PIPELINE AND RISER LOSS OF CONTAINMENT 2001 – 2012 (PARLOC 2012)

6TH EDITION of PARLOC REPORT SERIES

March 2015

Published by
ENERGY INSTITUTE, LONDON
The Energy Institute is a professional membership body incorporated by Royal Charter 2003
Registered charity number 1097899
and
Oil & Gas UK
Oil & Gas UK is the leading representative body for the UK offshore oil and gas industry.
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Company No: 1119804

ISBN 978 0 85293 727 3

Published by the Energy Institute in conjunction with Oil & Gas UK

Hard copy and electronic access to publications is available on www.energypublishing.org and www.oilandgasuk.co.uk.

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FOREWORD

The Pipeline and Riser Loss of Containment (PARLOC) report is the preferred source of risk assessment data for generic loss of containment frequencies. It covers pipelines and risers in the offshore oil and gas industry. This revision of PARLOC (PARLOC 2012) updates the previous report which is known as PARLOC 2001.

The results presented in this report are based on data gathered for loss of containment incidents that occurred at pipelines and risers on the UK continental shelf (UKCS) during the 12-year period 2001 – 2012.

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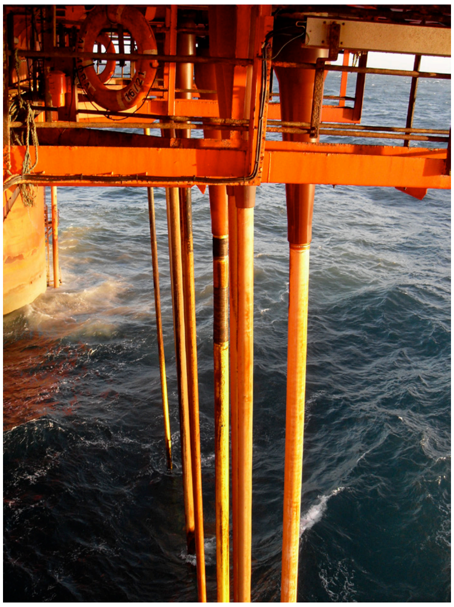

Figure 1: Flexible risers

ACKNOWLEDGEMENTS

This project was undertaken by DNV GL. Early contribution and funding for preliminary work on the update were made by BP Exploration Operating Company Ltd. The main phase of the work was funded by Oil & Gas UK and the EI.

The EI and Oil & Gas UK wish to record their appreciation of the work carried out by the steering group for the original work and the technical review. Significant contributions were made by the following:

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Affiliations refer to the time of preparation.

This report would not have been possible without the assistance of pipeline operators who graciously provided their incident data and photographs to Oil & Gas UK. Their trust and cooperation is greatly appreciated.

All photographs have been used with the owners' permission.

EXECUTIVE SUMMARY

Pipeline and Riser Loss of Containment (PARLOC) reports are recognised within the oil and gas industry as the preferred source of statistical data and loss of containment frequencies for offshore pipelines and risers.

This report (PARLOC 2012) updates the loss of containment failure rate data for pipelines and risers. The following table summarises loss of containment frequencies for both steel and flexible pipelines averaged across categories and sizes of pipelines. This summary table shows that the average loss of containment frequencies in the PARLOC 2001 and PARLOC 2012 studies are similar.

Comparison of failure frequencies – PARLOC 2001 vs. PARLOC 2012

	PARLOC 2001 Frequency (per km-year)	PARLOC 2012 Frequency (per km-year)
Steel pipelines	4.88×10^{-4}	4.23×10^{-4}
Flexible pipelines	4.66×10^{-3}	5.47×10^{-3}
Control umbilicals	No estimate	1.0×10^{-3}

This report introduces many changes to the layout and content seen in previous PARLOC reports; the last report (PARLOC 2001) was issued more than 10 years ago. Some of the changes are described below:

1. This report covers a different geographical scope as it includes all offshore pipelines and risers operating on the UKCS:
   - Includes UK sector of North Sea, eastern Irish Sea, and west of Shetland.
   - PARLOC 2001 covered only UK North Sea, plus incident data from Norwegian/Danish/Dutch sectors.
2. This report covers a different time period:
   - Report is based on entirely new incident data.
   - Time period covered is start of 2001 through the end of 2012.
   - It does not include any incident data covered by the PARLOC 2001 study.
3. The analysis methodology is described in detail to improve transparency of analysis:
   - Comprehensive description of methodology included.
   - Incident and pipeline population data are described in detail.
   - Includes a thorough explanation of the methods used to account for incomplete descriptions of incidents.
   - Description of analysis shows how incident data are combined with pipeline population data to obtain generic loss of containment frequencies.
4. Uncertainties in the data are accounted for in different ways:
   - A much wider range of uncertainties is recognised.
   - Sources of uncertainty are discussed in detail but not quantified.
   - Error bars are not included, unlike the PARLOC 2001 report.

Despite any uncertainties, the statistics and loss of containment frequencies presented in this report are considered to be the best available data applicable to currently operating oil and gas pipelines and control umbilicals on the UKCS, and they are recommended for use in quantified risk assessments.

Summary tables in the report show the numbers of incidents by pipeline and riser type and also the pipeline operating experience. The numbers of incidents and operating experience have then been combined to obtain the recommended generic frequencies of loss of containment. The results from this data analysis are presented in this PARLOC 2012 report.

The average loss of containment frequencies or failure rates have been derived using the following basic formula:

$$\text{Failure rate} = \frac{\text{Number of failures}}{\text{Operating experience}}$$

where operating experience is expressed in terms of km-years, and the units of failure rate are per km-year. (For risers the operating experience is measured in riser-years, and the unit of failure rate is per riser-year.)

The results presented in this report are based on extensive efforts to gather data on loss of containment incidents as recorded in the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR), Petroleum Operations Notice 1 (PON 1) reporting systems and data gathered using questionnaires that were issued to operators of offshore oil and gas pipelines.

The compiled incident data and pipeline population data have been recorded in two separate databases: a PARLOC 2012 incident database and a PARLOC 2012 pipeline database. These databases are held by Oil & Gas UK. The full contents are confidential.

1 INTRODUCTION

Historical statistics for hydrocarbon leaks from process equipment and pipelines form the basis of estimates for future leak frequencies from similar equipment and pipelines. These estimates are one of the key inputs to risk assessments that inform decision making on risk reduction in design and operation.

Before issue of this report, the most recent major reinterpretation of data for leak frequency estimates for offshore pipelines and risers on the UKCS was PARLOC 2001 (reference 5) which was based on leak incidents and pipeline population data up to the end of 2000. Prior to issue of the current report, PARLOC 2001 was the preferred reference for generic leak frequency data for use in quantified risk assessments of North Sea pipeline and riser systems. The PARLOC 2001 report superseded all earlier PARLOC reports: PARLOC 90, 92, 94, and 96 (references 1–4) because it was based on all known loss of containment incidents in the North Sea up to the end of 2000.

Work on the PARLOC 2012 update started with efforts to recover the incident data and pipeline population data that had been used in the PARLOC 2001 study. These efforts were unsuccessful because only partial incident data from the PARLOC 2001 update were available. For this reason, the current PARLOC 2012 report does not include any incident data prior to 2001.

Having recognised that the update would not include any data prior to 2001, it was decided that the scope of the update should change. In particular, it was decided that the 2012 update would be based on incidents that had occurred on the UKCS and not include any incidents from non-UK waters. (The 2001 update had included incident data from the Norwegian, Danish and Dutch sectors of the North Sea.) Inclusion of Norwegian incidents in the PARLOC 2012 was initially considered, but differences in reporting meant that this was not feasible. It can be noted that the scope of the PARLOC 2012 study includes the eastern Irish Sea and west of Shetland which were not covered by the 2001 study.

The scope of the PARLOC 2012 study therefore covers loss of containment incidents from pipelines and risers on the UKCS in the 12-year period from the beginning of 2001 to the end of 2012. The data have been collected from leak incidents that have been reported to Health and Safety Executive (HSE), the Department of Energy and Climate Change (DECC) and a questionnaire survey of pipeline operators.

Data on the population of pipelines and risers on the UKCS have been compiled from two main sources: a commercial pipelines database developed by Infield Systems Ltd. and a database compiled by Oil & Gas UK. The former has been used as the basis of the estimated populations of steel and flexible pipelines. The latter has been used as the basis of the population of control umbilicals on the UKCS.

The report presents failure frequency statistics for generic types of offshore pipeline and control umbilical. In order for the estimated failure rates to be meaningful, the records of failures and pipeline population, which are the basis of the analysis, should ideally be complete and accurate. Having obtained complete and accurate records, the average failure rates can be derived from the following basic formula:

$$\textit{Failure rate} = \frac{\textit{Number of failures}}{\textit{Operating experience}}$$

where operating experience is expressed in terms of km-years, and the units of failure rate are per km-year. (For risers the operating experience is typically measured in riser-years, and the unit of failure rate is per riser-year.)

It is noted that the current update is based on relatively recent incident data (2001 to 2012 and is therefore not biased by older data (pre-2001) that might reflect outdated practices in pipeline design, installation and operations.

The approach used in developing the PARLOC 2012 update aims to improve the traceability of data from the information in the incident and pipeline population databases all the way through to the final analysis and tabulated generic loss of containment failure rates.

PARLOC 2012 takes a simplified approach to treatment of uncertainty. PARLOC 2001 presented graphs of failure frequency statistics with error bars related to the limited number of incidents that had been observed. PARLOC 2012 does not present uncertainties in this manner but recognises that uncertainties arise from a wide range of sources.

The report is structured as follows:

- Section 1: Introduction describes the intended application and scope of the report.
- Section 2: Incident database definition explains how the incident data were collected and compiled to create the PARLOC 2012 incident database.
- Section 3: Pipeline database definition describes the available sources of pipeline data and the definition of the PARLOC 2012 pipeline database.
- Section 4: Incident data analysis contains tables showing the numbers of different categories of incidents in the incident database.
- Section 5: Pipeline data analysis contains tables showing the operating experience of different categories of pipelines and control umbilicals.
- Section 6: Loss of containment frequencies presents the average loss of containment failure frequencies for generic pipeline categories.
- Section 7: Discussion contains a comparison of the high-level results from PARLOC 2012 and PARLOC 2001 studies. This section also discusses the uncertainties associated with the statistics presented in this report and identifies the key assumptions on which this work is based.
- Section 8: Conclusions and recommendations.
- Section 9: References.

The report also contains annexes as follows:

- Annex A: Incident questionnaire shows the incident questionnaire that was issued to pipeline operators for collection of incident data.
- Annex B: Description of the incident database describes important database fields.
- Annex C: Pipeline population data sources contains supplementary information on the available sources of pipeline population data.
- Annex D: Glossary defining the meaning of acronyms in the main body of the report.

Figure 2 shows the report sections and the flow of information through the report. In particular, it shows how the results from sections dealing with the collection and analysis of data are used in subsequent sections.

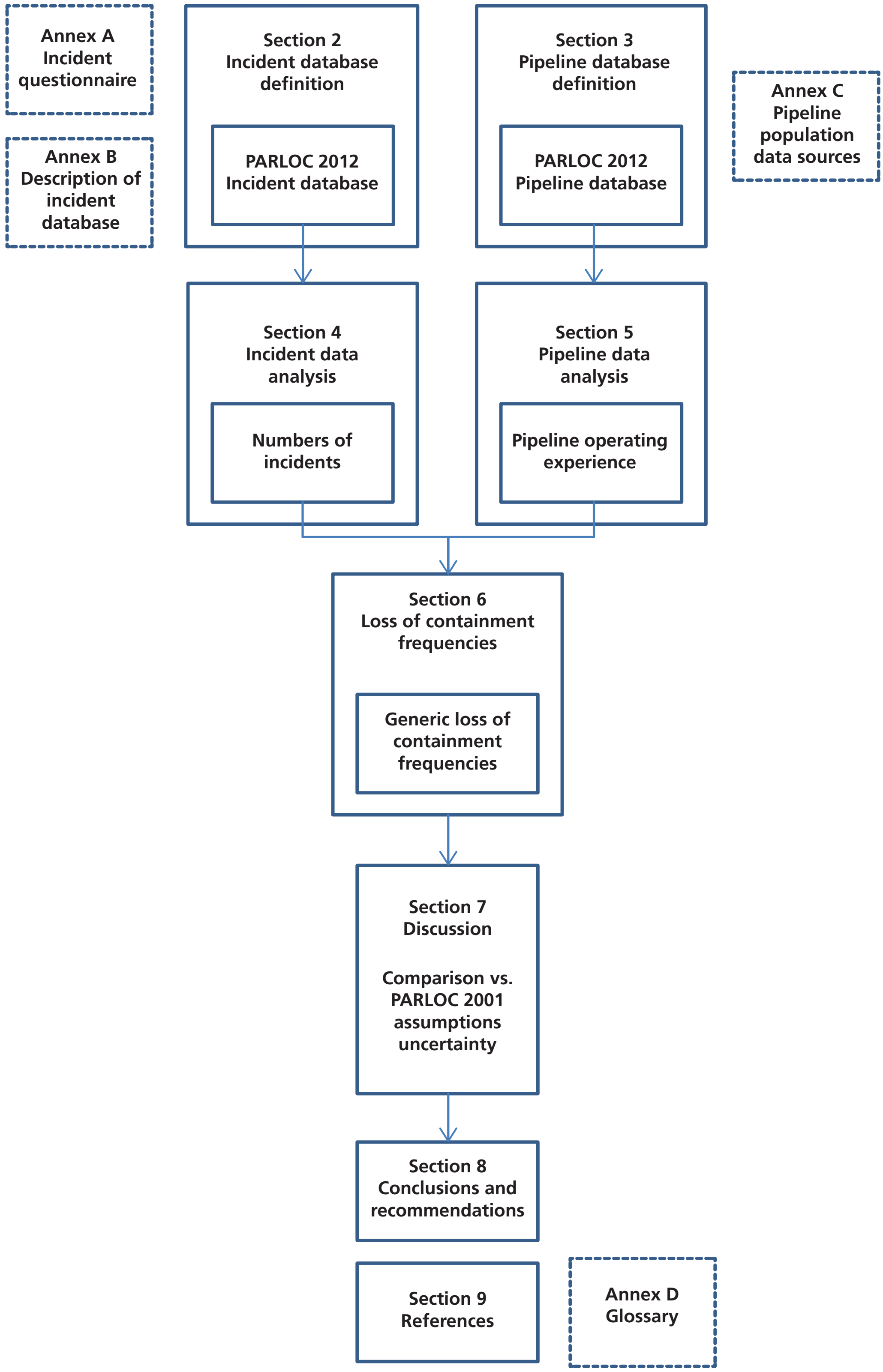

Figure 2: Flow diagram – structure of the report

1.1 SCOPE

This report is concerned with loss of containment statistics i.e. average failure (leak) frequencies and probabilities.

The PARLOC incident database is intended to include all leak incidents from pipelines and risers that have occurred in the 12-year period from the start of 2001 to the end of 2012. The leak incidents include those that have occurred on the UKCS but exclude leak incidents that have occurred in the oil and gas industries of other countries with territorial waters in the North Sea. The scope of the incidents therefore includes pipelines in the North Sea, eastern Irish Sea and UK waters west of Shetland – see map, Figure 3 (note that this map shows only the larger diameter pipelines on the UKCS). (This scope differs from the earlier PARLOC 2001 study which included incidents from all sectors of the North Sea but excluded eastern Irish Sea and west of Shetland.) The population data are similarly restricted to pipelines, or the proportions of pipelines, operated within the offshore oil and gas industry on the UKCS. Pipeline interconnectors (connecting Norway – England, Scotland – Ireland, and Netherlands – England) are excluded from the scope.

The physical extent of the pipelines and risers in the incident database includes risers up to the first isolation point – the riser emergency shutdown valve (ESDV) or a pig trap/launcher on the pipeline. Leaks from the pipeline body, flanges and other connections are included together with associated equipment (subsea isolations valves [SSIV], etc.). The incident database covers leaks of hydrocarbons and non-hydrocarbons (oil, gas, condensate, injection water, methanol, glycol, etc.). The database includes incidents from both steel and flexible pipelines. Control umbilicals are also included.

The PARLOC incident database also includes information on some incidents where there was no leak i.e. near miss incidents. PARLOC is not intended to include details of all near miss incidents. It is expected that the reported near miss incidents in the PARLOC database are only a small fraction of the total near miss incidents that have occurred. Details of these incidents have been included in this report as a source of information of situations which could result in loss of containment.

This study is primarily concerned with the development of statistics that describe representative loss of containment failure rates at pipelines and risers on the UKCS. The study does not describe the details of specific loss of containment events. The primary purpose of PARLOC is as a reliable reference source of statistics on pipeline leaks for the offshore oil and gas industry. The lists of leak incidents and pipelines on which this report is based are intended to be as complete as possible so that any uncertainty in the statistics is minimised. It is however inevitable that some leaks are omitted from the list of incidents. Uncertainties associated with the statistics are discussed in Section 7.4.

1.2 APPLICATION

The main purpose of this report is to present generic data on loss of containment failure rates in pipelines and risers that can be used in risk assessments in support of design and operation of offshore oil and gas facilities. The generic loss of containment failure frequencies presented in this report are considered to be the best available values, and they are recommended for use in quantified risk assessments of pipelines and risers in the oil and gas industry on the UKCS.

The source data have been collected from activities carried out in the UK offshore industry; the reported failure rates therefore reflect the practices in that geographic region and industry.

The failure frequencies reported in PARLOC 2001 have been applied to geographic regions beyond the UK and to industries other than the offshore oil and gas. It is anticipated that the readers may want to apply the data presented in this PARLOC 2012 report to areas other than the UK offshore oil and gas industry. These readers must understand that practices may be different in geographical areas around the world, and results of this report should be applied with caution outside the UKCS.

It is not the intention of this report to derive distribution factors for leak location, leak size, etc. such as may be required for input to a risk assessment. Data are presented which readers may use to derive such distributions, but the approach adopted and assumptions made in deriving such distributions is the readers' own responsibility.

