# 4 Review of UKOPA Incidents

## 4.1 Introduction

UKOPA (United Kingdom Onshore Pipeline Association) is a cooperation of fifteen UK gas and oil pipeline operators and the UK HSE. One of the aims of UKOPA is to collate pipeline and product loss incident data from the onshore Major Accident Hazard Pipelines (MAHPs). There are nearly 22,000 km of MAHPs in the UK with 20,000 km transporting natural gas above 7 bar, 1,000 km transporting ethylene and the remainder transporting spiked crude oil, LNG and other hydrocarbons. UKOPA's Pipeline Fault Database covers pipeline loss incidents from 1962 to the present day and is currently maintained by GL. In addition to product loss incidents, the UKOPA database also captures information on damage incidents resulting in no product loss.

Section 4.2 presents some general trends for all the data from 1962 to the latest available data (2008) and Section 4.3 discusses the applicability of this data to this incident review

## 4.2 General Trends

In this section, summary tables are presented for the 2869 incidents captured in the UKOPA database; this includes both product loss incidents (248 incidents) and incidents that result in part-wall damage to the pipeline (2,621 incidents). The 5th UKOPA report, [15], documents 174 product loss incidents between 1962 and 2006; these incidents are a subset of the incidents below, as incidents to fittings are excluded from the UKOPA summary.

### 4.2.1 Incidents by Cause and Year of Occurrence

Table 31 below presents the number of incidents split by failure/damage mechanism and the year of occurrence. Detailed information is less readily available for incidents prior to 1970 and this is reflected in the small number of incidents for this time period.

| Cause | Decade of Occurrence | | | | | Total | |
|---|---|---|---|---|---|---|---|
| | 1960-1969 | 1970-1979 | 1980-1989 | 1990-1999 | 2000-2008 | | |
| External Corrosion | 0 | 52 | 402 | 198 | 268 | 920 | *32.1%* |
| Internal Corrosion | 0 | 1 | 3 | 22 | 0 | 26 | *0.9%* |
| External Interference | 17 | 231 | 222 | 109 | 56 | 635 | *22.1%* |
| Pipe Defect | 3 | 40 | 164 | 26 | 8 | 241 | *8.4%* |
| Girth Weld Defect | 2 | 12 | 54 | 23 | 57 | 148 | *5.2%* |
| Seam Weld Defect | 0 | 3 | 9 | 4 | 3 | 19 | *0.7%* |
| Ground Movement | 0 | 8 | 10 | 6 | 4 | 28 | *1.0%* |
| Damage during construction | 0 | 14 | 120 | 54 | 25 | 213 | *7.4%* |
| Pipe Mill Damage | 0 | 0 | 59 | 35 | 28 | 122 | *4.3%* |
| Other | 11 | 116 | 162 | 40 | 59 | 388 | *13.5%* |
| Unknown | 0 | 41 | 27 | 11 | 50 | 129 | *4.5%* |
| Total | 33 | 518 | 1232 | 528 | 558 | 2869 | *100%* |
| | *1.2%* | *18.1%* | *42.9%* | *18.4%* | *19.4%* | *100%* | |

Table 31: Number of incidents by cause and year of occurrence

The table above demonstrates that the most significant causes of failure/damage are external corrosion and external interference (or third party damage).

### 4.2.2 Incidents by Vintage

Table 32 presents the number of incidents by failure type and the age of the pipeline. Table 33 presents the number of incidents by failure type and the year of pipeline installation. The product loss incidents are separated into ruptures and leaks and the damage incidents are separated into "severe" and "slight".

The UKOPA database defines a rupture as a hole with a cross-sectional area greater than the cross-sectional area of the pipeline. The leak column in the tables below captures all sizes of leaks from pin-holes to punctures. The tables below use the categorisation assigned to the incident as used by the person completing the incident report.

