Short-term	Yes Subsoil impregnated	140 000	18
13.	P/L	5LA 216x8 (8.63x0.25)	Crude Oil	25	20	5	Pressure testing	Corrosion C (a)	General corrosion, coating decomposed, failed pressure test	No	50	20 000	< 30
		Total		2184	893	1291						8 654 000	

Cause/Category: A - Mechanical failure
(a) Construction fault
(b) Materials fault

B - Operational error
(a) System malfunction
(b) Human error

C - Corrosion
(a) External
(b) Internal

D- Natural hazard
(a) Landslide or subsidence
(b) Flooding
(c) Other

E - Third party activity
(a) Direct damage - accidental
(b) Direct damage - malicious
(c) Incidental damage

Notes: In the Clean-up Days column, + indicates that clean-up had not been entirely completed at the date the spillage report was made.
The value of the European Currency Unit (ECU) at end 1989 was £ 0.727 and $ 1.164.

Table 2 Analysis of 1989 spillage incidents

Main category	Number of incidents*		Spillage in cubic metres (m^3)			Average volume per incident	
	Pipeline	Pump-station	Gross	Recovered	Net	Gross	Net
Mechanical failure	3	1	184	170	14	46	4
Operational error	-	-	-	-	-	-	-
Corrosion	3	-	665	420	245	222	82
Natural hazard	-	-	-	-	-	-	-
Third party activity	6	-	1335	303	1032	223	172
Total	12	1	2184	893	1291	168	99

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report no.4/91

performance of oil industry cross-country pipelines in western europe

statistical summary of reported spillages - 1990

Prepared by the CONCAWE Oil Pipelines Management Group's Special Task Force on Pipeline Spillages (OP/STF-1)

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Brussels
November 1991

2. PIPELINE PERFORMANCE

2.1 GENERAL DATA

The total length of oil industry cross-country pipelines in operation in Western Europe at the end of 1990 was reported by the 63 respondents to be about 19 350 km. The pipeline network consists of nearly two hundred separate lines. The reported length is some 450 km more than in 1989; 300 km is new pipelines and the balance includes pipeline systems which existed previously but which are reported for the first time following the merger between a respondent company and a non-respondent one. In total, 549 million m^3 of crude oil and refined products was transported through the pipeline systems. This resulted in a total traffic volume of 92.5 x 10^9 m^3 km, of which products amounted to about 23.3 x 10^9 m^3 km.

2.2 DETAILS OF SPILLAGE INCIDENTS

Three incidents were recorded in which reportable oil spillages occurred. For the sake of consistency with previous reports, causes have been categorized as shown in the footnote to Table 1 and further tabulated by category and volume in Table 2. Total net loss to the environment was 520 m^3. The volume recovered amounted to 62 m^3, equivalent to 10% of the gross volume spilled (582 m^3). The combined cost of pipeline repair and clean-up was reported to be only 35 thousand ECU.

Two of the three cases occurred in arid rural areas and the third was centred on a pumpstation also in a dry area. In all cases, light products were involved and little or no clean-up could be effectively carried out, nor was it thought to be necessary for environmental reasons.

Effectiveness of clean-up efforts

Spillage recovery (%)	No. of incidents
100	0
75 - 100	0
50 - 75	0
25 - 50	0
0 - 25	2
0	1

Clean-up time

In none of the incidents were there reports of specific clean-up periods during the reinstatement activities.

2.3 CAUSES

2.3.1 Mechanical failure

There were no mechanical failure incidents.

2.3.2 Operational

The accidental closure by a pipeline workman of a main line valve at a pumpstation caused a scraper-pig trap at an upstream facility to be over-pressurized. A spillage of 252 m^3 gross of jet fuel occurred. The pipeline was out of service for two days while the trap installation was modified. There was no significant pollution.

A 105 m^3 gross spillage occurred during a pipeline stopple operation. In the course of the stoppling procedure a 1" drain valve on one of the sandwich valves was knocked and broken. Two hours pipeline shutdown was required to stop the leak by repairing the damage. The spillage was of light product in a rural area with porous ground which caused no significant pollution problems.

2.3.3 Corrosion

There were no spillages due to corrosion.

2.3.4 Natural hazard

No spillages were reported in this category.

2.3.5 Third party activity

A 225 m^3 gross spillage occurred in a rural area when a bulldozer engaged in road construction punctured a pipeline. The pipeline operator was unaware of the work proceeding in the pipeline's vicinity. The pipeline is permanently marked at 500 m intervals and two of the markers were visible to the bulldozer operator. Following a temporary repair, the pipeline was put back into service 12 hours later. The spillage was of light product onto porous ground, and caused no ongoing ground pollution.