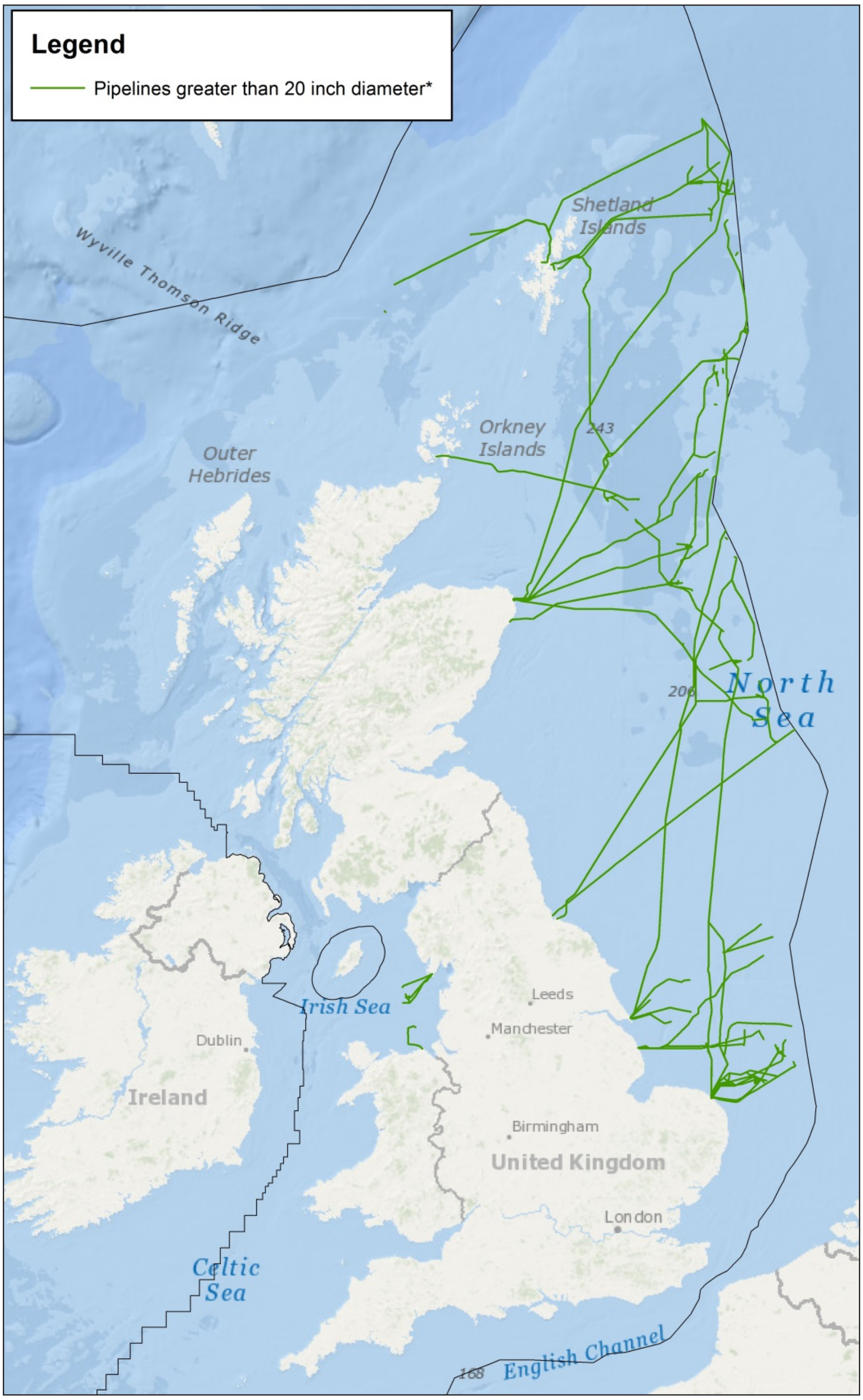

Figure 3: Map – geographic scope of PARLOC 2012 study

2 INCIDENT DATABASE DEFINITION

Work on the current PARLOC update started with efforts to retrieve the original incident data used in the PARLOC 2001 report in order to produce an integrated incident data base. However, only partial incident data from the PARLOC 2001 report were available, and it was decided that the current update should be based on a compilation of incident data from the start of 2001 onwards.

This section describes the work done to develop a database of loss of containment incidents that occurred on the UKCS in the period from the start of 2001 to the end of 2012.

For purposes of this study, an incident is any unintentional loss of containment of fluid from a pipeline (or control umbilical). Each identified incident is described by a single record in the incident database.

Data on relevant leak incidents on the UKCS are available from the following sources:

- PON 1 data from the UK Government's DECC. Licensees and operators of offshore installations and pipelines are obliged to report some defined categories of leak events. Specifically, PON 1 forms are used for reporting oil and chemical releases and Permitted Discharge Notifications from offshore installations and pipelines. PON 1 data are publicly available.
- Data reported as a regulatory requirement under RIDDOR using form OIR9B from the UK HSE, the UK regulator for health and safety matters. RIDDOR information from OIR9B is confidential and held by HSE but was made available to Oil & Gas UK on the basis that only aggregated, anonymous statistics would be published.
- Data from Hydrocarbon Releases Database (HCRD) collected using form OIR12 supplementary to OIR9B from HSE.

It was also recognised that it may be possible to collect data through questionnaires issued to the operators of offshore oil and gas installations and pipelines.

Available incident data from DECC's PON 1 records and HSE's RIDDOR records were reviewed. This review activity included preparation of lists of incidents relevant to the PARLOC update. A questionnaire was then issued to pipeline operators together with the lists of relevant incidents. The pipeline operators were invited to use the questionnaire to describe any loss of containment incidents that had occurred in the period under study. The questionnaire responses from the operators (plus PON 1 and RIDDOR data) were used as the basis for defining the PARLOC 2012 incident database.

Figure 4 summarises steps in the process leading to development of the PARLOC 2012 incident database.

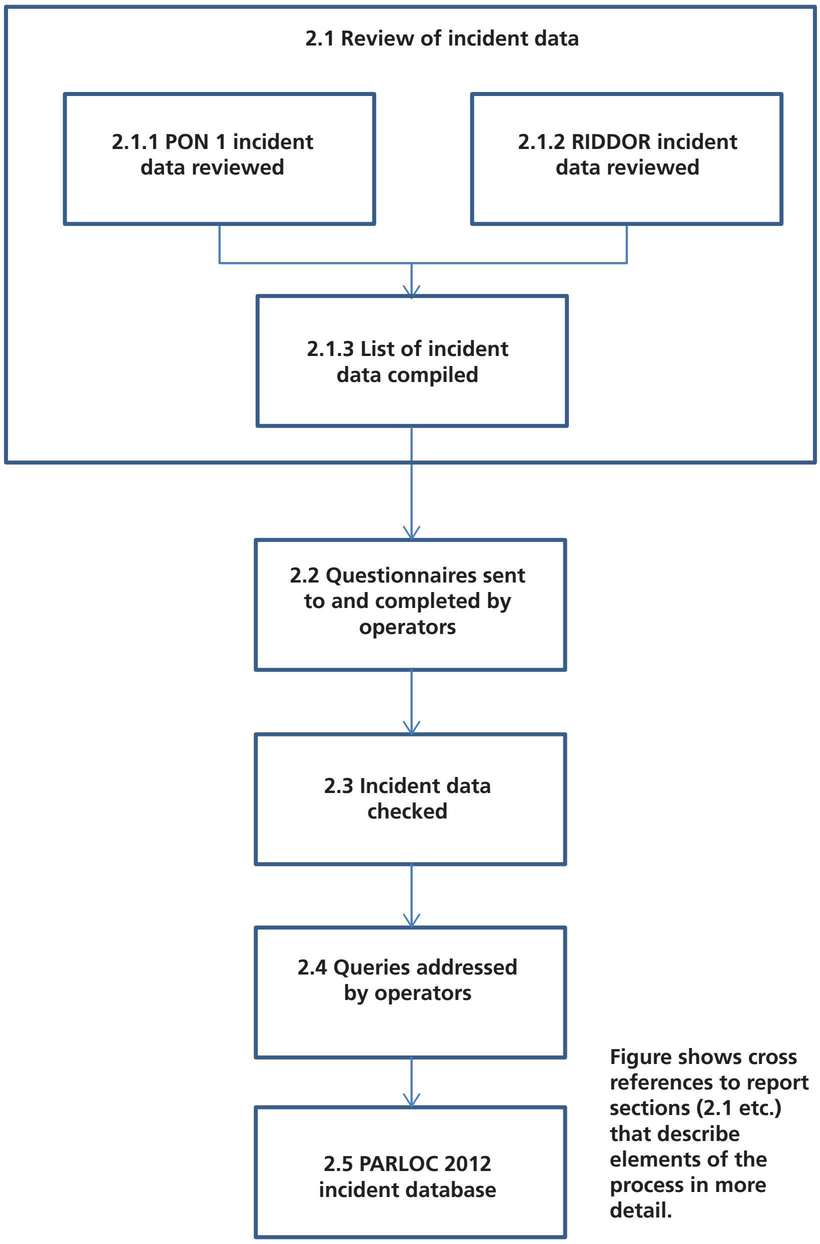

Figure 4: Flow diagram – development of PARLOC 2012 incident database

2.1 REVIEW OF INCIDENT DATA

The identification of loss of containment incidents started with a review of available data from RIDDOR and PON 1 reports from 2001 to the end of 2012 in order to identify those incidents that might be relevant to the PARLOC update.

It should be noted that RIDDOR and PON 1 records are produced for specific purposes; the level of detail in PON 1 and RIDDOR records does not always clearly determine whether the incidents are relevant to PARLOC.

2.1.1 DECC PON 1 data

The PON 1 form is used for reporting oil and chemical releases/discharges from offshore installations and pipelines. Specifically, the PON 1 process aims to meet the reporting requirements of the following:

- Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (OPPC);
- Offshore Chemicals Regulations 2002 (OCR), and
- Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998.

PON 1 incidents are reported to the UK Maritime and Coastguard Agency, DECC and Joint Nature Conservation Committee (JNCC). The focus of the PON 1 process is on the reporting of pollution incidents and immediate visible environmental effects. PON 1 scope is therefore limited to discharges to sea of oil and other liquid chemicals; gas leaks are not reported through PON 1.

Spreadsheets containing PON 1 reports (2007 onwards) have been published by DECC online and are available for download (reference 6). Information from earlier PON 1 reports (2001 to the end of 2006) was obtained from DECC via a Freedom of Information request (reference 19).

The PON 1 records covering the period from start of 2001 onwards were reviewed in order to identify incidents that were relevant to PARLOC.

It can be noted that the relevance of PON 1 records to PARLOC is not always evident. For example, the reports do not always identify the equipment where the leak occurred so it is not always possible to determine whether the incident is from a pipeline, riser, riser ESDV or equipment inboard of the riser ESDV. The review was therefore largely based on an examination of the free text descriptions in the PON 1 reports to infer the location of the leak.

Examples of PON 1 incident reports that were deemed to be not relevant included the following: releases occurring in connection with well operations, releases from topsides process equipment and releases reported as being from pipelines but occurring inboard of the ESDV or pig launcher.

2.1.2 RIDDOR data

The RIDDOR incident data used in this update of PARLOC were collected under the requirements of the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations, 1995. These regulations define requirements for reporting of dangerous occurrences which are generally applicable and also specific requirements for the offshore workplace. (A revised version of the regulations came into force in 2013, but incidents reported under the 2013 regulations are outside the scope of this update.) Specifically, a release is reportable if it results in the following: a fire or explosion, the taking of action to prevent or limit the consequences of a potential fire or explosion, or could cause a specified injury or the death of any person. Regarding leaks from pipelines, a dangerous occurrence at a pipeline includes only those leaks which could cause personal injury to any person or which result in the pipeline being shut down for more than 24 hours. (Also reportable are any unintentional changes in pipeline position, or in the subsoil or seabed in the vicinity, which require immediate attention to safeguard the pipeline's integrity or safety.)

RIDDOR reports for offshore dangerous occurrences are made online using Form OIR/9B.

HSE additionally requests voluntary supplementary information on hydrocarbon releases to enable the HCRD to be maintained. In particular, HSE asks duty holders to submit further details (using Form OIR/12) for releases that are reportable under RIDDOR. OIR/12 data are recorded in the HCRD. Generic, anonymised OIR/12 data are publicly available for download from the HSE website.

OIR/12 records were however excluded from the review. The main reasons for this exclusion were:

- Formal cross-references are not available for OIR/12 records back to RIDDOR records.
- There are no other alternative means of cross-referencing the OIR/12 records back to the RIDDOR records. OIR/12 records are publicly available but deliberately omit references to names of operators or installations in order to maintain anonymity in the voluntary reporting scheme. Similarly the OIR/12 records do not give specific dates for incidents, but refer only to the year and quarter.
- Descriptive text fields in the data are omitted from the data that are publicly available.
- All OIR/12 incidents are also reported through the OIR/9B system.

The data were derived from HSE databases and data held by Oil & Gas UK. It was therefore expected that this dataset would include nearly all incidents that are relevant to PARLOC and any omissions would be small in number.

2.1.3 List of incidents

The review of the PON 1 and RIDDOR data resulted in the manual compilation of lists of incidents categorised by operator and relevance to PARLOC.

The identification of relevant incidents from RIDDOR data was generally more straightforward than those described in PON 1 reports. This difference is mainly due to the nature of the incident descriptions which are generally more detailed than those given in PON 1 reports. These descriptions are however given in a free text field, and there is limited guidance on the type of information that should be provided. The PON 1 and RIDDOR recording processes may lead to quality-deficient data and omission of information in the incident descriptions.

The review of RIDDOR data identified many duplicate records of a single dangerous occurrence event. These duplicate events were, so far as possible, removed from lists of incidents.

Some incidents were identified that appeared to have been reported through both the RIDDOR and PON 1 systems. Such incidents were noted, but there was no attempt to remove the double reporting in this review because either the reviewers could not be fully confident that these reports referred to the same incident or there was additional information that would be lost by simply deleting one of the two records.

The results from the review were lists of reported incidents that were manually compiled identifying:

- incidents that were definitely relevant to PARLOC;
- incidents that were definitely not relevant to PARLOC, and
- incidents where the relevance to PARLOC could not be determined.

Identification of the relevant operator was not always straightforward; the name of the operating company is given in the PON 1 and RIDDOR data but in many cases the installations and pipelines have changed ownership since the date of the original report. Some of the original operating companies are no longer operating in UK waters. So far as possible, lists of incidents were prepared for each of the relevant current operators. These lists prioritised the incidents that were definitely relevant to PARLOC but also included the incidents where the relevance to PARLOC could not be clearly determined.

While reviewing the PON 1 and RIDDOR records and compiling the tables of incidents, it became evident that there was potential for underreporting of incidents. Incidents were therefore omitted from the tables only if there was a high level of confidence that the incidents were not relevant to PARLOC.

2.2 INCIDENT QUESTIONNAIRE

An incident questionnaire was prepared and issued to each pipeline operator along with a specific list of incidents (based on RIDDOR and PON 1 records) that were either definitely or potentially relevant to PARLOC for that pipeline operator. Annex A shows the incident questionnaire together with the associated guidance.

Operators were requested to complete the questionnaire to provide further details of the RIDDOR/PON 1 incidents, plus details of any other incidents relevant to the PARLOC update.

The questionnaire included sections as follows:

A. Introduction – e.g. contact details for person completing questionnaire and cross reference to related RIDDOR/PON 1 record.
B. Pipeline – describing the pipeline/riser where the incident occurred – pipeline number assigned by DECC/DTI (Department of Trade and Industry), type of pipeline/riser, name of operator, pipeline dimensions, pipeline age, contents, design and operating pressure/temperature, materials and coatings, etc.
C. Incident location – describing the location on the pipeline/riser where the incident occurred.
D. Incident description – describing the nature of the incident, cause, item that failed, size of release, consequences, pipeline status etc.
E. Repair – repair works required and timescale for repair.

The questionnaire included guidance to assist operators in preparing the response. Guidance was also developed for assessing the received responses.

The questionnaires were issued to the pipeline operators through Oil & Gas UK, which also handled the receipt of responses. The completed responses returned to Oil & Gas UK were then forwarded to DNV GL.

2.3 QUESTIONNAIRE RESPONSES

The questionnaire responses were reviewed to ensure, so far as possible, that the received information was complete and consistent. Specific checks included:

– Check for completeness of the responses e.g. have all sections of the questionnaire been completed?
– Cross-check against pipeline database e.g. do the PL number and pipeline description in the response correspond to the description in the pipeline database? Full cross-checks were limited by the availability of confirmed PL numbers.
– Note any apparent inconsistencies in the received responses.
– Completion of standardised response codes for specific questions.
– Check for possible double counting of incidents (e.g. incident reported under both RIDDOR and PON 1).
– Check that each of the existing relevant incident data records (as derived from PON 1, RIDDOR) appears in the final incident database.

These checks led to specific actions as follows:

– Exclusion of some records from the incident database e.g. where the incident was found to be unrelated to either pipelines or risers, or where two questionnaires had been received for a single leak incident.
– Queries arising from the received questionnaire responses, mainly seeking clarification or completion of incomplete questionnaire fields.
– Preparation of new pre-populated questionnaires for RIDDOR and PON 1 incidents where a questionnaire had been expected but not received.

The questionnaire responses also identified some additional leak incidents that did not appear in the RIDDOR or PON 1 data.

2.4 DATA QUERIES

Queries arising from the checking of questionnaires were addressed by returning the questionnaires to the pipeline operators (again via Oil & Gas UK).

The review of questionnaires identified incidents where a completed questionnaire was expected, but no response had been received. Pre-populated questionnaires for missing incidents were therefore sent to the operators for confirmation, correction and/or completion.

Responses from the operators dealing with queries and missing incident questionnaires were returned via Oil & Gas UK.

It is noted here that Oil & Gas UK was able to obtain responses from its members. However one pipeline operator was not a member of Oil & Gas UK, and it was not possible to get data from this operator.

The programme of work allowed for one round of queries arising from the review of questionnaire responses. The initial questionnaires and query responses from pipeline operators were then used to define the basis of an incident database.

At the end of the data gathering phase of the work, questionnaires had been issued to 23 pipeline operators. Completed questionnaires were received from 21 operators; the other two operators did not have any data relevant to PARLOC. No questionnaire was issued for one additional pipeline operator that was not a member of Oil & Gas UK. The number of questionnaire responses initially received from pipeline operators was 153, but following queries raised with operators, a further 44 completed questionnaires were received. Many of these query responses added information to questionnaires that had already been received but others described additional incidents. DNV GL completed questionnaires for PON 1 and RIDDOR reports that were evidently related to loss of containment incidents at risers and pipelines for which no information had been received.

2.5 COMPILATION OF PARLOC 2012 INCIDENT DATABASE

The PARLOC 2012 incident database was compiled using the checked questionnaire responses. Where data were still missing after receipt of responses, instances were identified in which some omissions by the pipeline operator could be confidently amended. These amendments were on the basis of inference taking surrounding information into account.