In 17.8% of cases, there is insufficient evidence available at the time of recording to categorise the incident and these are recorded in the "Other" column.

| Age of pipeline | Failure type | | | | | Total | |
|---|---|---|---|---|---|---|---|
| | Pipeline Failure (product loss) | | Pipeline Damage (no product loss) | | Other | | |
| | Rupture | Leak | Severe | Slight | | | |
| <1 | 1 | 2 | 0 | 6 | 3 | 12 | *0.4%* |
| 1 to 5 | 2 | 35 | 17 | 110 | 42 | 206 | *7.2%* |
| 6 to 10 | 0 | 28 | 52 | 281 | 25 | 386 | *13.5%* |
| 11 to 15 | 4 | 28 | 46 | 466 | 47 | 591 | *20.6%* |
| 16 to 20 | 2 | 19 | 88 | 329 | 39 | 477 | *16.6%* |
| 21 to 25 | 1 | 33 | 57 | 184 | 20 | 295 | *10.3%* |
| 26 to 30 | 3 | 48 | 57 | 160 | 12 | 280 | *9.8%* |
| 31 to 35 | 3 | 24 | 59 | 145 | 28 | 259 | *9.0%* |
| 36 to 40 | 1 | 3 | 92 | 99 | 37 | 232 | *8.1%* |
| 41 to 45 | 0 | 4 | 21 | 81 | 5 | 111 | *3.9%* |
| 46 to 50 | 0 | 1 | 1 | 4 | 0 | 6 | *0.2%* |
| >50 | 1 | 2 | 4 | 2 | 0 | 9 | *0.3%* |
| Unknown | 0 | 3 | 0 | 2 | 0 | 5 | *0.2%* |
| Total | 18 | 230 | 494 | 1869 | 258 | 2869 | *100%* |
| | *6.7%* | *2.3%* | *8.0%* | *65.1%* | *17.8%* | *100%* | |

Table 32: Number and percentage distribution of incidents by vintage and failure type

| Year of Installation | Failure type | | | | | Total | |
|---|---|---|---|---|---|---|---|
| | Pipeline Failure (product loss) | | Pipeline Damage (no product loss) | | Other | | |
| | Fracture | Leak | Severe | Slight | | | |
| <1960 | 7 | 68 | 46 | 38 | 6 | 165 | *5.8%* |
| 1960 to 1969 | 9 | 138 | 346 | 1235 | 174 | 1902 | *66.3%* |
| 1970 to 1979 | 2 | 19 | 76 | 517 | 68 | 682 | *23.8%* |
| 1980 to 1989 | 0 | 2 | 4 | 17 | 2 | 25 | *0.9%* |
| 1990 to 1999 | 0 | 0 | 20 | 58 | 7 | 85 | *3.0%* |
| 2000 to 2007 | 0 | 0 | 2 | 2 | 1 | 5 | *0.2%* |
| Unknown | 0 | 3 | 0 | 2 | 0 | 5 | *0.2%* |
| Total | 18 | 230 | 494 | 1869 | 258 | 2869 | *100%* |
| | *0.6%* | *8.0%* | *17.2%* | *65.1%* | *9.0%* | *100%* | |

Table 33: Number and percentage distribution of incidents by year of installation and failure type

Table 33 demonstrates that there have been no product loss incidents, either leak or rupture, on pipelines constructed since 1990.

### 4.2.3 Incidents by Failure Type and Failure Cause

Table 34 presents the number of incidents recorded in the UKOPA database by failure type and failure cause. As in the previous section, product loss incidents are split into ruptures and leaks and damage incidents are split into "severe" and "slight". There are 9% of incidents which had insufficient evidence at the time of recording to categorise the damage; these have been captured as "other".

| Cause | Failure type | | | | | Total | |
|---|---|---|---|---|---|---|---|
| | Pipeline Failure (product loss) | | Pipeline Damage (no product loss) | | Other | | |
| | Rupture | Leak | Severe | Slight | | | |
| External Corrosion | | 37 | 183 | 685 | 15 | 920 | *32.1%* |
| Internal Corrosion | | 2 | 7 | 21 | | 30 | *1.0%* |
| External Interference | 12 | 30 | 107 | 403 | 83 | 635 | *22.1%* |
| Pipe Defect | | 12 | 15 | 210 | 4 | 241 | *8.4%* |
| Girth Weld Defect | | 34 | 58 | 34 | 22 | 148 | *5.2%* |
| Seam Weld Defect | | 3 | 7 | 8 | 1 | 19 | *0.7%* |
| Ground Movement | 3 | 7 | 4 | 6 | 8 | 28 | *1.0%* |
| Damage during construction | | | 43 | 122 | 48 | 213 | *7.4%* |
| Pipe Mill Damage | | | 12 | 103 | 7 | 122 | *4.3%* |
| Other | 2 | 92 | 51 | 188 | 51 | 384 | *13.4%* |
| Unknown | 1 | 13 | 7 | 89 | 19 | 129 | *4.5%* |
| Total | 18 | 230 | 494 | 1869 | 158 | 2869 | *100%* |
| | *0.6%* | *8.0%* | *17.2%* | *65.1%* | *9.0%* | *100%* | |