Table 1 Details of spillage incidents 1990

No.	Pipe-line or Pump-stn.	Pipe Spec. mm (inch)	Commodity	Spillage (m^3)			How Discov-ered	Cause		Water Pollution /Type	Soil Pollution Area (m^2)	Estimated Cost (ECU)	Clean -up Days
				Spilled	Recov-ered	Net		Category	Origin				
1.	P/L	5LX-X42 277x6.35 (10.75x0.25)	Products	225	31	194	Third Party	Third Party E (a)	Bulldozer hit pipeline	None	2500	17 000	No report
2.	P/L	1" Valve	Products	105	0	105	P/L Oper-tor	Operat-ional B (b)	Drain valve broken by accidental blow during stopple operation	None	30	1 000	No report
3.	P/S	Pig Trap	Jet Fuel	252	31	221	Third Party	Operat-ional B (b)	Overpressure of pig trap due to erroneous closure of line valve	None	1500	17 000	No report
			Total	582	62	520						35 000	

Cause/Category: A - Mechanical failure
(a) Construction fault
(b) Materials fault

B - Operational
(a) System mal-function
(b) Human error

C - Corrosion
(a) External
(b) Internal

D - Natural hazard
(a) Landslide or subsidence
(b) Flooding
(c) Other

E - Third party activity
(a) Direct damage - accidental
(b) Direct damage - malicious
(c) Incidental damage

Note: The value of the European Currency Unit (ECU) at end 1990 was £0.709 and $1.353.

Table 2 Analysis of 1990 incidents

Main category	Number of incidents		Spillage in cubic metres (m^3)			Average volume per incident	
	Pipeline	Pump-station	Gross	Recovered	Net	Gross	Net
Mechanical failure	-	-	-	-	-	-	-
Operational	1	1	357	31	326	178	163
Corrosion	-	-	-	-	-	-	-
Natural hazard	-	-	-	-	-	-	-
Third party activity	1	-	225	31	194	225	194
Total	2	1	582	62	520	194	173

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statistical summary of reported spillages - 1991

Prepared by the CONCAWE Oil Pipelines Management Group's Special Task Force on Oil Pipeline Spillages (OP/STF-1)

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November 1992

2. PIPELINE PERFORMANCE

2.1 GENERAL DATA

The total length of oil industry cross-country pipelines in operation in Western Europe at the end of 1991 was reported by the 65 respondents to be 21 000 km. For the first time, pipelines in the eastern part of Germany are included. The pipeline network consists of about 210 separate lines. The reported length is some 1650 km more than in 1990; the eastern German pipelines comprise 1100 km, new product pipelines in Spain and the UK add 650 km, closures amounted to 200 km, and the balance is due to other pipeline systems which existed previously but which are reported for the first time. In total, 593 million m^3 of crude oil and refined products was transported through the pipeline systems. This resulted in a total traffic volume of 101 x 109 m^3 km, of which products amounted to about 24 x 109 m^3 km.

2.2 DETAILS OF SPILLAGE INCIDENTS

The 1990 spillage notified late was a spillage of 325 m^3 of fuel oil due to external corrosion. After clean-up, the net oil lost into the environment was some 11 m^3. This takes the 1990 total to four spillages, the gross spillage for that year increases to 907 m^3 and the net loss goes up to 531 m^3. This is still a notably better than average performance.

In 1991, fourteen incidents were recorded in which reportable oil spillages occurred. For the sake of consistency with previous reports, causes have been categorized as shown in the footnote to Table 1 and further tabulated by category and volume in Table 2. Total net loss to the environment was 902 m^3. The volume recovered amounted to 444 m^3, equivalent to 33% of the gross volume spilled (1346 m^3). The combined cost of pipeline repair and clean-up was reported to be about 7.9 million ECUs.

Of the eleven incidents where the action taken on clean-up was reported, two incidents required little to be done whereas three incidents in particular required extensive and costly remediation. Two of the latter involved light products entering water courses causing extensive but not persistently damaging pollution. No potable water supplies were implicated. None of the incidents caused injury to people. One spillage ignited but did not result in fire damage that adversely affected pipeline operations.

Effectiveness of clean-up efforts

Spillage recovery (%)	No. of incidents
100	2
76 - 99	2
51 - 75	3
26 - 50	3
1 - 25	2
0	2

Clean-up time

Time taken	No. of incidents
Less than one day	1
Two days up to one week	3
Over one week up to one month	2
Longer than one month	5
Not reported	3

In four of the cases, in-situ bioremediation (land-farming) techniques were mentioned as included in the clean-up actions.

2.3 CAUSES

The 1990 spillage (reported late) resulted from external corrosion of an insulated pipeline carrying heated fuel oil. The fibre/bituminous coating had become damaged by unsuitable backfill material used at a road crossing and an area of general corrosion had developed. A spillage of 325 m^3 gross of fuel oil occurred. The pipeline was out of service for a month for inspection and repair. Some 314 m^3 of oil was picked up with contaminated soil and from along 3 km of a river into which much of the spillage had percolated underground. Although temporarily the contamination was widespread, no lasting environmental damage was reported.