Based on the information received, the PARLOC 2012 database contains the following sections:

– Loss of containment 2001 – 2012: records of loss of containment events from pipelines and umbilicals in the period from the start of 2001 to the end of 2012 i.e. records that are in the scope of the PARLOC update and form the basis of the incident data on which this report is based. The completeness of this set of incident records is discussed in Section 7.4.
– Near miss 2001 – 2012: records of incidents from pipelines and umbilicals that did not result in any loss of containment but could have resulted in a loss of containment under slightly different circumstances. These incidents are briefly mentioned in this report but are excluded from the main statistical analysis. It is likely that the majority of near miss events have not been captured in this data gathering exercise.
– Incidents in 2013: records of loss of containment incidents that are out of scope because they occurred in 2013. These incidents are not a complete list of incidents in 2013 but will be relevant to a future PARLOC update. There is no further discussion of these incidents.
– Irrelevant incidents: records of incidents that are not relevant to PARLOC. Details of these incidents have been retained in the consolidated database for the sole purpose of ensuring full traceability of the responses from operators. Examples of responses that were deemed to be irrelevant included: incidents reported more than once, leaks from topside pipelines inboard of the ESDV or pig trap, ESDV/SSIV seat leaks (but no external leak), ESDV closure time test failure, leaks from Xmas trees, downhole leaks, and a hoist failure while lifting a riser. There is no further discussion of these incidents.

The numbers of incident records in each of these categories are shown in Table 1.

Table 1: Number of UKCS incident records by category 2001 – 2013

Incident record category	Number of records
Loss of containment incidents 2001 – 2012	183
Near miss incidents 2001 – 2012	23
Incidents in 2013	6
Irrelevant incidents	39

The 183 loss of containment incidents that occurred in the 12-year period 2001 to 2012 are the basis of the analysis of incidents presented in Section 4.

Annex B contains a high-level description of the PARLOC 2012 incident database. The database is confidential and held by Oil & Gas UK.

Figure 5: Loading of rigid pipeline onto reel of pipelay barge

3 PIPELINE DATABASE DEFINITION

There is no single definitive industry standard pipeline database for the UKCS. Therefore, in order to derive failure rate statistics for loss of containment from pipelines, risers and control umbilicals, it is necessary to establish a corresponding list of the pipelines, risers and control umbilicals where the loss of containment incidents have occurred.

This section briefly describes the available sources of pipeline data and the advantages and disadvantages of each source. Annex C contains supplementary details of these data sources.

The preferred datasets used in the PARLOC 2012 update are then described.

For the purposes of this study the relevant sections of a pipeline include: all pipework, fittings and equipment in the main flow path and any associated risers, pig traps and valves. If a pipeline does not have a pig trap, then the first in-line valve above water level is the termination point.

Figure 6 summarises the process leading to development of the PARLOC 2012 pipeline database. The figure includes cross-references to report sections that describe elements of the process in more detail.

3.1 PIPELINE POPULATION DATA SOURCES

A review of available sources of pipeline population data identified several lists of pipelines. The following paragraphs summarise the key findings from a review of these data sources.

3.1.1 DECC data

A list of pipelines has been published by DECC (reference 6), but this list is incomplete and not up-to-date; it identifies 433 pipelines but omits a large number of other pipelines. (This DECC database has however assisted in cross-checks of the incident data collected for the PARLOC 2012 update.)

DECC is known to hold data on a larger number of pipelines, but it was not practical to access this larger dataset because of the difficulty of retrieving data in a form that could be used in the PARLOC update.

DECC is responsible for allocating unique identification numbers to pipelines as part of its activity in issuing Pipeline Works Authorisations (PWA). These identification numbers are sometimes referred to as "PL" identifiers because of the prefix in the identifier. Various numbering formats are used, for example PL2409 (sequential number), PL2798.2 (one of a group of related lines), PLU2679 (umbilical), and PL1257A (replacement line – new pipelines are allocated a new number and replacement pipelines are identified by appending a letter "A" to the original identification number).

It is noted that although pipelines on the UKCS are uniquely defined by the assigned PL numbers, many operators also have their own identification systems.

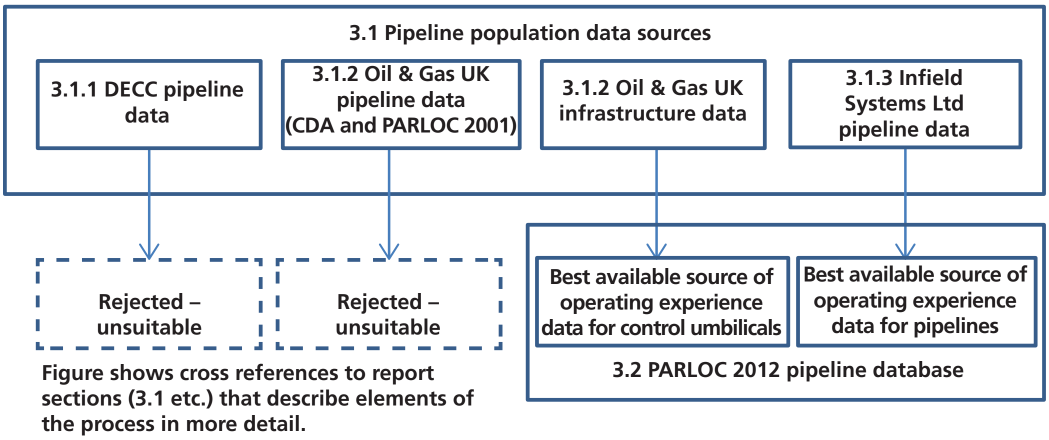

Figure 6: Flow diagram – development of PARLOC 2012 pipeline database

3.1.2 Oil & Gas UK data

Several pipeline databases have been compiled by Oil & Gas UK and its subsidiary company Common Data Access Ltd (CDA).

The original PARLOC 2001 database could not be located. A modified version of the PARLOC 2001 database (described here as the modified PARLOC 2001 database) was identified (reference 7), but this was found to be unusable; it appears that a merger of the original 2001 PARLOC database and the FishSafe database had introduced some errors. For example, the pipeline diameter field contains data which are apparently a mixture of units (inches and mm) with no systematic way of distinguishing between the different units. The data for pipeline outer diameters, wall thickness and maximum allowable operating pressure (MAOP) also appear to contain data in a mixture of units. The modified PARLOC 2001 database also contains duplicate entries.

The main CDA pipeline database (reference 8) was also reviewed but considered unsuitable for the PARLOC 2012 update because many of the data fields are incomplete. (This database has however assisted in cross-checks of incident data collected for the PARLOC 2012 update.)

Oil & Gas UK has also compiled a list of pipelines (reference 9) as part of an exercise to identify subsea infrastructure and establish baseline requirements for decommissioning on the UKCS. There are gaps in these data, but this Oil & Gas UK decommissioning database was identified as the most suitable available source of population data for control umbilicals.

3.1.3 Infield Systems Ltd. data

The Infield pipeline database (reference 10) has been developed for commercial purposes using information collected over several years; it describes pipelines in terms that are broadly aligned with requirements for the PARLOC 2012 update. Review of the Infield database (reference 11) showed that it contains details of steel and flexible pipelines that are omitted from the modified PARLOC 2001 and DECC databases. In particular, it includes many shorter pipelines that are absent from the other databases. An important aspect of this database was the completeness of pipeline descriptions (i.e. there were no gaps in the data fields describing pipelines). Spot checks of the information in this database showed broad agreement with other data sources, although the total length of relevant pipelines in the Infield database was found to be about 9 % smaller than the length in the modified PARLOC 2001 database. The reasons for this difference are not fully understood; potential reasons may relate to duplicate records in the modified PARLOC 2001 database or different accuracies in estimates of length.

As a result of the review, the Infield database was judged to be the preferred listing of pipelines available for use in the PARLOC 2012 update. This preference was largely because of the relative completeness of the Infield database (all data fields were fully populated), but it is noted that none of the sources of pipeline data is ideal as a basis for the PARLOC 2012 update.

Deficiencies identified in the Infield database include:

- PL numbers: the Infield data do not include PL numbers. Identification of PL numbers aids cross-referencing of the incident data with the pipeline database. PL numbers are therefore useful but not essential for the PARLOC update. In the absence of a full listing of PL numbers as assigned by DECC, DNV GL did further work to identify PL numbers in the Infield database and identify pipelines that had been decommissioned. Infield also attempted to assign PL numbers to the records in the Infield database using available information. This work is described in Annex C.
- Cessation dates: the Infield database gives approximate dates for start of operation but does not indicate cessation dates. In order to estimate pipeline failure frequencies it is necessary to know the number of years that each pipeline has been operating. For pipelines that were marked as "not in use" (removed, abandoned, decommissioned), DNV GL estimated the dates of cessation from various sources of data – mainly DECC's online listing of decommissioning programmes.
- Alignment of database fields: the estimation of leak frequencies for specific categories of pipelines requires that these categories can be identified in both the incident data and the pipeline population data. The categories in the incident data and population data did not generally match, so it was necessary to recategorise some fields in either the questionnaire or the pipeline database. Annex C shows an example of this work, showing how the Infield pipeline product categories were mapped onto the incident codes used to describe pipeline fluids.
- Riser identification: the Infield data do not fully identify all offshore risers. They explicitly identify some risers where they are counted as separate pipelines, but in many cases the riser is implicitly included as part of a pipeline.
- Control umbilicals: the reviewed version of this database did not provide any records for control umbilicals.

None of the deficiencies in the Infield database prevents its use in the PARLOC 2012 update. These deficiencies do however relate to uncertainties in the population of pipelines and risers that must be recognised because these affect the uncertainties in the best estimate loss of containment frequencies.

Overall, the quality and completeness of the Infield data meant that they were identified as the most suitable available source of population data for steel and flexible pipelines.

3.2 PARLOC 2012 PIPELINE DATABASE

After review of the available pipeline data, it was decided to base the PARLOC 2012 update on two databases:

– Infield Systems Ltd. database for steel and flexible pipelines, and
– Oil & Gas UK decommissioning database for control umbilicals.

3.2.1 Counting conventions

In order to estimate the pipeline experience for different groups of pipelines, it is important to establish some conventions for counting the total exposure of pipeline types.

Pipeline length: Bundles, pipe-in-pipe and piggy-back line types each involve groups of pipelines that are laid along the same route. For these pipeline types, the Infield database records each pipeline in a separate record. As an example, Table 2 shows some data from four records which relate to a single bundle.

Each record a has a unique record number, but the “Line ID” field shows that these lines belong to a single bundle. Each line has the same length of 4.3 km (as expected for a bundle), but the four lines together contribute 17.2 km to the length of pipelines in the full database.

Table 2: Illustrative extract from pipeline database showing four lines in a single bundle

Record number	Line ID	Diameter (inch)	Length (km)	Product	Content code	Type
524628	80137	35	4.3	Carrier	XXX	Steel
524629	80137	10	4.3	Oil	OIL	St/St
524630	80137	4	4.3	Gas lift	GAS	Steel
524631	80137	12	4.3	Water injection	WATR	Steel

Risers: The Infield database does not explicitly identify all risers. Some risers are explicitly identified, typically in cases where the flexible riser is attached to a steel pipeline. Other records in the database identify pipelines that are connected directly to a platform and allow the existence of the riser to be inferred. The number of risers in the population analysis is based on the number of explicitly identified risers plus the number of pipelines that are recorded as being connected directly to a platform.

Table 3 shows how the risers are counted for the example shown in Table 2. It is assumed that the bundle carrier does not extend to the riser, but each of the individual flowlines is tied into a separate riser. The following table shows how the number of risers would be counted depending on the bundle’s end connections.

Table 3: Illustration of method for counting risers at the example bundle

From	To	Number of risers
Subsea unit	Subsea unit	0
Subsea unit	Platform	3
Platform	Platform	6

For risers that are encased in caissons, the caisson is not counted separately.

Years of operation: The scope of the PARLOC 2012 update runs from the start of 2001 to the end of 2012, a period of 12 years. It is necessary to estimate the number of years of actual pipeline operation in this period for each pipeline taking account of the start of operation and cessation of operation. The Infield database defines the date laid but does not identify dates of cessation of operation. Some cessation dates have been identified but other dates are unknown despite the pipeline being not in use. Table 4 illustrates the counting convention for years of operation. It can be seen that where the year of cessation is unknown, 2012 has been assumed. This assumption maximises the estimate of the years of service, which reduces the calculated frequency and so could be considered to be an optimistic assumption. However, this small optimism is considered to be more than offset by conservatisms elsewhere in the calculation process.

Table 4: Illustration of method for counting years of operation (examples)

Year laid	Year of cessation of operation	Estimated years of operation
2001	2012	12
1996	2012	12
1996	2014 (i.e. forecast)	12
2006	2008	3
2001	Not known	12
1996	Not known	12
2006	Not known	7

The dates for cessation of operation have, in most cases, been estimated from published decommissioning programmes as submitted to DECC for approval (reference 12); the approved decommissioning programmes show the year of approval for the programme. These dates provide an indication of the date of cessation, but the actual date is not stated. Operators may also take pipelines out of service without decommissioning; DECC will generally try to avoid removing (or making unusable) elements of infrastructure that may be reused by another party at some later date. Where decommissioning plans have been submitted, approval of decommissioning plan must occur at some time before the execution of the plan. Furthermore, in many cases the pipeline physically remains on the seabed after decommissioning.

Operating experience: Operating experience for pipelines is calculated in km-years as the product of pipeline length and years of operation, summed across relevant pipelines. Operating experience for risers is calculated in riser-years as the years of operation summed across relevant risers.

It is noted that corrosion and fatigue damage are functions of the complete operating life, not just the statistical period. This report does not estimate the complete operating life of pipelines or make any assessment of the effect of age on failure rates.

Diameter and length ranges: The loss of containment statistics show the variation of failure frequency with diameter. The data are presented in ranges of diameter as follows:

– steel pipelines: up to 6 inch, >6 to 10 inch, >10 to 16 inch, and >16 inch, and
– flexible pipelines: up to 4 inch, >4 to 6 inch, and >6 to 8 inch, and >8 inch.

Results for variation of frequency with diameter for control umbilicals are not presented.

Descriptions of pipeline diameters follow normal engineering conventions; for steel pipelines the diameter refers to nominal bore or nominal pipe size (NPS), and the diameter of a flexible pipeline refers to nominal internal diameter.

The loss of containment statistics show the variation of failure frequency with length. The data are presented in ranges of length as follows:

- control umbilicals: up to 10 km, and > 10 km;
- steel pipelines: up to 3 km, >3 to 10 km, >10 to 30 km, and >30 km, and
- flexible pipelines: up to 1 km, >1 to 5 km, >5 to 10 km, and >10 km.

The selection of these bands has been a compromise taking account of the number of incidents and the number of pipelines in each range with the aim of obtaining meaningful failure rate statistics in each range.

Causes of failure: The analysis of incidents categorises the various causes of loss of containment under the following headings:

- Impact: failures due to anchoring, trawling and other impacts.
- Material: failures due to corrosion (internal or external) and other material causes.
- Operations and maintenance: incorrect operation (such as over-pressurisation) or error during maintenance or removal (e.g. release resulting from incomplete flushing of the line prior to opening the line).
- Construction: failures during commissioning tests or occurring as inadvertent by-product of construction.
- Other: failures due to buckling, natural hazards (such as loss of position in extreme weather) and other causes that do not fall under the other headings.

Rupture: Line ruptures are generally assumed to have a hole diameter equal to the pipeline's nominal diameter i.e. NPS (unless a specific hole size has been reported by the operator).

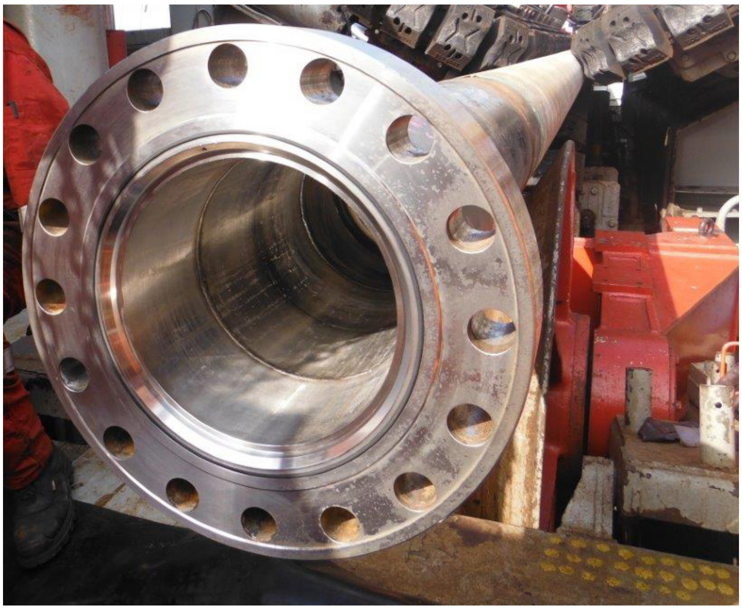

Figure 7: Pipeline flange connection

4 INCIDENT DATA ANALYSIS

This section presents a series of tables which summarise the numbers of loss of containment incidents that occurred in the period 2001 to 2012 inclusive. Figure 8 summarises incidents that are relevant to this section.