Table 34: Number of incidents by failure mode and cause of failure

Table 34 indicates that less than 10% of all product loss incidents result in a rupture based on the text entry supplied in the database. Alongside this text entry, for the majority of product loss incidents, is information on the cross-sectional area of the hole. Table 35 below presents the product loss incidents in terms of the ratio of the release cross-sectional hole area to the pipeline cross-sectional area. Under these circumstances, based on the definition of rupture within the UKOPA database, all ruptures should have a ratio greater than one.

As Table 35 below demonstrates, there are 10 product loss incidents categorised as ruptures that have a cross-sectional area of release smaller than the cross-sectional area of the pipeline. It may be appropriate to re-categorise these incidents as leaks in the trend analysis.

| Ratio of hole area to pipeline cross-sectional area | Release type | | Total | |
|---|---|---|---|---|
| | Rupture | Leak | | |
| < 1E-05 | 0 | 6 | 6 | *2.4%* |
| 1E-05 to 0.99E-04 | 0 | 43 | 43 | *17.3%* |
| 1E-04 to 0.99E-03 | 0 | 81 | 81 | *32.7%* |
| 1E-03 to 0.99E-02 | 3 | 60 | 63 | *25.4%* |
| 1E-02 to 0.99E-01 | 5 | 21 | 26 | *10.5%* |
| 1E-01 to 0.99 | 2 | 3 | 5 | *2.0%* |
| >= 1 (full bore rupture) | 7 | 0 | 7 | *2.8%* |
| Unknown | 1 | 16 | 17 | *6.9%* |
| Total | 18 | 230 | 248 | *100%* |
| | *7.3%* | *92.7%* | *100%* | |

Table 35: Number of product loss incidents by ratio of hole area to pipeline cross-sectional area

### 4.2.4 Incidents by Failure Mode and Diameter

Table 36 below presents the number of incidents recorded in the UKOPA database for a series of pipeline diameter ranges. The table below use the rupture/leak categorisation assigned to the incident as discussed above. The majority of pipelines captured in the UKOPA database are for the UK transmission and distribution networks and these networks do not include any pipelines greater than 48 inch diameter. The table below indicates that 76% of incidents occur on pipelines greater than 10 inches; however, without information on the distribution of diameter within the overall pipeline population it is unclear whether this is directly correlated to the mileage of pipeline in each category.

| Diameter (in) | Failure type | | | | | Total | |
|---|---|---|---|---|---|---|---|
| | Pipeline Failure (product loss) | | Pipeline Damage (no product loss) | | Other | | |
| | Rupture | Leak | Severe | Slight | | | |
| < 2 | 0 | 0 | 1 | 0 | 0 | 1 | *0.0%* |
| 2 to 4 | 1 | 11 | 24 | 16 | 2 | 54 | *1.9%* |
| 4 to 6 | 2 | 33 | 25 | 80 | 1 | 141 | *4.9%* |
| 6 to 8 | 6 | 45 | 35 | 80 | 7 | 173 | *6.0%* |
| 8 to 10 | 1 | 55 | 85 | 135 | 37 | 313 | *10.9%* |
| 10 to 20 | 5 | 66 | 209 | 714 | 124 | 1118 | *39.0%* |
| 20 to 48 | 3 | 20 | 115 | 844 | 87 | 1069 | *37.3%* |
| Total | 18 | 230 | 494 | 1869 | 258 | 2869 | *100%* |
| | *0.6%* | *8.0%* | *17.2%* | *65.1%* | *9.0%* | *100%* | |