For 1991, the 14 reported spillages of 1 m^3 gross or more are categorized as follows.

2.3.1 Mechanical failure

Seven of the 1991 incidents are categorized as mechanical failure.

A 29 m^3 gross spillage occurred when a pipewall fissure developed due to a metallurgical defect in the pipe which was found to have originated during manufacture of the steel plate from which the pipe was formed. The pipeline was repaired and back in service inside two days. To avoid the environmental damage during clean-up which excavation would have caused to the site (a cultivated field), land-farming techniques are being used to break down the oil in-situ. Although none of the spillage was recovered, it is reported that the field will be back in use for crops in a year.

Subsidence in a coal mining region caused an 80 cm long crack in a pipeline from which 275 m^3 gross of product leaked. Because of the known risk of progressive subsidence in this area the pipeline is specially instrumented and monitored to detect any effects of ground movements. The mining activities in and around the particular area of rupture had come to an end more than a decade ago. Neither during the period of mining activities nor thereafter had any indications of trouble been received. Incomplete data monitoring techniques have to be assumed as the probable reason for the undetected tensions which eventually caused the rupture. When the pipeline ruptured, the leakage was detected within a few seconds and located to within 300 m by the installed automatic leak detection system and the emergency shutdown action and emergency response plan was immediately initiated. Actions taken included the closure of an adjacent motorway. The pipeline was repaired within 4 days and returned to service for extensive testing procedures over a number of weeks. The environmental damage limitation and clean-up activities, however, were more extended, extensive and costly, recovering some 157 m^3 of spilled product. Some 20 000 tons of soil had to be excavated and taken away for subsequent microbiological remediation at a specially prepared place.

A plug in a pipeline valve put in ten years ago became loose and a spillage of roughly 50 m^3 gross of condensate occurred. The plug was found to be in excellent condition and retightening, without needing to shut down the pipeline, cured the leak. It could be surmised that vibration may have loosened the plug. About 12 m^3 of free oil was recovered and a quantity of oil-contaminated soil was removed.

The rupture of a bellows in a specific gravity meter caused the spillage of 4 m^3 of product. The pipeline was returned to service in 4 hours. The clean-up operation removed some 3 m^3 of the spilled product.

A thermal expansion relief valve opened during normal pumping operations resulting in a 172 m^3 gross spill. The spillage was detected by an instrumented leak detection system. The pipeline was put back into service in 15 hours. About 104 m^3 of the spillage was picked up in the subsequent clean-up operation.

A 2 m^3 spill happened after the failure of a gasket in a valve flange in the 2" ancillary piping of a pig detector. The pipeline was back in service in 15 hours. The clean-up reportedly removed essentially all of the spilled oil.

Faulty construction work led to the laying of a damaged piece of pipe which some 24 years later developed a split 17 cm in length and spilled 20 m^3 of crude oil. The pipeline was quickly back in service and 7 m^3 of the spill were recovered in the clean-up done immediately afterwards. The area was left to recover naturally and was still in the process of recovering more than a year afterwards.

2.3.2 Operational

There were no "*operational*" spillages.

2.3.3 Corrosion

There were four spillages due to corrosion, three because of internal and one from external corrosion.

A 3 mm hole in an expansion fitting caused by internal corrosion resulted in spillage of 20 m^3 of crude oil in a pipeline from a producing oilfield. The pipeline was repaired and put back in service within a day. The spilled oil was reported removed in its entirety.

An 80 m^3 spillage occurred from a crack caused by external corrosion under a pipeline's polyurethane insulation at a wet section of the right of way. The bulk of the spillage, 76 m^3, was recovered during clean-up, and land-farming techniques are reported to have given good remediation results after three months.

Internal corrosion of a pipeline at a cased road-crossing location, caused a rupture from which roughly 100 m^3 of product was spilled. The leak was detected by a static pressure test. After replacing a section with new pipe, the pipeline restarted in 14 days. Some 40 m^3 of oil was recovered from the site.

Another spillage occurred from the same pipeline when the thinning from internal corrosion led to a 10 cm split from which about 15 m^3 spilled. Roughly 5 m^3 of the oil was recovered. In view of the lost integrity and finding widespread thinning, shortly afterwards it was decided to retire the pipeline and build anew.

2.3.4 Natural hazard

There were no spillages due to occurrences of natural hazards.

2.3.5 Third party activity

There were three incidents caused by third parties; two resulted from malicious acts and one developed from incidental (prior) damage.

Roughly 10 m^3 of condensate was spilt after a 12 mm deep dent in a pipeline developed a 10 mm long crack. The crack was caused by metal fatigue due to stresses focused by the dent and cycling pipeline pressures. The cause of the dent is not known for sure but an excavator which had previously made local groundworks is suspected. It took 7 days to make a final repair of the pipeline, and most of the spillage was removed by excavating the affected soil.