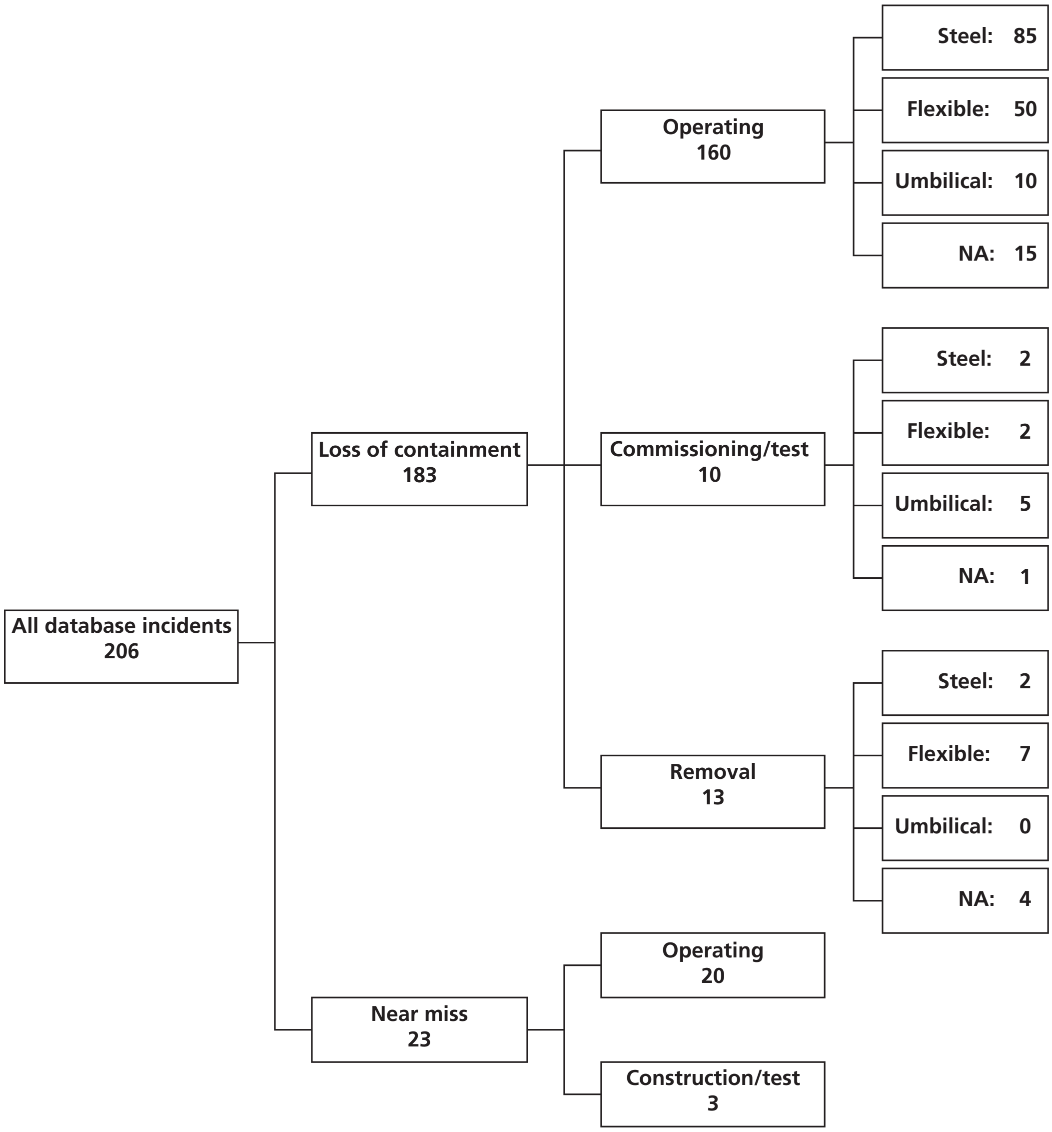

Figure 8: Breakdown and descriptions of number of incidents in the PARLOC 2012 database

The database lists 183 loss of containment incidents as follows:

– 160 incidents at operating lines; these include pipelines and control umbilicals during normal operations and those described as occurring during process restart, routine shutdown, nominally operating but shut-in, preparations for pigging, well being brought on line, or shut in for maintenance on ESDV.

– 10 incidents at lines during commissioning and/or line test; these include leaks described as occurring during commissioning, pressure test, and one incident related to upheaval buckling and fishing gear damage.
– 13 incidents at lines that were in the process of removal.

The number of ignited events among these loss of containment incidents has not been reported or identified.

This section also briefly describes 23 near miss incidents where no leak occurred as follows:
– 20 incidents at operating lines, and
– three incidents during construction/test.

No statistics are presented for the near miss incidents because these are not expected to be a complete listing of such events. The circumstances of these incidents are described briefly because of their relevance to future hazard identification.

Figure 9 summarises the process for development of the incident data tables presented in this section. The figure includes cross-references to sections that describe elements of the process in more detail.

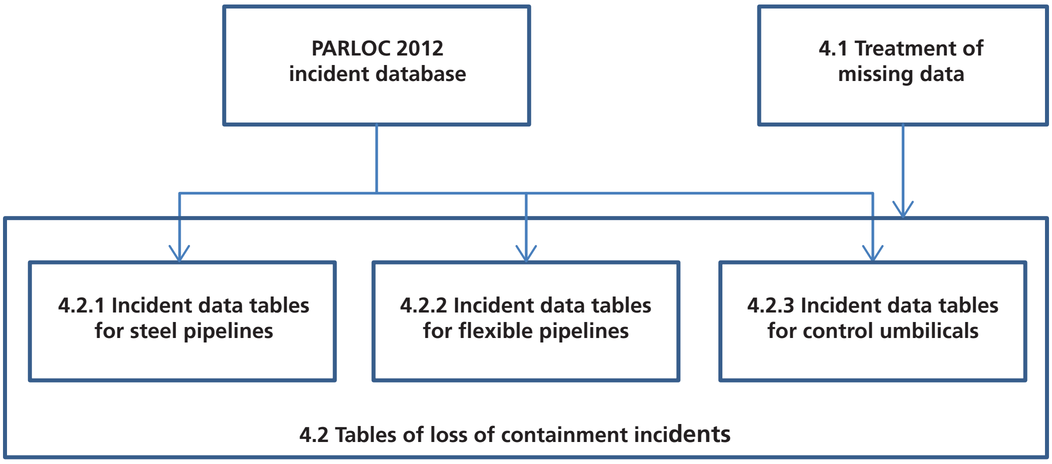

Figure shows cross references to report sections (4.1 etc.) that describe elements of the process in more detail.

Figure 9: Flow diagram – preparation of incident data

Many of the incident descriptions are incomplete. If records with incomplete data are ignored, this would lead to significant underestimates of the true numbers of many categories of events. Section 4.1 describes how the incomplete data is handled in order to maximise the available information and obtain estimates of the true numbers in different categories of incidents. Section 4.2 then presents tables of the numbers of loss of containment incidents that have occurred. Sections 4.3, 4.4 and 4.5 then present a description of some special categories of incidents – those occurring during pipeline removals, those occurring during commissioning and test, and finally near miss incidents where there was no loss of containment.

4.1 TREATMENT OF INCOMPLETE DATA

Section 2 described how initial quality assurance of the questionnaires allowed some missing data to be filled in, and queries issued to the operators resulted in more missing data being completed. At this stage there remained many parts of the incident descriptions where data were still incomplete.

Two types of incomplete data must be recognised in the following discussion:

- Some recorded incidents have incomplete descriptions. For example, there are incident records where the pipeline type, incident location and pipeline diameter are shown as NA, meaning not available. Where data are shown as NA, they are assumed to be missing at random (MAR) (reference 16). In statistical analyses, MAR describes scenarios where the reason for data being missing is not related to the value of the missing data such that the available data and the missing data have the same underlying distribution. Reference 17 provides a simple description of the various methods for analysing data sets that have missing data. The approach adopted in PARLOC data is based on the facts that the PARLOC data are categorical and the MAR assumption that the distribution of data that are present is representative of the data that are absent.
- Some categories of rare event have not been observed among the recorded loss of containment incidents. Some categories of incidents are plausible but are sufficiently rare that their absence is explained by the size of the statistical sample (183 loss of containment events that have occurred over a period of 12 years, including 160 from operating lines). An additive smoothing technique is used to estimate the number of rare incidents – a fractional number – that might have occurred in this sampling period. A variety of smoothing methods is described in various textbooks for statistical analysis (e.g. reference 14). Reference 15 provides a simple summary of the approach adopted in PARLOC 2012.

Users of the results presented in this report should have at least a basic understanding of the methods used for handling such cases because they affect the estimates of numbers of events that are carried through to the estimates of generic failure frequencies.

A third type of incomplete data should also be recognised i.e. incidents that have not been reported. This type of missing data is not addressed in this section; the section effectively assumes complete identification of loss of containment incidents that have occurred. The implications of potential underreporting of incidents are discussed in Section 7.4.1.

Sections 4.1.1 to 4.1.5 describe how the full set of available incident data is included in the analysis while minimising the effects of missing data. The method for handling missing data aims to avoid potential underestimates of loss of containment frequencies through a process involving pro rata redistribution of incidents containing NA data. Sections 4.1.1 to 4.1.5 show how the additive smoothing technique is used to account for rare events where no event has been observed and present a simple illustrative example of the process used to redistribute the NA data. The full set of incident data describes 183 loss of containment incidents, but for the purposes of this example, the following method description is based on a smaller simple set of 25 (fictitious) incidents.

4.1.1 Illustrative example data

Table 5 shows a simplified example of 25 hypothetical incident records described by only two fields – type and location. These incident records are not taken from any actual report and are for illustrative purposes only. Several of these records are incomplete because the data for type and location are missing. These hypothetical incident records will be used to illustrate the key principles of the method for analysing the data and obtaining best estimates of the numbers of specific categories of incidents. In this table, NA indicates that the type or location is not known i.e. not available.

In this simple example, the incidents have occurred at only two types of pipeline, either rigid steel or flexible. Furthermore, the incidents have occurred at only one of two locations, either on the riser or in the safety zone. The example data include several incidents where data for either the type of pipeline or location are not available. The data also include records where the incident is known to have occurred, but neither the pipeline type nor location is known.

(The real data are more complex; the data include control umbilicals, and the incidents also include other locations. The actual database also includes many more data fields – pipeline length, diameter, fluid content, etc. Nevertheless, this example illustrates the method that has been used to handle NA data in the analysis of the PARLOC 2012 incident database.)

Table 5: Treatment of incomplete data – example incident data

Incident number	Type	Location
1	NA	Riser
2	Flexible	NA
3	Steel	Riser
4	Flexible	Riser
5	NA	NA
6	NA	Safety zone
7	Steel	Riser
8	Steel	Riser
9	Steel	Riser
10	NA	Safety zone
11	NA	Riser
12	NA	NA
13	NA	NA
14	Steel	Riser
15	Flexible	NA
16	NA	Riser
17	Flexible	Riser
18	NA	Riser
19	NA	NA
20	Flexible	NA
21	Steel	Riser
22	Steel	Safety zone
23	Steel	NA
24	NA	NA
25	Steel	Riser

Table 6 shows the number of records in each category for the data shown in Table 5.

Table 6: Treatment of incomplete data – categories of incidents

Type	Location	Reported number of incidents
Steel	Riser	7
Steel	Safety zone	1
Steel	NA	1
Flexible	Riser	2
Flexible	Safety zone	0
Flexible	NA	3
NA	Riser	4
NA	Safety zone	2
NA	NA	5
	Total	25

4.1.2 Best estimate number of incidents

Given the incomplete data, the challenge is to make the best estimate of the actual numbers of incidents that have occurred in each of the four categories:

– steel/riser;
– steel/safety zone;
– flexible/riser, and
– flexible/safety zone.

Estimates of the numbers of incidents in these four categories must address two key issues:

– treatment of zero frequency events, and
– redistribution of incidents with missing (NA) data.

The method assumes that data are MAR. MAR describes a situation in statistical analysis where the reason for data being missing is not related to the value of the missing data. This assumption means that incidents with missing data can be redistributed pro rata across these four categories. Simple pro rata redistribution of incidents introduces another problem in situations where some of the categories have experienced no events. In this example, Table 6 shows that no incidents have occurred at flexible pipelines in the safety zone. However, it seems unreasonable to assume zero failure frequency just because no incidents have been observed during the data collection period. Failures of flexible pipelines in the safety zone are plausible events, and it is reasonable to assume that the long-term average frequency of failure of flexible pipelines in the safety zone is not zero.

4.1.3 Handling zero frequency events

An additive smoothing method is used to account for the possibility of such failures. Additive smoothing is a standard statistical technique for handling zero observed event statistics. It involves adding a small number of extra incidents, or pseudocount, to each category. The modified distribution is then renormalised to restore the correct total number of incidents. Additive smoothing methods typically add a fractional number of incidents in the range 0 to 1, where 0 corresponds to no smoothing; the approach adopted here adds 0.5 incidents to each of the four categories. For unobserved events, addition of 0.5 effectively assumes that the observed experience of events takes us halfway (probabilistically) to seeing an event. Exceptions are made for categories where no incidents are expected. For example, a control umbilical is not expected to carry hydrocarbon product, so the number of incidents in this category is expected to be zero, and no extra incidents are added. Assumption of 0.5 incidents is an application of the Jeffrey-Perks Law (reference 22).

Reference 14 describes the method and discusses the relative advantages and disadvantages of different pseudocount values. (When the pseudocount is 1, the method is termed Laplace smoothing. In the situation where the pseudocount is less than one, it is sometimes termed Lidstone smoothing.)

4.1.4 Redistribution of incidents

The next step is to redistribute the NA data across the smoothed incidents. The redistribution process identifies three groups of NA data in this example:

- pipeline type identified, but location is NA;
- pipeline type is NA, but location is identified, and
- pipeline type and location are both NA.

Table 7 shows the pro rata redistribution of these three groups of NA data. The redistribution effectively assumes that the NA data are missing at random, such that the missing data have the same distribution as the present data. Columns 1, 2 and 3 show the original data. The right-most column (column 12) shows the final number of incidents in the four categories after application of additive smoothing and redistribution of incidents in the NA data categories.

Table 7: Treatment of incomplete data – best estimate numbers of incidents

CHECK: 0.02778/0.0556 = 0.0309/0.0062 (discrepancy due to rounding)

1	2	3	4	5	6	7	Redistribution of incidents			11	12
Type	Location	Number of incidents	Pseudocount	Apply additive smoothing	Normalise to restore total	Fraction of incidents in each category	8 Location NA	9 Type NA	10 Location and Type NA	Fraction of incidents after redistributing NA data	Final number of incidents
Steel	Riser	7	0.5	7.5	6.944	0.2778	0.0309	0.1111	0.1157	0.5355	13.387
Steel	Safety zone	1	0.5	1.5	1.389	0.0556	0.0062	0.0556	0.0231	0.1404	3.511
Steel	NA	1	0	1	0.926	0.0370					
Flexible	Riser	2	0.5	2.5	2.315	0.0926	0.0926	0.0370	0.0386	0.2608	6.520
Flexible	Safety zone	0	0.5	0.5	0.463	0.0185	0.0185	0.0185	0.0077	0.0633	1.582
Flexible	NA	3	0	3	2.778	0.1111					
NA	Riser	4	0	4	3.704	0.1481					
NA	Safety zone	2	0	2	1.852	0.0741					
NA	NA	5	0	5	4.630	0.1852					
	Total	25		27	25	1.000				1.000	25

CHECK: 0.0370 = 0.0309 + 0.0062 (discrepancy due to rounding)

The columns of data in Table 7 are constructed as follows:

– Use 0.5 as a pseudocount (column 4). The pseudocount is applied only to the fully defined categories. If any categories are considered to be impossible the added pseudocount is zero.
– Add pseudocount to each category of fully defined data (column 5).
– The total of column 5 is now 27. The number of incidents is then normalised (divide by 27 and multiply by 25) to restore the original total number of incidents (column 6). Column 7 shows the fraction of incidents obtained in each category. This distribution of fully defined incidents is now used as a basis for distributing the incidents that are not fully defined i.e. those incidents where one or more fields is NA.
– The NA incidents are distributed pro rata. The highlighted cells in columns 7 and 8 are used to illustrate the redistribution process, taking the category steel/NA as an example. The fraction of incidents in the steel/NA category is 0.0370 (highlighted) and this is now distributed across the steel/riser and steel/safety zone categories in the ratio 0.2778:0.0556 (highlighted cells). The results of this redistribution are shown in the highlighted cells in column 8. The value of 0.0309 is allocated to the steel/riser category and the value of 0.0062 is allocated to the steel/safety-zone category. The other categories of NA incidents are redistributed in a similar manner. Column 8 shows how incidents with NA location have been redistributed. Column 9 shows how incidents with NA type have been redistributed. Column 10 shows how incidents with NA location and type have been redistributed.
– When all NA data have been redistributed the fractions of fully defined categories are summed (column 11). A simple cross-check of the redistribution process confirms that the fractions in each category sum to 1.0.
– Finally, the fractions are multiplied by 25 to restore the total number of incidents (column 12).

The values shown in column 12 of Table 7 are the best estimate numbers of incidents in the categories:

– steel/riser;
– steel/safety zone;
– flexible/riser, and
– flexible/safety zone.

4.1.5 Implications for uncertainty from choice of pseudocount value

There are limitations to the pseudocount methodology which should be understood by users of the data presented in this report because of the implications for uncertainty and potential for misuse of the presented data.

When no incidents have been observed but the event seems plausible, estimates of frequency must be based on theoretical considerations and/or expert judgement. The additive smoothing method does not prescribe the value of the pseudocount. The value should take account of the circumstances and anything else that is known about the situation. In the PARLOC 2012 situation it is known that there have been 160 loss of containment incidents recorded at operating pipelines but some categories of incidents have not been observed. Setting aside the fact that some data are marked as NA, the absence of any observed incidents in these empty categories indicates that the frequency of these incidents is low relative to the other cases where incidents have been observed. There have been 160 opportunities to observe an incident in the empty category, but none has been observed. This suggests that the probability of the incident in the empty category is likely to be less than 1 in 160. The probability may be very much smaller than 1 in 160, but in the absence of further information on which to refine the estimate the true probability cannot be determined. The approach adopted for the PARLOC analysis is pragmatic; it assumes that the probability of each zero event is 0.5 i.e. it has a probability of 0.5 in 160. (In principle, the estimate could be improved by expert judgement considering each zero event case separately on its merits and assigning a pseudocount that is tailored to each zero event case.)

Reference 18 describes alternative ways of estimating frequencies of rare events when no instances of the rare event have been observed. The discussion in reference 18 is not presented in terms of pseudocount, but it implies pseudocount values in the range 0.25 to 0.5. There is no clear consensus on the best value to choose because it must depend on the specific situation and what else is known about it.

As previously explained, the methodology effectively assumes that there are initially 0.5 events in each plausible category of leaks. It is important to recognise that this can lead to event frequencies being significantly overestimated if the number of events is summed across several zero event categories. Users of the data in this report should therefore avoid deriving failure frequencies by summing frequencies across several zero event categories.

4.2 OPERATING PIPELINES AND CONTROL UMBILICALS

Tables of loss of containment incidents at operating pipelines and control umbilicals are presented in three groups: steel pipelines (85 incidents), flexible pipelines (50 incidents) and control umbilicals (10 incidents). There are a further 15 incidents where loss of containment is known to have occurred but the line type is categorised as NA.

The tables in this section summarise the numbers of incidents as recorded in the PARLOC 2012 database and estimate the numbers of incidents after taking account of NA data and zero event categories. Each table in this section describes:

– category of incident, such as specific diameter band, length band, location, leaking item, etc.;
– reported number i.e. the number of incidents in each category as reported in the PARLOC 2012 incident database, and
– estimated number i.e. the best estimate of the number of leak incidents after accounting for all NA data and zero event categories.