Table 36: Number of incidents by failure mode and diameter

### 4.2.5 Incidents by Failure Cause and Wall Thickness

Table 37 below presents the number of incidents recorded in UKOPA for each wall thickness of pipeline against failure cause. The largest number of incidents is observed as occurring on pipelines with a wall thickness of between 0.25 inches and 0.5 inches. However, without information on the distribution of wall thicknesses in the overall pipeline population it is unclear whether this is directly correlated to the mileage of pipeline in each category.

| Failure Cause | Wall thickness (inches) | | | Total | |
|---|---|---|---|---|---|
| | < 0.25 | 0.25 - 0.5 | 0.5 -1 | | |
| External Corrosion | 161 | 546 | 213 | 920 | *32.1%* |
| Internal Corrosion | 16 | 11 | 3 | 30 | *1.0%* |
| External Interference | 101 | 443 | 91 | 635 | *22.1%* |
| Pipe Defect | 8 | 145 | 88 | 241 | *8.4%* |
| Girth Weld Defect | 32 | 90 | 26 | 148 | *5.2%* |
| Seam Weld Defect | 0 | 17 | 2 | 19 | *0.7%* |
| Ground Movement | 0 | 19 | 9 | 28 | *1.0%* |
| Damage during construction | 14 | 160 | 39 | 213 | *7.4%* |
| Pipe Mill Damage | 15 | 96 | 11 | 122 | *4.3%* |
| Other | 56 | 233 | 95 | 384 | *13.4%* |
| Unknown | 41 | 57 | 31 | 129 | *4.5%* |
| Total | 444 | 1817 | 608 | 2869 | *100%* |
| | *15.5%* | *63.3%* | *21.2%* | *100%* | |

Table 37: Number of incidents by failure cause and wall thickness

Another factor often considered by engineers in the design of the pipeline is the ratio of pipe diameter (D) to wall thickness (t). Therefore, Table 38 considers how the number of incidents varies with the D/t ratio.

| D/t Ratio | Failure type | | | | Other | Total | |
|---|---|---|---|---|---|---|---|
| | Pipeline Failure (product loss) | | Pipeline Damage (no product loss) | | | | |
| | Rupture | Leak | Severe | Slight | | | |
| < 2 | 0 | 0 | 1 | 0 | 0 | 1 | *0.0%* |
| 2 to 20 | 1 | 11 | 24 | 16 | 2 | 54 | *1.9%* |
| 20 to 40 | 2 | 33 | 25 | 80 | 1 | 141 | *4.9%* |
| 40 to 60 | 6 | 45 | 35 | 80 | 7 | 173 | *6.0%* |
| 60 to 80 | 1 | 55 | 85 | 135 | 37 | 313 | *10.9%* |
| > 80 | 5 | 66 | 209 | 714 | 124 | 1118 | *39.0%* |
| Unknown | 3 | 20 | 115 | 844 | 87 | 1069 | *37.3%* |
| Total | 18 | 230 | 494 | 1869 | 258 | 2869 | *100%* |
| | *0.6%* | *8.0%* | *17.2%* | *65.1%* | *9.0%* | *100%* | |

Table 38: Number of incidents by failure mode and diameter/wall thickness ratio

### 4.2.6 Incidents by Pipe Location and Damage Location

Table 39 indicates that in the UKOPA database 96% of incidents recorded are located below ground on the pipeline or associated fittings. The remaining incidents are shown in Table 39 to be located at crossings or within compounds.

| Location of Damage | Location of Pipe | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Below Ground | Compound | Rail Crossing | River Crossing | Road Crossing | Other | | |
| Bend | 127 | | | | | 1 | 128 | *4.5%* |
| Other | 52 | 1 | | | 1 | 2 | 56 | *2.0%* |
| Pig Trap | 3 | 2 | | | | | 5 | *0.2%* |
| Pipe | 2464 | 23 | 6 | 9 | 12 | 10 | 2524 | *88.0%* |
| Sleeve | 27 | | | | | | 27 | *0.9%* |
| Tee | 20 | | | | | | 20 | *0.7%* |
| Valve | 40 | 5 | | | | 6 | 51 | *1.8%* |
| Unknown | 32 | 8 | | 14 | | 4 | 58 | *2.0%* |
| Total | 2765 | 39 | 6 | 23 | 13 | 22 | 2869 | *100%* |
| | *96.4%* | *1.4%* | *0.2%* | *0.8%* | *0.5%* | *0.8%* | *100%* | |