An act of vandalism by persons unknown at a line block valve caused the spillage of 84 m^3 gross and a subsequent fire. The pipeline was returned to service in 18 hours. Only some 9 m^3 of the spillage was recovered but in the circumstances no significant pollution was reported to have occurred.

Also due to vandalism, a spillage resulted in the loss of 485 m^3 of products. The pipeline operator noticed the loss of receipts immediately and the pipeline was shut down and secured within 5 minutes, but it took some 5 hours to reach the site and to stop the leakage completely. The pipeline returned to service in 14 hours. Due to the spillage being of light product in porous arid ground, none could be recovered.

Table 1a Details of spillage incidents 1990 (additional)

				Spillage (m^3)				Cause					
No.	Pipeline or Pump Station	Pipe Spec. mm (inch)	Commodity	Spilled	Recovered	Net	How Discovered	Category	Origin	Water Pollution /Type	Soil Pollution Area (m^2)	Estimated Cost (ECU)	Clean-up Days
4	P/L	5LB 277 x 6.35 (10.75 x 0.25)	Fuel Oil	325	314	11	P/L operator	Corrosion C(a)	Corrosion under wet insulation	River effected temporarily	Yes under-ground	800 000	6
			TOTAL	907	376	531						835 000	

Table 1b Details of spillage incidents 1991

				Spillage (m^3)				Cause					
No.	Pipeline or Pump Station	Pipe Spec. mm (inch)	Commodity	Spilled	Recovered	Net	How Discovered	Category	Origin	Water Pollution /Type	Soil Pollution Area (m^2)	Estimated Cost (ECU)	Clean-up Days
1	P/L	5LX-X52 305 x 7.14 (12 x 0.28)	Products	29	0	29	Third party	Mechanical failure A(b)	Flaw in pipe steel	No	Yes 600	Not reported	365
2	P/L	5LX-42 194 x 7.1 (7 x 0.275)	Crude Oil	20	20	0	Third party	Corrosion C(b)	Water/salt internal corrosion	No	Yes 300	30 000	Not reported
3	P/L	St 53.7/43.7 508 x 7.1/14.2 (20 x0.28/0.56)	Products	275	157	118	Auto leak detection	Mechanical Failure A(a)	Incomplete data monitoring	Stream affected temporarily	Yes 14 000	6 000 000	30 +
4	P/L	5LX-X52 254 x 5.56 (10 x 0.22)	Products	80	76	4	Third party	Corrosion C(a)	Water penetration of insulation	No	Yes 1 500	1 100 000	70
5	P/L	Line valve plug	Condensate	50	12	38	Third party	Mechanical failure A(a)	Leaking plug	No	Yes 1 200	Not yet known	30 +
6	P/L	5L-X46 219 x 4.78 (8 x 0.19)	Condensate	10	9	1	Third party	Third party E(c)	Stress crack in dent	No	Yes 30	130 000	< 30
7	P/S	Bellows of S.G. meter	Products	4	3	1	Auto leak detection sytem	Mechanical failure A(b)	Ruptured bellows	No	Yes 250	13 000	14
8	P/S	Thermal expansion valve	Products	172	104	68	Auto leak detection system	Mechanical failure A(b)	Relief valve failure	River affected temporarily	Yes 100 000	45 000	7
9	P/L	Line valve	Products	84	9	75	Auto leak detection system	Third party E(b)	Vandalism	No	No	140 000	2
10	P/L	Pig detector valve	Products	2	2	0	Third party	Mechanical failure A(b)	Gasket failure	No	No	500	7
11	P/L	5LX-42 325 x 6.35 (12.75 x 0.25)	Products	485	0	485	Pipeline operator	Third party E(b)	Vandalism	No	Yes 16 000	7 000	None
12	P/L	St 52-3 200 x 5 (8 x 0.2)	Product	100	40	60	Pressure test	Corrosion C(b)	Water/salt internal corrosion	No	Yes 10 000	-	Not reported
13	P/L	St 52-3 200 x 5 (8 x 0.2)	Product	15	5	10	Pressure test	Corrosion C(b)	Water/salt internal corrosion	No	Yes 25	-	Not reported
14	P/L	14 G 2 500 x 10 (20 x 0.4)	Crude Oil	20	7	13	Third party	Mechanical failure A(a)	Pipe damage during construction	No	Yes 4 500	450 000	>365
			TOTAL	1346	444	902						7 915 500	

Cause/Category:

A Mechanical failure
(a) Construction fault
(b) Materials fault

B Operational
(a) System malfunction
(b) Human error

C Corrosion
(a) External
(b) Internal

D Natural hazard
(a) Landslide/subsidence
(b) Flooding
(c) Other

E Third party activity
(a) Direct damage - accidental
(b) Direct damage - malicious
(c) Incidental damage

Note: The value of the European Currency Unit (ECU) at end 1991 was £0.715 and $1.343.