The tables also show the totals for numbers of events. It will be noted that there are different totals for numbers of incidents as reported and the best estimate numbers. This difference is due to the allocation of NA data. The reason for this difference is as follows: the incident database identifies the numbers of incidents occurring at operating steel and flexible pipelines as 85 and 50 respectively. It identifies a further 10 loss of containment incidents at operating control umbilicals. These numbers (85, 50 and 10) are the totals as reported and are shown in the tables. But the incident database also includes a further 15 events where the type of the pipeline is NA i.e. not recorded. These 15 events have been redistributed across the different pipeline types using the method described in Section 4.1 and are included in the "estimated number" category. As shown in Section 4.1, the redistribution depends on the detailed distribution of the NA data across several data fields. The estimate totals therefore vary from one table to another.

NA data are not presented in all tables; these data are omitted from tables that show the distribution of incidents across several parameters. For example, the numbers of NA data are not shown in Table 13 which shows the distribution of incidents for steel pipelines across different locations and pipeline diameters. The NA data are omitted in these cases because of the complex distribution of the NA data.

The "estimated numbers" shown in these tables are typically not whole numbers. The presentation of significant digits is intended to aid traceability of the results; it does not indicate that the results are accurate to these numbers of digits.

Where tables show percentages, these relate to the "estimated number" category.

The estimated numbers are considered to be best estimates for use in the assessment of loss of containment frequencies. These values are carried forward into the reporting of loss of containment frequencies in Section 6.

The tables refer to the near and far safety zones. Safety zone – near refers to the incidents occurring within 100 m of the platform; Safety zone – far refers to incidents occurring within the safety zone but more than 100 m from the platform.

In the following tables "riser – unknown" refers to incidents where it is not known whether the loss of containment was above or below sea level. Incidents reported as "riser – unknown" have been redistributed in the estimated numbers into the above and below sea level categories. Similarly "safety zone – unknown" refers to incidents where it is not known whether the loss of containment was in the near or far areas of the safety zone; these have been redistributed in the estimated numbers into the near and far categories.

4.2.1 Steel pipelines

The incident database identifies 85 loss of containment events at operating steel pipelines in the period 2001 to 2012 inclusive. The distributions of these incidents across lines of different diameters and lengths are shown in Table 8 and Table 9.

Table 8: Steel pipelines – number of incidents by diameter

Diameter (inch)	Reported number	Estimated number
<= 6	25	32.4
>6 to 10	25	32.4
>10 to 16	16	20.9
>16	5	7.0
NA	14	–
Total	85	92.7

Table 9: Steel pipelines – number of incidents by length

Length (km)	Reported number	Estimated number
<=3	13	16.9
>3 to 10	23	29.5
>10 to 30	28	35.7
>30	8	10.7
NA	13	–
Total	85	92.8

Table 10 and Table 11 show the distribution of locations and types of fluid released in these incidents. Descriptions of the other location category include statements such as the following:

– spool piece;
– manifold crossover;
– line to subsea well;
– joint at manifold;
– towhead;
– seabed, and
– near SSIV.

Table 10: Steel pipelines – number of incidents by location on pipeline or riser

Location *	Reported number	Estimated number
Riser – above sea level	8	10.2
Riser – subsea	8	9.7
Riser – unknown	0	–
Safety zone – near	6	9.1
Safety zone – far	4	5.9
Safety zone – unknown	2	–
Midline	17	20.8
Well safety zone	5	6.6
SPM	0	0.55
Other	24	27.1
NA	11	–
Total	85	90.0
* The incident questionnaire also asked about loss of containment at the splash zone but no such incidents were identified.		

There are 16 loss of containment events that are explicitly identified as occurring at operating steel risers. The data in Table 10 indicate that 50 % (eight incidents) occurred above sea level and 50 % (eight incidents) occurred below sea level.

Table 11: Steel pipelines – number of incidents by pipeline fluid (continues overleaf)

Content	Reported number	Estimated number
Oil	25	28.1
Condensate	1	1.4
Gas	12	12.4
Multiphase	17	17.8
Methanol	6	6.6
Glycol	4	4.9

Table 11: Steel pipelines – number of incidents by pipeline fluid (continued)

Content	Reported number	Estimated number
Chemicals	3	3.6
Water	17	17.2
Other	0	0.47
NA	0	–
Total	85	92.4

Table 12 shows the numbers of incidents by type of equipment where leaks occurred. Descriptions of the other category include statements such as the following:

– stub pipework that holds the temperature sensor;
– below spider-deck level, above sea level on gas lift riser to subsea well;
– position unknown, near towhead;
– autoclave fitting;
– small-bore corrosion injection system, and
– sample collection point.

Table 12: Steel pipelines – number of incidents by leaking equipment type

Leak item	Reported number	Estimated number	Proportion
Body	40	45.8	50.6 %
Flange or connection	12	14.3	15.7 %
Valve	5	6.0	6.6 %
Pig trap	3	3.8	4.2 %
PLEM/PLET	2	2.7	3.0 %
Well equipment	4	4.9	5.4 %
Other	11	13.1	14.5 %
NA	8	–	–
Total	85	90.6	100 %

The analysis of incidents shows that leaks from steel pipelines are associated with failures in the body of the steel pipe and also failures from associated equipment and fittings. Table 12 shows the distribution of leaks from steel pipelines across the body of the pipeline and the associated equipment and fittings. It indicates that about 50 % of leaks from steel pipelines are from the body of the pipeline and a further 16 % are from connections (i.e. flanges or welds).

Table 13 shows the number of incidents at steel pipelines organised by location and diameter of the pipeline. Descriptions of the other category include statements such as those given at Table 10.

Table 13: Steel pipelines – number of incidents by location and diameter

Location	Diameter (inch)	Reported number	Estimated number
Riser	<= 6	3	4.3
	>6 to 10	4	5.5
	>10 to 16	6	9.2
	>16	0	0.66
Safety zone	<= 6	2	3.1
	>6 to 10	6	8.1
	>10 to 16	1	2.2
	>16	0	0.67
Midline	<= 6	6	7.1
	>6 to 10	4	4.9
	>10 to 16	4	5.8
	>16	2	3.0
Well safety zone	<= 6	0	0.9
	>6 to 10	1	2.6
	>10 to 16	1	2.9
	>16	0	0.90
Other	<= 6	13	13.2
	>6 to 10	9	9.3
	>10 to 16	0	0.59
	>16	2	2.7
Total		64	87.4

Table 14 shows the number of incidents at steel pipelines organised by type of pipeline fluid and diameter of the pipeline.

Table 14: Steel pipelines – number of incidents by pipeline fluid and diameter (continues overleaf)

Fluid	Diameter (inch)	Reported number	Estimated number
Oil	<= 6	5	6.00
	>6 to 10	8	9.27
	>10 to 16	4	4.91
	>16	4	4.91
Condensate	<= 6	0	0.40
	>6 to 10	1	1.20
	>10 to 16	0	0.40
	>16	0	0.40

Table 14: Steel pipelines – number of incidents by pipeline fluid and diameter (continued)

Fluid	Diameter (inch)	Reported number	Estimated number
Gas	<= 6	6	6.89
	>6 to 10	1	1.59
	>10 to 16	1	1.59
	>16	1	1.59
Multiphase	<= 6	5	4.95
	>6 to 10	7	6.75
	>10 to 16	4	4.05
	>16	0	0.45
Methanol	<= 6	5	5.32
	>6 to 10	0	0.48
	>10 to 16	0	0.48
	>16	0	0.48
Glycol	<= 6	4	3.94
	>6 to 10	0	0.44
	>10 to 16	0	0.44
	>16	0	0.44
Chemical	<= 6	0	0.53
	>6 to 10	1	1.59
	>10 to 16	1	1.59
	>16	0	0.53
Water	<= 6	0	0.52
	>6 to 10	7	7.85
	>10 to 16	6	6.80
	>16	0	0.52
Other	<= 6	0	0.40
	>6 to 10	0	0.40
	>10 to 16	0	0.40
	>16	0	0.40
Total		71	88.9

Table 15 shows the distribution of incidents by cause and location as reported in the incident database. Table 16 shows estimated numbers of incidents by cause and location after accounting for zero event categories and NA data.

Table 15: Steel pipelines – number of incidents (as reported) by location and cause

	Riser	Safety zone	Midline	Well safety zone	Other	Total
Impact	0	0	5	0	2	11.5 %
Material	5	5	9	1	12	52.5 %
Ops and Maintenance	4	0	1	0	2	11.5 %
Construction	0	2	1	1	2	9.8 %
Other	3	1	0	0	5	14.8 %
Total	19.7 %	13.1 %	26.2 %	3.3 %	37.7 %	100 %

Table 16: Steel pipelines – number of incidents (best estimates) by location and cause

	Riser	Safety zone	Midline	Well safety zone	Other	Total
Impact	0.62	0.62	5.74	0.81	2.43	12.0 %
Material	7.04	7.13	10.36	2.50	12.75	46.7 %
Ops and Maintenance	5.93	0.94	1.69	0.85	2.65	14.2 %
Construction	0.62	3.12	1.57	2.43	2.43	12.0 %
Other	4.32	1.87	0.52	0.81	5.35	15.1 %
Total	21.8 %	16.1 %	23.4 %	8.7 %	30.1 %	100 %

The categorisation of causes of failure is based on information provided by operators and judgement of the likely primary cause (multiple causes are identified for some incidents). Specific descriptions of the causes of leaks from steel pipelines include statements such as the following:

- thought to be due to a manufacturing defect;
- suspect faulty weld;
- internal corrosion (also suspect erosion from high velocity fluids);
- gas leak from chemical injection lines within the bundle is suspected but is NOT proven;
- corrosion exacerbated by chemical injection arrangement;
- suspected causes are combination of corrosion, erosion and structural failure;
- internal corrosion seen as pitting & through wall defects in lower half of the pipe;
- suspected MIC (microbial induced corrosion), under-deposit corrosion;
- potentially PWC (preferential weld corrosion);
- failed clamp on pipeline;
- mechanical damage suffered by the seal ring during initial installation;
- hydrogen induced stress cracking due to high temperature operation (within the design envelope);
- galvanic corrosion due to monel plug used on a duplex valve;

– erosion;
– design flaw;
– leak from valve stem gland, cause unknown (wear and tear);
– over-pressure of bundle caused rupture of carrier pipe (internal corrosion);
– over-pressurisation, and
– due to trawl gear.

Figure 10: External corrosion of steel riser

Of the 85 loss of containment event records at steel pipelines, the leaking hole size can be estimated in only 24 records as summarised in Table 17. In eight of these cases, the loss of containment is described as a rupture, and the hole size corresponds to the pipeline diameter. (The hole size is inferred from the pipeline diameter in some cases that are reported as ruptures.) Based on these data it is estimated that approximately 9 % of leaks from steel pipelines are ruptures. The data in Table 17 should not be used to obtain a representative distribution of hole sizes because this will overestimate the proportion of rupture cases. It is likely that these eight rupture cases include all ruptures that have occurred at steel pipelines. The causes of these ruptures are described as four material causes, two related to impact, and one associated with natural hazards.

Table 17: Steel pipelines – recorded hole size diameters (continues overleaf)

Hole diameter (mm)	Rupture	Pipeline diameter (inch)
406.4	Yes	16
304.8	Yes	12
273.1	Yes	10
254	Yes	10
254	Yes	10
114.3	Yes	4

Table 17: Steel pipelines – recorded hole size diameters (continued)

Hole diameter (mm)	Rupture	Pipeline diameter (inch)
101.6	Yes	4
88.9	Yes	3
50	No	6
15	No	14
12	No	8
10	No	8
5	No	8
5	No	6
5	No	4
5	No	8.625
5	No	12
3	No	3.125
3	No	8
2	No	3
1.5	No	3
0.3	No	3
0.1	No	10

Figure 11: Leak from steel pipeline, detected using green dye

4.2.2 Flexible pipelines

The incident database identifies 50 loss of containment events at operating flexible pipelines in the period 2001 to 2012 inclusive. The distributions of these incidents across lines of different diameters and lengths are shown in Table 18 and Table 19.

Table 18: Flexible pipelines – number of incidents by diameter

Diameter (inch)	Reported number	Estimated number
<= 4	8	11.2
>4 to 6	10	13.8
>6 to 8	16	21.7
>8	6	8.5
NA	10	–
Total	50	55.2

Table 19: Flexible pipelines – number of incidents by length

Length (km)	Reported number	Estimated number
<= 1	24	30.9
>1 to 5	5	6.9
>5 to 10	8	10.7
>10	5	6.9
NA	8	–
Total	50	55.4

Table 20 and Table 21 show the distribution of locations and types of fluid released in these incidents. Descriptions of the other category in Table 20 include statements such as the following:

- manifold;
- close to loading buoy;
- NRV skid, and
- umbilical termination.

Table 20: Flexible pipelines – number of incidents by location on pipeline or riser (continues overleaf)

Location *	Reported number	Estimated number
Riser – above sea level	0	0.65
Riser – subsea	19	23.9
Riser – unknown	1	–
Safety zone – near	2	2.9

Table 20: Flexible pipelines – number of incidents by location on pipeline or riser (continued)

Location *	Reported number	Estimated number
Safety zone – far	2	2.7
Safety zone – unknown	0	–
Midline	3	4.1
Well safety zone	9	11.3
SPM	2	2.7
Other	6	7.1
NA	6	–
Total	50	55.5
* The incident questionnaire also asked about loss of containment at the splash zone but no such incidents were identified.		

There are 20 loss of containment events that are explicitly identified as occurring at operating flexible risers. The data in Table 20 show that 19 releases occurred below sea level. The location of the other event is not known. No events are explicitly identified as occurring in the section of riser above sea level.

Table 21: Flexible pipelines – number of incidents by pipeline fluid

Content	Reported number	Estimated number
Oil	10	11.6
Condensate	0	0.00
Gas	8	8.4
Multiphase	22	22.8
Methanol	3	3.6
Glycol	0	0.54
Chemicals	1	1.5
Water	6	6.4
Other	0	0.47
NA	0	–
Total	50	55.3

Note that the estimated number of incidents involving leak of condensate from a flexible pipeline is zero because the population database does not identify any flexible pipelines carrying condensate.

Table 22 shows the numbers of loss of containment incidents at flexible pipelines per type of leaking item. Descriptions of the other category include descriptions such as the following:

- exact failure point to be determined as part of failure analysis;
- end of bend stiffener at lower tie-in end of riser;
- between riser base and mid water arch;
- flow meter, and
- swivel.

Table 22: Flexible pipelines – number of incidents by leaking equipment type

Leaking item	Reported number	Estimated number	Proportion
Body	22	23.8	42.8 %
Flange or connection	5	5.9	10.6 %
Valve	2	2.5	4.6 %
Pig trap	0	0.51	0.9 %
PLEM/PLET	0	0.51	0.9 %
Well equipment	1	1.5	2.7 %
Other	19	20.8	37.5 %
NA	1	–	–
Total	50	55.5	100 %

The analysis of incidents shows that leaks from flexible pipelines are associated with failures in the body of the flexible pipe and also failures from associated equipment and fittings. Table 22 shows the distribution of leaks from flexible pipelines across the body of the pipeline and the associated equipment and fittings. The tabulated values indicate that about 43 % of leaks from flexible pipelines are from the body of the pipeline and a further 11 % are from connections.

Table 23 shows the number of incidents at flexible pipelines organised by location and diameter of the pipeline. Descriptions of the other category include statements such as those given at Table 20.

Table 23: Flexible pipelines – number of incidents by location and diameter (continues overleaf)

Location	Diameter (inch)	Reported number	Estimated number
Riser	<= 4	0	0.6
	>4 to 6	4	5.7
	>6 to 8	10	12.1
	>8	4	5.0
Safety zone	<= 4	0	0.50
	>4 to 6	2	2.9
	>6 to 8	1	1.6
	>8	1	1.5
Midline	<= 4	2	3.1
	>4 to 6	0	0.7
	>6 to 8	0	0.6
	>8	0	0.6

Table 23: Flexible pipelines – number of incidents by location and diameter (continued)

Location	Diameter (inch)	Reported number	Estimated number
Well safety zone	<= 4	2	2.8
	>4 to 6	2	3.2
	>6 to 8	3	4.1
	>8	1	1.7
Other	<= 4	4	5.9
	>4 to 6	0	0.74
	>6 to 8	1	2.0
	>8	0	0.66
Total		37	56.1

Figure 12: Failure of flexible pipeline outer sheath

Table 24 shows the number of incidents at flexible pipelines organised by type of pipeline fluid and diameter of the pipeline.

Table 24: Flexible pipelines – number of incidents by pipeline fluid and diameter

Fluid	Diameter (inch)	Reported number	Estimated number
Oil	<= 4	1	2.02
	>4 to 6	2	3.37
	>6 to 8	2	3.37
	>8	1	2.02
Gas	<= 4	3	4.14
	>4 to 6	1	1.78
	>6 to 8	0	0.59
	>8	1	1.78
Multiphase	<= 4	1	1.28
	>4 to 6	6	5.56
	>6 to 8	13	11.55
	>8	2	2.14
Methanol	<= 4	3	2.99
	>4 to 6	0	0.43
	>6 to 8	0	0.43
	>8	0	0.43
Glycol	<= 4	0	0.44
	>4 to 6	0	0.44
	>6 to 8	0	0.44
	>8	0	0.44
Chemical	<= 4	0	0.63
	>4 to 6	0	0.63
	>6 to 8	0	0.63
	>8	0	0.63
Water	<= 4	0	0.55
	>4 to 6	1	1.65
	>6 to 8	1	1.65
	>8	2	2.75
Other	<= 4	0	0.40
	>4 to 6	0	0.40
	>6 to 8	0	0.40
	>8	0	0.40
Total		40	56.35

Table 25 shows the distribution of incidents by cause and location as reported in the incident database. Table 26 shows the distribution of incidents (best estimate) by cause and location after accounting for NA data.