Table 39: Number of incidents by pipe and damage location

### 4.2.7 Incidents by Fuel Type and Failure Cause

The UKOPA data stores incident data for 22,000km of UK's major accident hazard pipelines. As discussed in Section 4.1, 91% of these pipelines are transporting natural gas above 7 bar, 4.5% of pipelines transport ethylene and the remaining pipelines are transporting other fuels. Table 40 separates out by cause the number of incidents that have occurred in terms of the fuel transported within the pipeline. From Table 40 the highest number (85%) of incidents is recorded on natural gas pipelines and 9% of incidents are recorded on ethylene pipelines. This is a direct correlation to the pipeline lengths stored for each fuel type.

| Cause | Fuel Type | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | Natural Gas (Dry) | Ethylene | Crude Oil - Spiked | Propylene | CO | Crude Oil - Dead | Other | | |
| External Corrosion | 723 | 98 | 60 | 30 | 9 | | | 920 | *32.1%* |
| Internal Corrosion | 7 | 5 | 1 | | 14 | 3 | | 30 | *1.0%* |
| External Interference | 606 | 27 | 1 | | | | 1 | 635 | *22.1%* |
| Pipe Defect | 235 | 6 | | | | | | 241 | *8.4%* |
| Girth Weld Defect | 146 | | 2 | | | | | 148 | *5.2%* |
| Seam Weld Defect | 19 | | | | | | | 19 | *0.7%* |
| Ground Movement | 26 | 2 | | | | | | 28 | *1.0%* |
| Damage during original construction | 173 | 33 | 2 | | | 4 | 1 | 213 | *7.4%* |
| Pipe Mill Damage | 87 | 34 | 1 | | | | | 122 | *4.3%* |
| Other | 338 | 41 | 4 | | 1 | | | 384 | *13.4%* |
| Unknown | 86 | 24 | 1 | 14 | 4 | | | 129 | *4.5%* |
| Total | 2446 | 270 | 72 | 44 | 28 | 7 | 2 | 2869 | *100%* |
| | *85.3%* | *9.4%* | *2.5%* | *1.5%* | *1.0%* | *0.2%* | *0.0%* | *100%* | |

Table 40: Number of incidents by fuel type and failure cause

### 4.2.8 Incidents by Stress Level and Failure Mode

Table 41 below records the number of incidents for each stress range. This has been calculated from the incident pressure, the material grade, the pipeline diameter and the wall thickness. This data indicates that 83% of ruptures have occurred at stress levels lower than 30% SMYS.

| Stress Range, %SMYS | Failure type | | | | Other | Total | |
|---|---|---|---|---|---|---|---|
| | Pipeline Failure (product loss) | | Pipeline Damage (no product loss) | | | | |
| | Fracture | Leak | Severe | Slight | | | |
| 0-9.9% | 6 | 75 | 81 | 282 | 38 | 482 | *16.8%* |
| 10-19.9% | 7 | 85 | 139 | 583 | 84 | 898 | *31.3%* |
| 20-29.9% | 2 | 30 | 123 | 447 | 49 | 651 | *22.7%* |
| 30-39.9% | 1 | 5 | 13 | 149 | 19 | 187 | *6.5%* |
| 40-49.9% | 1 | 8 | 13 | 114 | 17 | 153 | *5.3%* |
| 50-59.9% | 0 | 1 | 38 | 76 | 36 | 151 | *5.3%* |
| 60-69.9% | 0 | 0 | 25 | 73 | 1 | 99 | *3.5%* |
| >70% | 0 | 0 | 2 | 0 | 1 | 3 | *0.1%* |
| Unknown | 1 | 26 | 60 | 145 | 13 | 245 | *8.5%* |
| Total | 18 | 230 | 494 | 1869 | 258 | 2869 | *100%* |
| | *0.6%* | *8.0%* | *17.2%* | *65.1%* | *9.0%* | 100% | |

Table 41: Number of incidents by stress range and failure mode

## 4.3 Applicability of Data

The UKOPA database stores both product loss and damage data for UK pipelines from 1962 to the present day. The database is generally well populated and the reliability of the data entries is good.