Table 2 Analysis of 1991 incidents

Main category	Number of incidents		Spillage in cubic metres (m^3)			Average volume per incident	
	Pipeline	Pump-station	Gross	Recovered	Net	Gross	Net
Mechanical failure	5	2	552	285	267	79	38
Operational	-	-	-	-	-	-	-
Corrosion	4	-	215	141	74	54	19
Natural hazard	-	-	-	-	-	-	-
Third party activity	3	-	579	18	561	193	187
Total	12	2	1346	444	902	96	64

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report no. 2/93

performance of oil industry cross-country pipelines in western europe

statistical summary of reported spillages - 1992

Prepared by the CONCAWE Oil Pipelines Management Group's Special Task Force on Oil Pipeline Spillages (OP/STF-1)

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2. PIPELINE PERFORMANCE

2.1 GENERAL DATA

The total length of oil industry cross-country pipelines in operation in Western Europe at the end of 1992 was reported by the 66 respondents to be 21 500 km. The pipeline network consists of about 215 separate lines. The reported length is some 500 km more than in 1991 with newly added product pipelines in Belgium, Spain and the UK. In total, 596 million m^3 of crude oil and refined products was transported through the pipeline system. This resulted in a total traffic volume of 105 x 10^9 m^3 km, of which products amounted to almost 26 x 10^9 m^3 km.

2.2 DETAILS OF SPILLAGE INCIDENTS

In 1992, seven incidents were recorded in which reportable oil spillages occurred. Consistent with the approach used for the previous reports, causes have been categorized as shown in the footnote to **Table 1** and further tabulated by category and volume in **Table 2**. Total net loss to the environment was 430 m^3. The volume recovered amounted to 374 m^3, equivalent to 47% of the gross volume spilled (804 m^3). The combined cost of pipeline repair and clean-up was reported to be about 0.6 million ECUs.

Of the six incidents where the action taken on clean-up was reported, two incidents required little to be done. In one incident achieving a high spillage recovery was straightforward and in two incidents the high recoveries resulted from more sustained clean-up efforts. In just one incident, significant pollution of soil and a river occurred but the clean-up was quickly done and the environmental effects were temporary. None of the spillages affected potable water supplies, nor were there any injuries to people.

Effectiveness of clean-up efforts

Spillage recovery (%)	No. of incidents
100	1
76 - 99	2
51 - 75	0
26 - 50	0
1 - 25	2
0	2

Clean-up time

Time taken	No. of incidents
Less than one day	2
Two days up to one week	2
Over one week up to one month	1
Longer than one month	1
Not reported	1

2.3 CAUSES

For 1992, the 7 reported spillages of 1 m^3 gross or more are categorized as follows.

2.3.1 Mechanical failure

Two of the 1992 incidents are categorized as mechanical failure.

A 128 m^3 gross spillage of product occurred due to the failure of a cathodic protection insulating joint on a pipeline section isolation valve. The failure occurred during a routine line packing operation at a pressure well below the maximum allowable pressure. The pipeline was repaired and back in service in one day. The spillage ran into a river which was cleaned up using booms to collect the oil which was then sucked out, recovering some 30 m^3. Oil-contaminated soil at the spillage site was removed and taken to a waste disposal site. The pipeline company is paying for restocking fish in the river. A programme of changing the insulating joints of all similar valves is underway.

Shortly after its installation following recalibration, a pressure safety valve in a pumpstation failed resulting in a gross spillage of 113 m^3 of product. The spillage was discovered by a pipeline maintenance official who observed oil entering the pumpstation's oil/water separator. The pipeline was put back in service in half a day. The spilled oil overflowed the separator, finding its way into the clean-water drain which led to oil reaching an estuary. The clean-up operation recovered some 105 m^3 of the spilled product.

2.3.2 Operational

Following a manual operation to change filter elements in a filter at a pumpstation a 2" drain valve was not closed. When pipeline pumping started a product spillage of 275 m^3 gross occurred. The control room operator was not immediately alerted to the problem because the high level alarm system on the sump tank failed to activate. The clean-up operation recovered some 27 m^3 of the spillage.

2.3.3 Corrosion

There were two spillages due to external corrosion.

A gross spillage of nearly 13 m^3 occurred at a point where a dead-leg at a road crossing remained after a pipeline relocation which was carried out some 27 years ago. The girth weld of the closure plate at the end of the dead-leg had corroded externally because the ends of the cut-off section had been inadequately coated. Some 12 m^3 of crude oil was recovered during the spillage clean-up.

A 200 m^3 gross spillage occurred due to external corrosion under a pipeline's heat insulation at a faulty join in the polyethylene sheathing. The pipeline was out of service for a week for repairs. The crude oil and fuel oil spilt was reported as totally cleaned up.

2.3.4 Natural hazard

There were no spillages due to occurrences of natural hazards.