Table 25: Flexible pipelines – number of incidents (as reported) by location and cause

	Riser	Safety zone	Midline	Well safety zone	Other	Total
Impact	0	0	1	0	0	3.7 %
Material	8	3	1	0	3	55.6 %
Ops and Maintenance	0	0	0	0	0	0.0 %
Construction	0	0	0	0	0	0.0 %
Other	7	1	1	0	2	40.7 %
Total	55.6 %	14.8 %	11.1 %	0.0 %	18.5 %	100 %

Table 26: Flexible pipelines – number of incidents (best estimates) by location and cause

	Riser	Safety zone	Midline	Well safety zone	Other	Total
Impact	0.64	0.49	1.55	2.02	0.65	9.8 %
Material	10.85	3.42	1.55	2.02	4.55	41.1 %
Ops and Maintenance	0.64	0.76	0.52	2.02	0.65	8.4 %
Construction	0.64	0.49	0.52	2.02	0.65	7.9 %
Other	9.57	1.46	1.55	2.02	3.25	32.8 %
Total	41.0 %	12.1 %	10.5 %	18.5 %	17.9 %	100 %

The categorisation of causes of failure is based on information provided by operators and judgement of the primary cause (multiple causes are identified for some incidents). Specific descriptions of the causes of leaks from flexible pipelines include statements such as the following:

– possible disbonding of end fitting from body of flexible (internal corrosion);
– floating, processing, storage and offloading (FPSO) vessel excursion (six leaks in the database associated with two extreme weather events);
– cracking due to poor fabrication and/or lack of process/quality controls in manufacturing;
– failure of temporary clamp;
– vibration of top screw fitting on bleed valve arrangement;
– corrosion or material defect, and
– leakage from pre-designed vent apparatus on the flexible flowline's outer sheath.

In addition, there were several events described as connection failures, but no specific reasons were given for the connection failure.

The hole sizes of leaks from flexible pipelines are not reported here because the only hole that can be seen in a flexible pipeline that has not ruptured is the hole in the outer sheath. Of the 50 loss of containment event records at operating flexible pipelines, nine are described as ruptures (Table 27). Based on these data it is estimated that approximately 18 % of loss of containment events at operating flexible pipelines are ruptures.

Table 27: Flexible pipelines – rupture cases

Hole diameter (mm)	Rupture	Pipeline diameter (inch)
304.8	Yes	12
254	Yes	10
203.2	Yes	8
203.2	Yes	8
152.4	Yes	6
152.4	Yes	6
19.1	Yes	0.75
19.1	Yes	0.75
NA	Yes	NA

Figure 13: Cut through section of used flexible pipeline

4.2.3 Control umbilicals

The incident database identifies only 10 loss of containment events at operating control umbilicals in the period 2001 to 2012 inclusive. The small number of total loss containment events for control umbilicals means that several categories in the following tables show only very small numbers of events including many zero event cases. Users should note the uncertainties associated with such data, particularly the issues described in Sections 4.1.5 and 7.4.

This section does not present any information on the variation of numbers of leak incidents by diameter; the diameter of an umbilical does not have the same significance as the diameter of a steel or flexible pipeline because the diameter of a control umbilical reflects the number of cores some of which are for power, signal and hydraulics.

The distribution of these incidents across umbilicals of different lengths is shown in Table 28. The data shown in Table 29 to Table 33 show additional information on the distributions of leak incidents from control umbilicals. Due to the small number of reported leak incidents, these data are provided for information only and are not carried forward into the analysis of frequencies.

Table 28: Control umbilicals – number of incidents by length

Length (km)	Reported number	Estimated number
<= 10	4	5.3
>10	5	6.5
NA	1	–
Total	10	11.8

Table 29: Control umbilicals – number of incidents by location on umbilical

Location	Reported number	Estimated number
Riser – above sea level	0	0.54
Riser – subsea	1	1.5
Riser – unknown	0	–
Safety zone – near	2	3.3
Safety zone – far	1	1.8
Safety zone – unknown	1	–
Midline	1	1.6
Well safety zone	3	3.8
SPM	0	0.49
Other	1	1.5
NA	0	–
Total	10	14.4

Table 30: Control umbilicals – number of incidents by content

Content	Reported number	Estimated number
Methanol	2	2.5
Glycol	1	1.6
Chemicals	7	7.6
Other	0	0.47
NA	0	–
Total	10	12.3

Table 31: Control umbilicals – number of incidents by leaking equipment type

Leaking item	Reported number	Estimated number	Total
Body	3	3.6	26.2 %
Flange or connection	0	0.52	3.8 %
Valve	0	0.50	3.6 %
Pig trap	0	0.50	3.6 %
PLEM/PLET	0	0.5	3.6 %
Well equipment	3	3.5	25.2 %
Other	4	4.7	34.1 %
NA	0	–	–
Total	10	13.9	100 %

The other category in Table 31 includes leaks from items described as fittings.

Table 32 shows the distribution of incidents by cause and location as reported in the incident database. Table 33 shows the distribution of incidents (best estimate) by cause and location after accounting for NA data. There are only a small number of incidents at control umbilicals where the cause and location are identified.

Table 32: Control umbilicals – number of incidents (as reported) by location and cause

	Riser	Safety zone	Midline	Well safety zone	Other	Total
Impact	0	0	0	0	1	14.3 %
Material	0	1	0	0	0	14.3 %
Ops and Maintenance	0	0	0	2	0	28.6 %
Construction	0	0	1	0	0	14.3 %
Other	1	1	0	0	0	28.6 %
Total	14.3 %	28.6 %	14.3 %	28.6 %	14.3 %	100 %

Table 33: Control umbilicals – number of incidents (best estimates) by location and cause

	Riser	Safety zone	Midline	Well safety zone	Other	Total
Impact	0.46	0.61	0.46	0.59	1.28	16.6 %
Material	0.46	1.82	0.46	0.59	0.43	18.4 %
Ops and Maintenance	0.46	0.88	0.46	2.93	0.43	25.3 %
Construction	0.46	0.61	1.37	0.59	0.43	16.9 %
Other	1.38	1.82	0.46	0.59	0.43	22.9 %
Total	15.8 %	28.1 %	15.6 %	25.9 %	14.6 %	100 %

The categorisation of causes of failure is based on information provided by operators and judgement of the likely primary cause (multiple causes are identified for some incidents). Specific descriptions of the causes of leaks from control umbilicals include statements such as the following:

– suspected anchor drop;
– existing umbilical severed during trenching for a new umbilical, and
– damage caused by a storm.

4.3 PIPELINE REMOVALS

The incident database identifies 13 loss of containment events that occurred during removal activities. Most of these leak incidents occurred in connection with incomplete flushing of lines and involve very small release quantities. The 13 incidents occurred at seven flexible lines, two steel lines and four where the type is NA.

This category includes leaks which occurred while flexible lines were being recovered from the seabed following an earlier extreme weather vessel excursion incident in which lines had been damaged. The original leaks which occurred during the vessel excursion are included in the statistics for operating lines.

Brief descriptions of the circumstances for some of these incidents include statements such as the following:

– release of small amount of oil residue as SSIV flange was removed to allow access;
– release of remnant oil from flowline as remotely operated vehicle (ROV) moved severed production line;
– residual oil from previously cut riser sections;
– surface sheen identified as residual oil trapped within production riser released during riser recovery operations;
– small release of oil release during recovery;
– release resulting from insufficient flushing of line prior to removal/incomplete riser flushing, and
– release of residual diesel from cut during decommissioning during decommissioning operations.

4.4 PIPELINE COMMISSIONING AND TEST

The incident database identifies 10 loss of containment events that occurred during pipeline commissioning and/or test activities. These incidents included two flexible lines, two steel lines, five control umbilicals and one where the type is unknown/NA.

Descriptions of the circumstances of these leaks include statements such as the following:
- hydrostatic pressure testing to design limit as part of repair to trawling damage (upheaval buckling);
- the methanol core has failed somewhere inside the umbilical, and
- opening of the wrong valve (incorrect operation).

4.5 NEAR MISS INCIDENTS

The primary focus of PARLOC is on incidents that resulted in a loss of containment. While gathering data on these incidents, some pipeline operators provided information on near miss incidents. These near miss incidents occurred during operations (20 incidents) and during construction/testing (three incidents).

Descriptions of the circumstances of these leaks include statements such as the following:
- tanker moored during a storm dragged anchor across pipeline;
- bend stiffener support wires failed;
- manufacturing defect;
- survey showed pipe had lost its concrete weight coating and was floating about 5 m above the seabed;
- pipeline was displaced from as-laid position such that a 40 m length of 50 mm anchor chain and a 200 m length of 50 mm wire detected and positioned perpendicular to the direction of the pipeline route (chain subsequently removed and the displacement believed to have occurred when a trenching plough caught the wire and dragged the pipeline);
- vessel collision at NUI – damage to the riser and clamping arrangements;
- scouring and freespan;
- intelligent pigging indicated that repairs were required;
- caisson parted from clamp and fell below sea level;
- during pipe lay a previously installed and tested dead man anchor (DMA), which was being used as the pull load, was dragged out of position;
- one of the main concrete covers that lays over the main export line has subsided causing damage to the bottom riser guide;
- break up of flexible riser internal material – “small pieces of steel and plastics were found inside the topside choke valve”;
- post-commissioning survey discovered upheaval buckling, and
- tow cable became slack and may have touched the seabed.

5 PIPELINE DATA ANALYSIS

This section presents a series of tables that describe the population data for control umbilicals, steel pipelines and flexible pipelines as contained in the PARLOC 2012 pipeline database.

The PARLOC 2012 database identifies 1,372 steel pipelines and 1,288 flexible pipelines with total operating experience of 219,165 km-years for steel pipelines and 10,133 km-years for flexible pipelines. The database identifies a combined population (steel and flexible) of 1,570 risers with operating experience of 15,971 riser years. Sections 5.1 and 5.2 describe the population data for steel pipelines and flexible pipelines in further detail.

As discussed in Section 3, the PARLOC 2012 pipeline population database uses the Oil & Gas UK decommissioning database as a basis for estimating the population of control umbilicals on the UKCS. The database contains 2,462 records. Of these records, 2,102 are on the UKCS, and these include 452 that are categorised as umbilicals. A close reading of the umbilical records shows that the term has been applied to both control umbilicals and flexible pipelines. Full identification of control umbilicals is therefore not explicit but must be inferred from information in various database fields including free text descriptions. Section 7 discusses the treatment of this source of uncertainty.

There is insufficient information in the umbilical population database to estimate a single number and operating experience for control umbilical risers.

Figure 14 summarises the process for development of pipeline operating experience data tables presented in this section. The figure includes cross-references to sections that describe elements of the process in more detail.

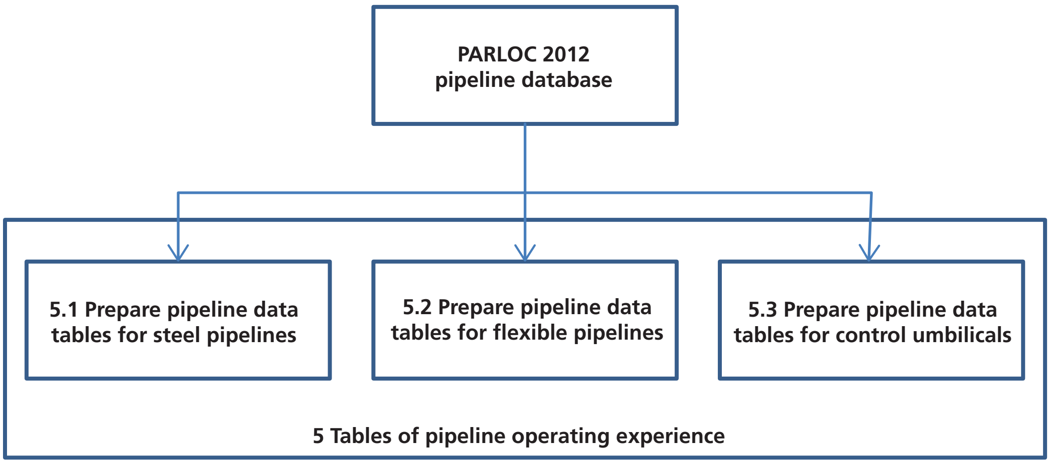

Figure shows cross-references to report sections (5.1 etc.) that describe elements of the process in more detail.

Figure 14: Flow diagram – preparation of pipeline operating experience data

5.1 STEEL PIPELINES

Table 34 shows the operating experience for steel pipelines and risers in each range of diameters. Table 35 shows the operating experience for steel pipelines in each range of lengths. Table 36 shows the operating experience for steel pipelines carrying different fluids. Table 37 shows the operating experience for steel risers.

Table 34: Steel pipeline operating experience in PARLOC 2012 database – diameter

Diameter (inch)	Pipelines		Risers	
	Number	Km-years	Number	Riser-years
<= 6	584	4,7051.6	372	3,856
>6 to 10	346	27,913.5	261	2,650
>10 to 16	234	36,004.5	275	2,936
>16	208	108,195.4	222	2,555
All diameters	1,372	219,165	1,130	11,997

Table 35: Steel pipeline operating experience in PARLOC 2012 database – length

Length (km)	Number	Km-years
<= 3	488	4,128.4
>3 to 10	439	27,453.1
>10 to 30	288	48,107.6
>30	157	139,475.9
All lengths	1,372	219,165

Table 36: Steel pipeline operating experience in PARLOC 2012 database – fluid content (continues overleaf)

Fluid	Pipelines		Risers	
	Number	Km-years	Number	Riser-years
Oil	159	31,195.2	168	1,805
Condensate	10	3,774.0	15	178
Gas	411	90,466.2	366	3,924
Multiphase HC	341	43,858.7	253	2,636
Methanol	98	16,558.3	121	1,259
Glycol	67	13,852.7	84	870
Chemicals	16	857.7	5	60
Water	147	8,310.0	91	963
Other	36	2,598.2	27	302

Table 36: Steel pipeline operating experience in PARLOC 2012 database – fluid content (continued)

Fluid	Pipelines		Risers	
	Number	Km-years	Number	Riser-years
Carrier *	87	7,694.2	0	0
All fluid types	1,372	219,165	1,130	11,997
* Steel pipelines marked as carrier occur as parts of pipeline bundles. They do not carry any fluid.				

Table 37: Steel riser operating experience in PARLOC 2012 database

Type	Number	Experience (riser-years)
Steel	1,130	11,997

5.2 FLEXIBLE PIPELINES

Table 38 shows the operating experience for flexible pipelines and risers in each range of diameters. Table 39 shows the operating experience for flexible pipelines in each range of lengths. Table 40 shows the operating experience for flexible pipelines carrying different fluids. Table 41 shows the operating experience for flexible risers.

Table 38: Flexible pipeline operating experience in PARLOC 2012 database – diameter

Diameter (inch)	Pipelines		Risers	
	Number	Km-years	Number	Riser-years
<= 4	511	2,338.8	65	593
>4 to 6	538	3,998.8	183	1,607
>6 to 8	148	2,446.6	102	860
>8	91	1,348.7	90	914
All diameters	1,288	10,132.8	440	3,974

Table 39: Flexible pipeline operating experience in PARLOC 2012 database – length

Length (km)	Number	Km-years
<= 1	1,028	1,195.5
>1 to 5	195	3,967.0
>5 to 10	58	4,088.6
>10	7	881.7
All lengths	1,288	10,132.8

Table 40: Flexible pipeline operating experience – fluid content

Fluid	Pipelines		Risers	
	Number	Km-years	Number	Riser-years
Oil	204	2,372.1	103	987
Gas	361	2,505.5	98	851
Multiphase HC	439	2,680.9	137	1,186
Methanol	15	522.0	11	128
Glycol	9	66.5	0	0
Chemicals	2	25.5	0	0
Water	231	1,694.8	71	608
Other	27	265.4	20	214
All fluid types	1,288	10,132.8	440	3,974

Table 41: Flexible riser operating experience in PARLOC 2012 database

Type	Number	Experience (riser-years)
Flexible	440	3,974

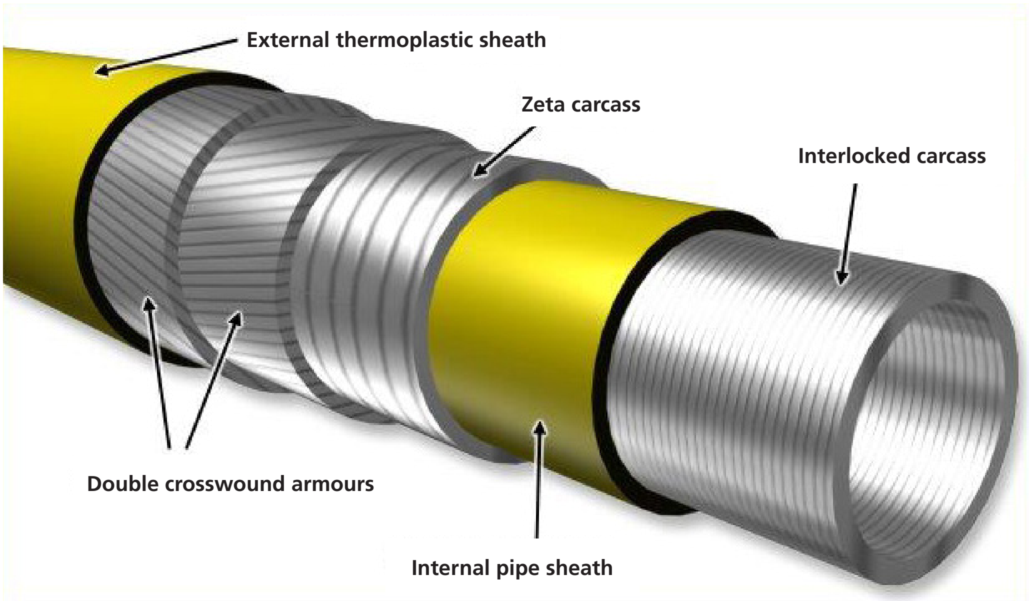

Figure 15: Basic flexible pipe structure

5.3 CONTROL UMBILICALS

Table 42 shows a high level summary of the entries in the Oil & Gas UK decommissioning database indicating the number of entries that are confidently identified as control umbilicals, lines that are confidently identified as not being control umbilicals and a group where type cannot be determined but are consistent with being control umbilicals.

Dates for commissioning and decommissioning of control umbilicals are not generally available for lines that are identified, or potentially identified, as control umbilicals. The commissioning year is known in a small number of cases and, where available, this has been included in estimates for the age of the umbilicals. Where the age is not known it has been assumed that the umbilical has been on the seabed for the full period 2001 to 2012 i.e. 12 years.

Data for the length of some control umbilicals are not available. Specifically, for the 209 records that are confidently identified as control umbilicals, the length is not known for 37 records (approximately 18 % of 209 records). For the additional 217 records that are also potentially control umbilicals, the length is not known for 43 records (approximately 20 % of 217 records). These factors are used to adjust the experience to obtain the best estimate experience values in Table 42.

Table 42: Control umbilicals in PARLOC 2012 database – experience

Control umbilicals	Number of records	Reported total length (km)	Reported experience (km-years)	Best estimate experience (km-years)
Yes	209	961	11,341	13,781
Cannot be determined	217	1,490	10,463	13,049
No	2,036	41,446	470,942	–

Table 42 shows that the best estimate population experience as measured in km-year for the lines whose type cannot be determined is similar to the experience to the lines that are confidently identified as control umbilicals. This indicates a high level of uncertainty in the estimates of population data for control umbilicals; the total experience of control umbilicals is estimated to be in the range 13,781 to 26,830 km-years i.e. the uncertainty in experience of control umbilicals is approximately a factor of two.

The estimates of average loss of containment frequency (Section 6.3) are based on the lower estimate of control umbilical experience (13,781 km-years) such that the average loss of containment frequency will be conservatively overestimated, by up to a factor of two, as the result of this source of uncertainty.

Column 3 of Table 43 shows the best estimate experience for umbilicals of different lengths.

Table 43: Control umbilical experience in PARLOC 2012 database – by length

Length (km)	Experience (km-years)	Best estimate experience (km-years)
<= 10	5,761.9	7,001.4
>10	5,579.6	6,779.8
All lengths	11,341.5	13,781.2

6 LOSS OF CONTAINMENT FREQUENCIES

This section presents a series of tables which describe generic loss of containment frequencies for operating pipelines and control umbilicals. These recommended generic frequencies of loss of containment are based on the numbers of incidents in the PARLOC 2012 incident database and corresponding operating experience (measured in km-years) in the PARLOC pipeline database which are presented in Sections 4 and 5.

The average loss of containment frequencies, or failure rates, have been calculated using the following basic formula:

$$\mathit{Failure\ rate} = \frac{\mathit{Number\ of\ failures}}{\mathit{Operating\ experience}}$$

where operating experience for pipelines is expressed in terms of km-years, and the units of failure rate are per km-year. For risers the operating experience is measured in riser years, and the unit of failure rate is per riser year.

Figure 16 summarises how the generic loss of containment frequencies are derived from incident data and pipeline operating experience.

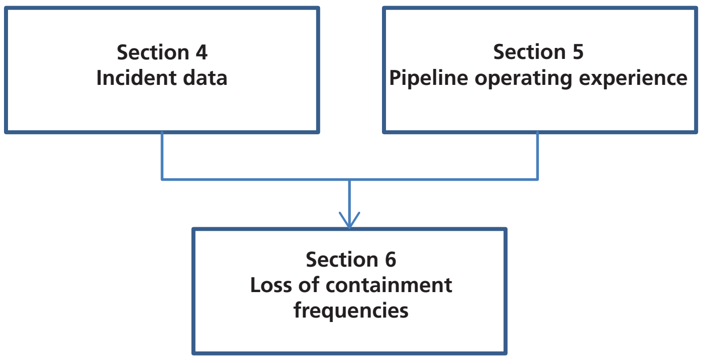

Figure 16: Flow diagram – definition of loss of containment frequencies

6.1 STEEL PIPELINES AND RISERS

The average frequency of loss of containment from operating steel pipelines (averaged across all categories of such pipelines) is estimated to be 4.2 x 10^{-4} per km-year. Based on the probability data discussed in Section 4.2.1, the frequency of rupture is estimated to be 4.0 x 10^{-5} per km-year.

Table 44 and Table 45 show the total frequency of loss of containment from steel pipelines (including associated equipment and fittings) and the variation of frequency by diameter and length. Note that Table 44 and Table 45 include the contributions to leak frequencies from risers.

Table 44: Steel pipelines – variation of failure frequency by diameter

Diameter (inch)	Estimated number of incidents	Experience (km-years)	Frequency (per km-year)
<= 6	32.4	47,051.6	6.88E-04
>6 to 10	32.4	27,913.5	1.16E-03
>10 to 16	20.9	36,004.5	5.82E-04
>16	7.0	108,195.4	6.45E-05
Total/average	92.7	219,165.0	4.23E-04

Table 45: Steel pipelines – variation of failure frequency by length

Length (km)	Estimated number of incidents	Experience (km-years)	Frequency (per km-year)
<= 3	16.9	4,128.4	4.10E-03
>3 to 10	29.5	27,453.1	1.07E-03
>10 to 30	35.7	48,107.6	7.43E-04
>30	10.7	139,475.9	7.64E-05
Total/average	92.8	219,165.0	4.23E-04

The failure frequencies presented in Table 45 show a clear trend with short pipelines having higher failure frequencies (per km-year) than longer pipelines. This trend may be due to longer pipelines being pigged and better managed; most short pipelines are not piggable. It is possible that this trend is also partially related to better reporting of incidents within the safety zone and greater likelihood of mechanical damage. Table 46 shows the variation of leak frequency by diameter for steel risers.

Table 46: Steel risers – variation of failure frequency by diameter

Diameter (inch)	Estimated number of incidents	Experience (riser-years)	Frequency (per riser-year)
<= 6	4.3	3,856	1.10E-03
>6 to 10	5.5	2,650	2.07E-03
>10 to 16	9.2	2,936	3.14E-03
>16	0.66	2,555	2.57E-04
Total/average	19.6	11,997	1.64E-03

Table 47 shows the frequency of loss of containment from steel pipelines and variation by type of fluid content.

Table 47: Steel pipelines – variation of failure frequency by pipe fluid

Pipe fluid	Estimated number of incidents	Experience (km-years)	Frequency (per km-year)
Oil	28.1	31,195.2	9.00E-04
Condensate	1.4	3,774.0	3.75E-04
Gas	12.4	90,466.2	1.37E-04
Multiphase	17.8	43,858.7	4.05E-04
Methanol	6.6	16,558.3	4.00E-04
Glycol	4.9	13,852.7	3.54E-04
Chemicals	3.6	857.7	4.16E-03
Water	17.2	8,310.0	2.07E-03
Other	0.47	2,598.2	1.82E-04

It is noted that the frequency of failure for steel pipelines carrying chemicals appears to be anomalously high when compared to the frequencies for other categories of steel pipelines. The result may be a statistical anomaly because it is based on a small number of incidents (two explicitly identified) in a relatively small population. These incidents both occurred at flowline terminations at the same facility (but apparently different terminations).

6.2 FLEXIBLE PIPELINES

The average frequency of loss of containment from operating flexible pipelines (averaged across all categories of such pipelines) is estimated to be 5.5 x 10^{-3} per km-year. Based on the probability data discussed in Section 4.2.2, the frequency of rupture is estimated to be 9.8 x 10^{-4} per km-year.

Table 48 and Table 49 show the total frequency of loss of containment from flexible pipelines (including associated equipment and fittings) and the variation of frequency by diameter and length. Note that Table 48 and Table 49 include the contributions to leak frequencies from risers.

Table 48: Flexible pipelines – variation of failure frequency by diameter

Diameter (inch)	Estimated number of incidents	Experience (km-years)	Frequency (per km-year)
<= 4	11.2	2,338.8	4.78E-03
>4 to 6	13.8	3,998.8	3.45E-03
>6 to 8	21.7	2,446.6	8.86E-03
>8	8.5	1,348.7	6.33E-03
Total/average	55.2	10,132.8	5.45E-03

Table 49: Flexible pipelines – variation of failure frequency by length

Length (km)	Estimated number of incidents	Experience (km-years)	Frequency (per km-year)
<= 1	30.9	1,195.5	2.58E-02
>1 to 5	6.9	3,967.0	1.75E-03
>5 to 10	10.7	4,088.6	2.62E-03
>10	6.9	881.7	7.86E-03
Total/average	55.4	10,132.8	5.47E-03

Table 50 shows the variation of leak frequency by diameter for flexible risers.

Table 50: Flexible risers – variation of failure frequency by diameter

Diameter (inch)	Estimated number of incidents	Experience (riser-years)	Frequency (per riser-year)
<= 4	0.6	593	9.34E-04
>4 to 6	5.7	1,607	3.56E-03
>6 to 8	12.1	860	1.41E-02
>8	5.0	914	5.45E-03
Total/average	23.4	3,974	5.89E-03

Table 51 shows the frequency of loss of containment from flexible pipelines and variation by type of fluid content.

Table 51: Flexible pipelines – variation of failure frequency by pipe fluid

Pipe fluid	Estimated number of incidents	Experience (km-years)	Frequency (per km-year)
Oil	11.6	2,372.1	4.87E-03
Gas	8.4	2,505.5	3.36E-03
Multiphase	22.8	2,680.9	8.52E-03
Methanol	3.6	522.0	6.84E-03
Glycol	0.54	66.5	8.19E-03
Chemicals	1.5	25.5	5.99E-02
Water	6.4	1,694.8	3.77E-03
Other	0.47	265.4	1.78E-03

It is noted that the frequency of failure for flexible pipelines carrying chemicals appears to be anomalously high when compared to the frequencies for other categories of flexible pipelines. The result may be a statistical anomaly because it is based only on one incident from a small population. This one incident occurred as the result of a vessel moving off station during extreme weather conditions. The cause of the failure is therefore unrelated to the fluid content.

6.3 CONTROL UMBILICALS

The incident database explicitly identifies only 10 loss of containment incidents, and the best estimate number of incidents is about 12 incidents including contributions from NA data. The operating experience for control umbilicals is estimated to be 13,781 km-year, but there is significant uncertainty associated with this estimate. Due to the small number of incidents and uncertainty in the operating experience, it is recommended that risk assessments adopt a single value of 1×10^{-3} per km-year for the frequency of loss of containment for all categories of control umbilicals.

Table 52 shows the total frequency of loss of containment from control umbilicals (including associated equipment and fittings) and the variation of frequency by length.

Table 52: Control umbilicals – variation of failure frequency by length

Length (km)	Estimated number of incidents	Experience (km-years)	Frequency (per km-year)
<= 10	5.31	7,001.4	7.59E-04
>10	6.49	6,779.8	9.57E-04
Total/average	11.80	13,781.22	8.56E-04

7 DISCUSSION

7.1 INTRODUCTION

This section includes a comparison of high level results from PARLOC 2001 and PARLOC 2012.

Key assumptions are then identified and discussed.

This is followed by an extended discussion of the various types of uncertainty in the results and the effect of these uncertainties on the estimated frequencies for loss of containment.

7.2 COMPARISON OF RESULTS 2012 VS 2001

This section compares the high level findings from the PARLOC 2001 and PARLOC 2012 studies.

When comparing the dimensions of the databases for PARLOC 2001 and PARLOC 2012, it is important to recognise the different scopes of these studies: PARLOC 2001 included all incidents and all operating experience in the oil and gas industry in the North Sea (including non-UK sectors) up to the end of 2000, whereas PARLOC 2012 covers only the incidents and experience in the oil and gas industry on UKCS in the 12-year period 2001 to 2012.

Regarding PARLOC 2001, it is noted that there is some uncertainty about the earliest start date for incidents. Reporting criteria were also different, and there is some uncertainty about the completeness of the PARLOC 2001 incident data set.

Table 53, Table 54 and Table 55 summarise the numbers of incidents and operating experience of pipelines and risers in the PARLOC 2012 and PARLOC 2001 databases.

The population data for PARLOC 2001 is based on reference 5, Table 3-1.

Table 53: Comparison of numbers of incidents, PARLOC 2001 vs. PARLOC 2012

Incident category	PARLOC 2001	PARLOC 2012
LOC incidents at operating lines, steel + flexible	188	135
LOC incidents at operating lines, steel	150	85
LOC incidents at operating lines, flexible	38	50

The total length of pipelines (steel and flexible) in the 2001 database was 24,837 km. The total length of pipelines (steel and flexible) in the 2012 database is 21,339 km.

Table 54: Comparison of populations PARLOC 2001 vs. PARLOC 2012 – pipelines and umbilicals

	PARLOC 2001		PARLOC 2012	
Type	**Number**	**Experience (km-years)**	**Number**	**Experience (km-years)**
Steel	1,069	307,246	1,372	219,165
Flexible	498	8,155	1,288	10,133
Total (steel and flexible)	1,567	315,401	2,660	229,298
Control umbilicals	–	–	209 to 426	13,781 to 26,830

Table 55: Comparison of populations PARLOC 2001 vs. PARLOC 2012 – risers

	PARLOC 2001		PARLOC 2012	
Type	**Number**	**Experience (riser-years)**	**Number**	**Experience (riser-years)**
Steel	1,256	16,776	1,130	11,997
Flexible	See note 1	1,052	440	3,974
Total (steel and flexible)		17,857	1,570	15,971
Notes: (1) value is not reported in PARLOC 2001.				

Table 56 shows the average failure rates for pipelines and control umbilicals as reported in the 2001 and 2012 studies. Comparison of these average failure rates shows that the change in the failure frequency for steel pipelines is small (the 2012 frequency is about 13 % smaller than the 2001 result). The consistency between the failure frequencies reported for steel pipelines in the PARLOC 2001 report and in this report increases the overall confidence that the failure frequency is broadly correct. The failure frequency for flexible flowlines in the PARLOC 2012 study is about 17 % higher than the PARLOC 2001 failure frequency. Again, the consistency between the failure frequencies reported for flexible pipelines in the PARLOC 2001 report and in this report increases the overall confidence that the failure frequency is broadly correct.

Table 56: Comparison of failure frequencies – PARLOC 2001 vs. PARLOC 2012

	PARLOC 2001 Frequency (per km-year)	**PARLOC 2012 Frequency (per km-year)**
Steel pipelines	4.88×10^{-4}	4.23×10^{-4}
Flexible pipelines	4.66×10^{-3}	5.47×10^{-3}
Control umbilicals	No estimate	1.0×10^{-3}

7.3 ASSUMPTIONS

This subsection describes the main assumptions that underlie the PARLOC 2012 assessment of pipeline and riser loss of containment frequencies. Table 57 lists these assumptions and provides a justification for each assumption together with comments on the implications of the assumption in the study.

Table 57: Key assumptions in the PARLOC 2012 update (continues overleaf)

Topic	Assumption	Comment/justification
Identification of incidents	The evaluation of loss of containment frequencies (Section 6) assumes that the incident database identifies all relevant loss of containment incidents that have occurred on the UKCS in the 12-year period 2001 to 2012.	The PARLOC 2012 update study has endeavoured to obtain a complete record of incidents. It is judged likely that relatively few incidents remain unidentified, but it seems inevitable that some incidents are missing from the database. (The report discusses reasons for underreporting of some categories of incident.) To the extent that loss of containment incidents have been omitted from the incident database, this assumption will tend to result in an underestimate of the loss of containment frequencies.
Description of incidents – handling of incomplete data	Where the description of a loss of containment incident is incomplete, the data are assumed to be missing at random (MAR). This assumption is used to impute the distribution of missing data. Specifically, the distribution of missing data is assumed to have the same distribution as known data.	There are gaps in the descriptions of identified incidents e.g. information on the diameter of a pipeline may be not available or the pipeline fluid type may be unrecorded. MAR describes a situation in statistical analysis where the reason for data being missing is not related to the value of the missing data. An exception to this assumption relates to the distribution of hole sizes where small hole sizes may be systematically underreported. It should be noted that this report does not attempt to provide a hole size distribution. This assumption applies only to incidents that have been identified. The report describes reasons why incidents that are entirely missing from the incident database may be missing not at random (MNAR) e.g. potential underreporting of gas leaks at remote sections of pipeline due to detection difficulties.

Table 57: Key assumptions in the PARLOC 2012 update (continued)

Topic	Assumption	Comment/justification
Description of incidents – handling of zero event categories	In order to avoid problems in the interpretation of incident data the analysis uses a smoothing technique that adds 0.5 events to each plausible category of events.	The PARLOC study deals with the interpretation of relatively rare events. The incident database records all known loss of containment events. There are several categories of events that are plausible but where no event has been found in the period covered by these records. A naive interpretation of the data for these zero event categories would indicate that the underlying frequency of this event is zero. The smoothing assumption is a significant improvement on this naive interpretation. The assumption is an application of the Jeffrey-Perks law. Issues related to this assumption are further discussed in Section 4.1.
Identification of pipelines and control umbilicals	The evaluation of loss of containment frequencies assumes that the pipeline (and control umbilical) population database identifies all relevant pipelines and control umbilicals that were operating on the UKCS in the 12-year period 2001 to 2012.	The PARLOC 2012 update study included a review of available pipeline databases. It is judged likely that the selected pipeline database identifies all relevant pipelines. The database of control umbilicals is the best that was available to the study, but the population of control umbilicals is uncertain. The main report discusses this uncertainty.
Description of pipelines and control umbilicals	The description of pipelines is assumed to be accurate and correctly aligned to the description of incidents.	The pipeline population database is derived from a commercial database. All data fields in the commercial database are fully populated. Spot checks on the data in this database show that it is generally in good agreement with the data in other databases.

Table 57: Key assumptions in the PARLOC 2012 update (continued)

Topic	Assumption	Comment/justification
Description of pipelines and control umbilicals continued...		Alignment of the incident and pipeline population databases refers to the descriptions of pipelines in the incident database. Specifically it is assumed that the databases use consistent terminology and definitions in the descriptions. Examples of necessary alignments include categorisation of lines as either steel, flexible or control umbilical, and categorisation of fluids as oil, condensate, gas, multiphase, methanol, glycol, chemical, water and other.
Operating experience – period of operation	Where the period of operation is not known, it is assumed that the pipeline has been operating for the full 12-year period of the study.	The pipeline and control umbilical databases do not identify the period operation for each pipeline. The operating period has been explicitly estimated for relatively few pipelines – mainly those that are known to have been decommissioned. It is judged likely that the large majority of the remaining pipelines have been operating for most, or all, of the 12-year period covered by the study. This assumption may result in the operating period being overestimated, and an overestimate of the loss of containment frequency. This report recommends that work is done to add operating experience data to the pipeline (and control umbilical) database. Section 3.2.1 contains further details of the counting conventions for operating experience.

Table 57: Key assumptions in the PARLOC 2012 update (continued)

Operating experience – effect of age on failure rates	The number of loss of containment incidents is assumed to be proportional to the operating experience as measured in km-years.	Corrosion and fatigue damage are functions of the complete life of the pipeline, not just the statistical period covered by this report. The number of loss of containment incidents due to corrosion and material damage may be more accurately measured in terms of km-years of full life. This report does not estimate the complete life of pipelines or make any assessment of the effect of age on failure rates.
Counting of risers	Some risers are explicitly identified in the PARLOC 2012 database, but others must be inferred from connections of pipelines to platforms. It is assumed that there is one riser for each pipeline connected to a platform (except for bundle carrier pipelines).	Section 3.2.1 describes the counting conventions for risers. This report recommends that risers should be explicitly identified in the PARLOC pipeline database.

7.4 UNCERTAINTY IN THE PARLOC 2012 RESULTS

Users of these failure rate data should recognise the limitations of the data presented in this report as best estimate generic averages. All of these data have some associated uncertainty; in practice the records of failures and pipeline population may be incomplete and/or inaccurate. This leads to uncertainties in the calculated average failure rates.