2.3.5 Third party activity

There were two incidents caused by third parties, both developed from incidental (prior) damage.

A 50 m^3 gross spillage occurred during a pressure test while the pipeline was filled with product. The site of the leak was found to be at a point where the pipeline had been damaged by machinery some time previously. As the pipeline had been inspected using a magnetic flux intelligence pig four years ago, it is assumed that the damage occurred since then. The repair was completed before the pipeline was scheduled to resume pumping product so no lost time was incurred. Oil contaminated soil was moved to a waste tip, but no oil was reported to have been recovered.

Also during the same pressure test, a gross spillage of 25 m^3 occurred at another location but otherwise the circumstances were identical. It is suspected that the damage was done during previous ground levelling works.

Table 1 Details of spillage incidents 1992

				Spillage (m^3)				Cause					
No.	Pipeline or Pump Station	Pipe Spec. mm (inch)	Commodity	Spilled	Recovered	Net	How Discovered	Category	Origin	Water Pollution /Type	Soil Pollution Area (m^2)	Estimated Cost (ECU)	Clean-up Days
1	P/L	Line valve insulating joint	Products	128	30	98	Routine monitoring P/L operator	Mechanical failure A(b)	Insulating joint failure	River affected temporarily	Yes 5 400	450 000	4
2	P/S	Pressure safety valve	Products	113	105	8	Pipeline maintenance official	Mechanical failure A(b)	Safety valve failure	Estuary affected temporarily	No	2 000	3
3	P/S	Filter 2" drain valve	Products	275	27	248	Routine monitoring P/L operator	Operational B(b)	2" valve left open	No	Yes 1 100	19 000	Not reported
4	P/L	5LX-42 200 x 6.35 (8 x 0.25)	Products	50	0	50	Pressure test	Third party E(c)	Pipeline previously hit by machinery	No	Yes 20	1 400	1
5	P/L	5LX-42 200 x 6.35 (8 x 0.25)	Products	25	0	25	Pressure test	Third party E(c)	Pipeline previously hit by machinery	No	Yes 60	1 400	1
6	P/L	24" Closure plate weld	Crude oil	13	12	1	Third party	Corrosion C(a)	External corrosion of girth weld	No	Yes 250	140 000	83
7	P/L	5 LS 200 x 4.73 8 x 0.19	Crude oil and fuel oils	200	200	0	Third party	Corrosion C(a)	External corrosion under heat insulation	No	Yes 300	16 000	< 30
			TOTAL	804	374	430						629 800	

Cause/Category:

A Mechanical failure
(a) Construction fault
(b) Materials fault

B Operational
(a) System malfunction
(b) Human error

C Corrosion
(a) External
(b) Internal
(c) Other

D Natural hazard
(a) Landslide/subsidence
(b) Flooding

E Third party activity
(a) Direct damage - accidental
(b) Direct damage - malicious
(c) Incidental damage

Note: The value of the European Currency Unit (ECU) at end 1992 was £0.777 and $1.2.

Table 2 Analysis of 1992 incidents

Main category	Number of incidents		Spillage in cubic metres (m^3)			Average volume per incident	
	Pipeline	Pump-station	Gross	Recovered	Net	Gross	Net
Mechanical failure	1	1	241	135	106	120	53
Operational	-	1	275	27	248	275	248
Corrosion	2	-	213	212	1	106	1
Natural hazard	-	-	-	-	-	-	-
Third party activity	2	-	75	0	75	37	37
Total	5	2	804	374	430	115	61

concawe

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statistical summary of reported spillages - 1993

Prepared by the CONCAWE Oil Pipelines Management Group's Special Task Force on Oil Pipeline Spillages (OP/STF-1)

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2. PIPELINE PERFORMANCE

2.1. GENERAL DATA

The total length of oil industry cross-country pipelines in operation in Western Europe at the end of 1993 was reported by the 63 respondents to be 21 600 km. The pipeline network consists of about 215 separate lines. The reported length is some 100 km more than in 1992 due to the inclusion of a new pipeline in Spain. In total, 601 million m^3 of crude oil and refined products was transported through the pipeline system. This resulted in a total traffic volume of 104×10^9 m^3 km, of which products amounted to 25.4×10^9 m^3 km.

2.2. DETAILS OF SPILLAGE INCIDENTS

In 1993, ten incidents were recorded in which reportable oil spillages occurred. Consistent with the approach used for the previous reports, causes have been categorized as shown in the footnote to **Table 1** and further tabulated by category and volume in **Table 2**. Total net loss to the environment was 2536 m^3. The volume recovered amounted to 3429 m^3, equivalent to 57% of the gross volume spilled (5965 m^3). The combined cost of pipeline repair and clean-up has not yet been been fully accounted for, with the costs of 3 incidents not yet reported. However, the 8.6 million ECUs reported so far already exceeds the previous highest figure which was in 1991.

Of the ten incidents in 1993, five have required extensive and costly clean-up programmes to be instituted. In at least 5 cases, clean-up was still underway at the time of this report. One of the spillages affected potable water supplies. None of the incidents involved injuries to people.

Effectiveness of clean-up efforts %

Spillage recovery (%)	No. of incidents
100	1
76 - 99	1
51 - 75	2
26 - 50	1
1 - 25	4
0	1

Clean-up time

Time taken	No. of incidents
Less than one day	2
Two days up to one week	0
Over one week up to one month	0
Longer than one month	8
Not reported	0

2.3. CAUSES

The additional 1992 spillage is categorized as resulting from a natural hazard, namely flooding of the region, causing displacement of the earth around the pipeline leading to a circumferential crack in the pipewall. A spillage of about 75 m^3 gross of heating oil occurred. No recovery of the spillage was reported, nor could any specific details of oil clean-up be distinguished from the general repair of the flood damage which was widespread. The pipeline was out of service for nearly three months. The spilled oil affected the local soil for less than six months.

For 1993, the ten reported spillages of 1 m^3 gross or more are categorized as follows.

2.3.1. Mechanical failure

Two of the 1993 incidents are categorized as mechanical failure.

A 248 m^3 gross spillage of crude oil occurred due to the failure of the pipewall at a point where a metallurgical blemish had been in existance since the pipe was manufactured. The blemish had acted as a focus for the stresses from operating pressure fluctations throughout 31-years of service resulting in fatigue failure causing a longitudinal split. The failure occurred while pressure testing the pipeline at 110% of the maximum operating pressure for a statutary 10-year test. The pipeline is not currently required in operation and has not been used since the incident. The spillage affected a large area of ground and resulted in substantial oiling of subsoil. A long-term oil containment and recovery programme has been instituted which has removed about 230 m^3 of the oil. The clean-up, which also includes the promotion of biodegradation, was still in progress more than six months after the event.

A 3 m^3 gross spillage occurred due to the failure of a gasket in a joint of a fitting located in a pump station. The operating pressure at the time was well below the pipeline test pressure. Virtually all of the spillage was recovered by the oil/water separator at the pump station.

2.3.2. Operational

There were no spillages in the operational category in 1993.

2.3.3. Corrosion

There were three spillages due to corrosion; two from internal and the other from external corrosion.

A gross spillage of about 14 m^3 occurred at a point where the pipeline runs under a road in a pipe duct. Some months earlier, the existance of external corrosion at the location had been identified by a metal loss detection intelligence pig. A plan to replace the affected section was in hand. Regular monitoring of the pipe in case of small leaks using an ultrasound pig indicated a very small leak, intermittantly plugging and unplugging. The corrosion was caused by adverse underground conditions with the pipeline in contact with groundwater flows. The pipeline was out of service for 10 days while the road-crossing section was replaced. Short-term measures recovered about 1 m^3 of the spilled oil and a long-term (>6 months) programme of in-situ remediation is underway to fully restore the site.

Internal corrosion in a bypass loop line at a river crossing caused a 580 m^3 gross spillage. The pipeline was previously inspected with intelligence pigs but the bypass, of smaller diameter than the principle pipeline, could not be so inspected. The dead-leg formed by the bypass has now been eliminated. About 80 m^3 of product has been recovered so far by the clean-up operation, and longer term actions to monitor and recover underground contamination are in progress.

A large spillage of roughly 2000 m^3 of crude oil occurred at a motorway crossing, when a pipeline split at a site of internal corrosion. The motorway had to be closed for a period. Immediate clean-up activities and extensive soil removal have removed some 1500 m^3 of the spill, and longer term measures to deal with widespread subsoil contamination have been put into effect. The duration of the clean-up and the costs are not yet known but clearly the final figure will be high, above any other so far recorded in Europe.

2.3.4. Natural hazard

There was one spillage in 1993 due to the effects of a natural hazard event.

A 10 m^3 gross spillage occurred from a pipeline in mountainous terrain due to earth movement associated with heavy rain which also resulted in regional flooding in lower lying areas. The movement caused cold bending of the pipeline leading to a hairline crack over part of its circumference on the outside of the bend. As well as local soil pollution, some groundwater contamination occurred and precautions were taken to protect drinking water. The clean-up involved forming shallow channels and collecting oil flushed out by water washing. Some contaminated soil was removed and safely disposed of off site. By these means some 3 m^3 of the spillage was recovered.

2.3.5. Third party activity

There were four incidents caused by third parties, two through direct accidental damage and two developed from incidental damages.

A 49 m^3 gross spillage of gasoline occurred after a pipeline ruptured when hit by a machine laying agricultural drain pipes. At least 10 m^3 of the spill has been recovered and disposed of. However, the contamination of subsoil was widespread and the longer term activities put in hand to fully restore the surrounding area are not yet reported completed.

A small hole was burned in a pipeline by a strong electrical current arcing through the soil following an accident to an overhead 132kV electric power transmission cable. The cable was brought down during a tree-felling operation to remove a tree which was interfering with a railway line. Some 8 m^3 of product leaked out but in the absense of any water courses was closely contained and the soil could be decontaminated over a period of time using routine techniques. About 2 m^3 of product was recovered.

A pipeline which was found to have been previously scraped by some sort of machine leaked 3m^3 of product when a small hole formed where the pipewall thickness had been reduced. Almost none of the oil could be recovered.

A split developed progressively due to fatigue focussed at a point where a pipeline had been struck by an unknown machine at some time in the past. A very large spillage, some 3050 m^3 gross, accumulated as an initially small rate of leakage grew progressively over several months until it became sizeable enough to be picked up by the installed measurement and integrity controls. A total of some 1600 m^3 of petroleum products is expected to be recovered/safely disposed of. Extensive operations are in progress to scavenge the subsurface oil being collected in boreholes, and venting with air associated with bioremediation measures will be continued until the area recovers.

Table 1 Details of 1992 (additional) and 1993 spillage incidents

No.	Pipeline or Pump Station	Pipe Spec. mm (inch)	Commodity	Spillage (m^3) Spilled	Recovered	Net	Cause How Discovered	Category	Origin	Water Pollution /Type	Soil Pollution Area (m2)	Estimated Cost (ECU)	Clean-up Days
1992													
8	P/L	5LX-X52 320 x * 12" x *	Product	75	-	75	Third party	Natural hazard D(b)	Flood/ earth movement	No	Yes N/A	N/A	>30
			TOTAL	879	374	505						629 800	
1993													
1	P/L	5L-X52 864 x 7.92 34" x 0.31"	Crude oil	248	230	18	Pressure test	Mechanical failure A(a)	Original tube blemish	No	Yes 45 000	1 200 000	>180
2	P/L	St 53.7 480 x 6.6 18" x 0.26"	Products	14	1	13	Ultrasonic inspection pig	Corrosion C(a)	External corrosion at road crossing	No	Yes 400	N/A	>180
3	P/L	5LX-52 600 x 7.92 24" x 0.31"	Products	49	10	39	Third party	Third party E(a)	Pipeline hit by drain laying machine	No	Yes 10 000	4 500 000	>180
4	P/S	Fitting	Products	3	3	0	Third party	Mechanical failure A(b)	Gasket failed	No	Yes 80	1 000	1
5	P/L	5LX-42 320 x 6.35 12.75" x 0.25"	Products	580	80	500	Right of way inspection P/L operator	Corrosion C(b)	Internal corrosion of by-pass line	No	Yes 800	N/A	>180
6	P/L	5 LX-42 170 x 5.16 6.625" x 0.20	Products	3	0	3	Third party	Third party E(c)	Prior damage by trenching machine	No	Yes 6	1 250	1
7	P/L	X-55 507 x 8.74 20" x 0.35"	Products	3050	1600	1450	Routine monitoring P/L operator	Third party E(c)	Prior damage by unknown machine	No	Yes N/A	2 000 000	>180
8	P/L	St 52-3/E 360.7 507 x 8 20" x 0.315"	Crude oil	2000	1500	500	Routine monitoring P/L operator	Corrosion C(b)	Internal corrosion	No	Yes 25 000	N/A (high)	90
9	P/L	LX-X52 220 x 4.78 8.625" x 0.19"	Product	8	2	6	Third party	Third party E(a)	Accident to electric cable	No	Yes 50	260 000	200
10	P/L	LX-X52 660 x 7.14 26" x 0.285"	Product	10	3	7	Third party	Natural Hazard D(a)	Earth movement due to heavy rain	Yes	Yes N/A	880 000	90
			TOTAL	5965	3429	2536						8 842 250	

Cause/Category:

A Mechanical failure
(a) Construction fault
(b) Materials fault

B Operational
(a) System malfunction
(b) Human error

C Corrosion
(a) External
(b) Internal

D Natural hazard
(a) Landslide/subsidence
(b) Flooding
(c) Other

E Third party activity
(a) Direct damage - accidental
(b) Direct damage - malicious
(c) Incidental damage

Notes: The value of the European Currency Unit (ECU) at end 1993 was £0.76 and $1.13
N/A = Not available.
* = Not reported

Table 2 Analysis of 1993 incidents

Main category	Number of incidents		Spillage in cubic metres (m^3)			Average volume per incident	
	Pipeline	Pump-station	Gross	Recovered	Net	Gross	Net
Mechanical failure	2	-	251	233	18	125	9
Operational	-	-	-	-	-	-	-
Corrosion	3	-	2594	1581	1013	865	338
Natural hazard	1	-	10	3	7	10	7
Third party activity	3	1	3110	1612	1498	777	374
Total	9	1	5965	3429	2536	597	254