Other sources of uncertainty would exist even if the failure rates were based on complete records of historical loss of containment failure events and complete records of pipeline population. Some of these uncertainties arise from variations in factors such as the physical characteristics, operating conditions and environment of individual pipelines which mean that some pipelines are inherently more susceptible to failure than others. Other uncertainties arise from the rarity of some types of incidents; PARLOC 2012 is based on incidents that have occurred in a 12-year period, but some categories of incidents have not been observed in this period. This lack of observation does not necessarily imply that the long-term frequency of such incidents is zero.

The magnitude of some uncertainties can be evaluated, but others cannot be evaluated other than through good judgement. This section describes some of the main sources of uncertainty.

It is noted that the PARLOC 2001 report presented graphs showing error bars that are related to the uncertainty associated with the number of reported incidents. The PARLOC 2012 update does not present error bars; it recognises that there is uncertainty associated with the size of the data set but also recognises several other sources of uncertainty. The practical outcome of these issues is that the generic frequencies presented in this report are the best available estimates of generic leak frequencies for pipelines, risers and control umbilicals in the offshore oil and gas industry. Users of these data should however know that there are uncertainties associated with these results. The following subsections discuss some of the main issues associated with these uncertainties.

7.4.1 Unreported incidents

It is inevitable that the PARLOC 2012 incident database does not list all loss of containment events that are relevant to PARLOC. The list of 183 relevant events is nevertheless the most complete listing that is currently available.

Figure 17 shows a Venn-type diagram which summarises (qualitatively) the likely extent of pipeline and riser leak incident reporting. Data that are potentially omitted from the database arise from the following:

- Limited scope of RIDDOR and PON 1 reporting: PON 1 reporting is driven by pollution incidents and immediately visible environmental effects; it therefore omits gas leak events. RIDDOR reporting is driven by events involving any damage to pipelines or facilities and/or accidental or uncontrolled release from a pipeline where either of these events could cause personal injury or pipeline shut down for more than 24 hours. RIDDOR reports are therefore expected to omit most events where there is no risk to people.

  The net effect of the PON 1 and RIDDOR reporting scopes is that loss of containment events in some locations (e.g. small gas leak events which occur outside defined safety zones) are expected to be unreported to either DECC or HSE, which in turn leads to underreporting of relevant loss of containment events in the PARLOC 2012 database. Unreported events are unlikely to add significantly to the risk to people. It is however noted that the causes of small unreported leaks may differ from those that are reported, and these leak events may be more important to integrity management.

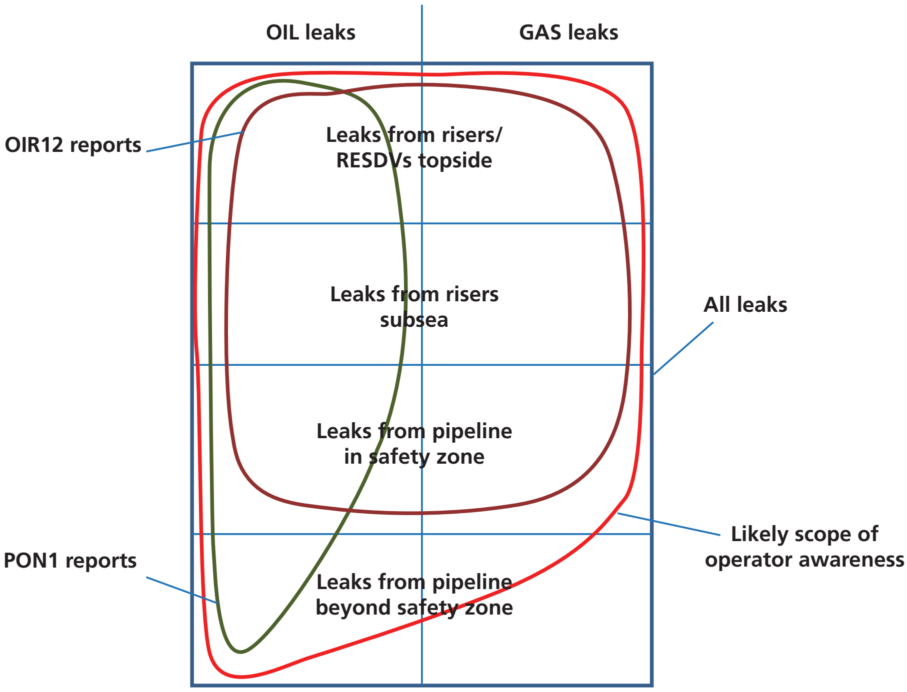

Figure 17: Scope of leak reporting and leak awareness

– Undetected leaks: loss of containment events cannot be included in the database unless they have first been detected. The descriptions of reported events indicate that some leaks may have been occurring for some considerable time before being detected. Some loss of containment incidents are initially detected during specific pipeline surveys or while work is being done on nearby subsea systems. Many of these leaks could have remained undetected but for the planned survey or work.

  Leaks of oil producing sheen at the sea surface are more likely to be detected if they occur close to an operating platform because they will be more easily associated with the platform and its pipelines, whereas it may not be evident that a sheen observed far from any platform is connected to subsea oil and gas infrastructure.

– Incomplete questionnaire responses: the questionnaire survey was issued by Oil & Gas UK using the list of operators identified in the RIDDOR and PON 1 incident descriptions as a basis for questionnaire distribution. Many pipelines have changed ownership in the period covered by this update. Some of the original operators no longer exist in their original form, while other operators have ceased operating pipelines on the UKCS. Oil & Gas UK endeavoured to identify a company that could provide details of historical incidents, but this was not always possible. In a small number of cases, an operator was identified, but no response was received. Some underreporting is related to failures occurring on divested assets (and potentially also lack of resources).

  It is estimated that about 25 % of incidents had occurred on pipelines where a different operator was now responsible for the pipeline.

  Based on questionnaires related to RIDDOR incidents, it is estimated that it was not possible to issue a questionnaire for about 8 % of incidents. No information was obtained from one operator. (It was not possible to get data from companies that are not members of Oil & Gas UK.) It should be noted that the pipeline population includes the pipelines operated by these companies.

It should be noted that incidents have been included in the database in some cases where no questionnaire response has been received. Specifically, if an incident description (in either RIDDOR or PON 1 records) appears to be related to a pipeline loss of containment, but no response was received, the incident has been included in the database. There is typically very little information available for such incidents.

Incidents omitted because they are not reportable under RIDDOR or PON 1 are each likely to be relatively small leaks. It is therefore expected that the database includes most of the larger relevant leak events that have occurred in the period 2001 to 2012.

Information is also omitted from many of the individual incident records in the PARLOC 2012 incident database. As previously discussed, data have been completed so far as possible based on strong inferences from incident descriptions and cross-referencing to other databases. Where important data are unavailable despite best efforts, the missing data are flagged as NA in the database (indicating "not available").

Omission of data from the database affects the accuracy of loss of containment statistics.

7.4.2 Incomplete incident descriptions

The descriptions of some reported loss of containment incidents are incomplete. These incomplete descriptions also contribute to uncertainty. An example of this type of uncertainty occurs where it is known that a leak has occurred, but the available records do not fully describe the details of the leak incident.

This type of scenario occurs in some PON 1 reports where the evidence for a leak is based on reported oil films on the sea surface along the route of a pipeline (or pipelines). It may be known that the PON 1 report relates to a leak from a subsea pipeline or its associated equipment, but the report is unlikely to identify the specific pipeline. If the pipeline operator cannot supply further information the description of the incident will be incomplete. In these circumstances it may not be possible to identify the type of pipeline, length, diameter and fluid. Missing data may also be connected with change of ownership of pipelines and the operator being unable to access the full details of the incident. Other data may be missing because they were not a part of the operator's reporting protocols.

It should be recognised that incident reports are completed for different reasons. These reasons may include: safety to personnel, ensuring continuation of production, environmental pollution and identification of causes. The information contained in the reports (and level of detail) will vary depending on the reasons for making the report.

In these cases, the incidents can be counted but it may not be possible to accurately categorise the incidents. This type of uncertainty has been handled using the methodology described in Section 4.1. This type of uncertainty is associated with the distribution of incidents across specific categories.

7.4.3 Number of reported incidents

The failure frequencies of operating lines (steel, flexible and control umbilical) in the PARLOC 2012 update are based on 160 incidents (85 at steel pipelines, 50 at flexible pipelines, 10 at umbilicals and 15 where the type of line is unknown/NA). There are smaller numbers of incidents within more refined subcategories. The PARLOC 2012 update uses these numbers to estimate the average frequency of loss of containment in each of these subcategories. The number of incidents in each category affects the accuracy of the estimate. In general, the average frequency in a specific subcategory will be more accurate if the number of incidents is large and less accurate if the number of incidents is small.

The number of incidents at control umbilicals is particularly small. PARLOC 2012 has therefore recommended that a single loss of containment frequency (1 x 10^{-3} / km-year) is used for all control umbilical assessments.

Uncertainty arising from limited numbers of observations can be quantified using chi-squared (X^2) statistics (reference 20). This uncertainty is the type that was used to generate the error bars in PARLOC 2001 charts.

7.4.4 Variation between pipelines

Not all pipelines of a specific type and dimension are exposed to the same hazards; some will be more prone to failure than others. This difference means that specific pipelines are expected to have failure frequencies that deviate from the estimated average frequencies presented in PARLOC 2012; some pipelines can be expected to have failure frequencies larger than the frequencies reported, while other pipelines can be expected to have smaller failure frequencies.

The characteristics of any specific pipeline introduce uncertainties to the expected failure frequency. Some of these uncertainties arise from variations in factors such as the detailed design specification, quality of construction, operating conditions and operating environment of individual pipelines. Therefore, some pipelines are more susceptible to failure than others.

PARLOC 2012 presents only average failure frequencies based on historical data. It does not quantify this type of uncertainty.

7.4.5 Pipeline database

The PARLOC pipeline database is based on a commercial database provided by Infield Systems Ltd. A review of available pipeline databases clearly showed that the Infield database was the preferred database for steel and flexible pipelines; the database identified more pipelines than the alternative available databases, and the database fields describing these pipelines were fully populated.

Uncertainties arising from any incompleteness or inaccuracy in the pipeline database are expected to be small compared to uncertainties in the incident database.

The population of control umbilicals was obtained from work done by Oil & Gas UK to establish a baseline for decommissioning of the offshore oil and gas industry infrastructure. This database was judged to be the best available, but the total population of control umbilicals could be identified only to within a factor of two.

7.4.6 Summary

Sections 7.4.1 to 7.4.5 have described some of the main sources of uncertainty associated with the estimated loss of containment failure frequencies in PARLOC 2012. The sources of uncertainty are not quantified; PARLOC 2012 aims to provide best estimates of failure frequency, subject to the following comments:

– Unreported incidents: the number of incidents that are entirely absent from the PARLOC 2012 incident database is not known. However, it seems likely that regulatory requirements for reporting and industry practices have resulted in most of the higher consequence loss of containment incidents being identified and hence included in the incident database. (The authors are aware of some very small gas leaks from remote parts of pipelines omitted from the incident database.) PARLOC 2012 does not attempt to make any adjustments to account for this source of uncertainty.

- Incomplete incident descriptions: information that is missing from the description of identified incidents is an important source of uncertainty. PARLOC 2012 has applied a systematic method to maximise the use of available information in the analysis. The magnitude of this uncertainty has not been quantified, but it will vary depending on the number of unknown/NA data items that must be redistributed (using the method described in Section 4.1).
- Number of reported incidents: the PARLOC 2012 update is based on only 183 loss of containment incidents of which 160 occurred at operating pipelines. The frequencies of loss of containment in some subcategories of pipeline are based on very few known incidents, and in some cases the number of incidents is zero. Section 4.1 describes a simple methodology that has been used to make estimates of frequencies where the number of observed loss of containment incidents is zero. The method described in Section 4.1 is likely to result in overestimates for frequency of loss of containment in these zero event cases.
- Variation between pipelines: the failure frequencies presented in PARLOC 2012 are averages for various categories and subcategories of pipelines. Users of these generic frequency data should recognise that the failure frequency at any specific pipeline is likely to deviate from these averages. The likelihood of failure at any specific pipeline can be minimised through application of good practice throughout the life of the pipeline from design through to abandonment.

Uncertainty in the estimate of failure frequency for control umbilicals is expected to be within a factor of about two (subject to the bullet point caveats listed in this section). The recommended failure frequency for control umbilicals in this report is likely to be biased towards an overestimate because it is based on the lower estimate of control umbilical population.

As previously noted, this report does not make an assessment of the uncertainties associated with overall average loss of containment failure frequencies at steel and flexible pipelines. Uncertainties in the number of incidents have been minimised, and the pipeline database is likely to make only a small contribution to uncertainty. The uncertainties associated with loss of containment frequencies at steel and flexible pipelines are therefore generally expected to be rather less than the uncertainty associated with control umbilicals.

Figure 18: Reel of flexible pipeline on board pipelay barge

8 CONCLUSIONS AND RECOMMENDATIONS

The study described in this report has resulted in the compilation of two databases:

- PARLOC 2012 incident database, which is a database of loss of containment incidents from pipelines, risers and control umbilicals operated in the UK offshore oil and gas industry, and
- PARLOC 2012 pipeline database, which is a database of the population of pipelines, risers and control umbilicals operated in the UK offshore oil and gas industry.

The scopes of the databases of incidents and pipelines cover:

- pipelines and associated risers (steel and flexible) in the offshore oil and gas industry on the UKCS;
- control umbilicals in the offshore oil and gas industry on the UKCS, and
- the 12-year time period from the start of 2001 to the end of 2012.

These databases are considered to be the most complete lists of such incidents and pipeline populations that are currently available.

The data on incidents and operating experience in these databases have been used to estimate the average loss of containment frequencies for various categories of pipeline and control umbilical.

The work has shown that the overall average loss of containment frequencies for steel pipelines and flexible pipelines as estimated in the current report, PARLOC 2012, are similar to those estimated in the previous issue of this report, PARLOC 2001. The loss of containment frequencies presented in this report are considered to be best available estimates for pipelines currently in operation.

The study does not include data for any incidents that occurred prior to 2001. This is because it was not possible to recover the incident data that had been used in the PARLOC 2001 update.

The incident data collected for this update are incomplete. It is believed that the data collection exercise is likely to have identified the majority of loss of containment incidents that occurred in the 12-year period 2001 to 2012, but the data describing these incidents contain many gaps.

The study also showed that the pipeline population data held by Oil & Gas UK are incomplete. The study identified an independent commercial database of pipelines as the preferred basis for the PARLOC 2012 update. This preferred database is relatively complete, but there are some data omissions. For example, the database does not identify pipeline PL numbers, and it does not identify any dates when pipelines have ceased operation.

Recommendations:

Pipeline operators in conjunction with Oil & Gas UK should make arrangements for the following:

1. The systematic ongoing collection of pipeline and riser loss of containment incident data. These data should be suitable for use in future PARLOC updates. The PARLOC 2012 incident database structure is generally suitable, but it should be reviewed to ensure that sufficient information is being captured for each incident and identify opportunities for improved alignment with the PARLOC pipeline database.

2. Improving and maintaining the PARLOC 2012 pipeline database. Specific improvements should include: checks by operators on the accuracy of current data, inclusion of PL numbers, inclusion of dates for end of operation, explicit identification of risers, and accurate identification of the population and operating experience of control umbilicals.

3. The regular reanalysis of loss of containment data and equipment population data in order to maintain an up-to-date database of equipment loss of containment frequencies and to identify any trends and causal patterns in such frequencies.

9 REFERENCES

1. PARLOC 90: Pipeline and Riser Loss of Containment Study, Advanced Mechanics & Engineering Ltd., OTH 91 337 ISPN 011 4133468
2. PARLOC 92: The Update of Loss of Containment Data for Offshore Pipelines, Advanced Mechanics & Engineering Ltd., OTH 93 424 ISBN 0 7176 0769 0
3. PARLOC 94: The Update of Loss of Containment Data for Offshore Pipelines, Advanced Mechanics & Engineering Ltd., OTH 95 468 ISBN 0 7176 1109
4. PARLOC 96: The Update of Loss of Containment Data for Offshore Pipelines, Advanced Mechanics & Engineering Ltd., OTH 951 ISBN 0 7176 1606 1
5. PARLOC 2001: The Update of Loss of Containment Data for Offshore Pipelines, Mott MacDonald Ltd., July 2003, ISBN 0 85293 404 1
6. DECC table of current pipelines – http://www.gov.uk/government/uploads/system/.../appendix14.xls, http://www.gov.uk/oil-and-gas-infrastructure (accessed 3 July 2014)
7. Modified PARLOC pipeline data http://www.ukoilandgasdata.com, 2014 (modified PARLOC 2001 pipeline database was removed from CDA website during 2014)
8. Oil & Gas UK / CDA pipeline database http://www.ukoilandgasdata.com, 2014
9. Pipeline data, email R. Borresen (Oil & Gas UK) to H. Harton (BP) and A Bolsover (DNV GL) with Excel attachment 'Pipeline database raw data for HSE.xlsx', 13 May 2014
10. UK Pipeline database, email H Harton (BP) to A Bolsover (DNV GL) with Excel attachment 'Pipelines_204080739.xls', 25 June 2013, http://www.infield.com. This site is the original source of the data.
11. Review of Pipeline Failure Rate Data, report by DNV GL for BP Exploration Operating Company Ltd, PP077495 / 189DYXJ-9, rev 0, 1 August 2013
12. Oil and gas: decommissioning of offshore installations and pipelines, https://www.gov.uk/oil-and-gas-decommissioning-of-offshore-installations-and-pipelines, 2014
13. A report on the matching of CDA data and Infield Systems UKCS pipeline datasets, Infield Systems Ltd., Version 1.0, 13 February 2014
14. An introduction to information retrieval, by C. Manning, P Raghavan and H. Schütze, Cambridge UP, online edition, 2009
15. Additive smoothing, http://en.wikipedia.org/wiki/Additive_smoothing, 2014
16. London School of Hygiene and Tropical Medicine, http://www.missingdata.org.uk, 2014
17. Missing data, http://en.wikipedia.org/wiki/Missing_data, 2014
18. What to do when nothing has happened?, by Raymond 'Randy' Freeman, Process Safety Progress, vol 30, issue 3, pages 204 – 211, September 2011
19. Private communication (letter) Ruth Ledingham (DECC) to Shayan Mortazavi (DNV) on availability of PON 1 data for the period 2001 to 2007, 13 August 2013
20. Methods for determining and processing probabilities, 'Red Book', Committee for the Prevention of Disasters, CPR 12E, 2nd edition, 1997
21. Meeting to discuss OGUK pipeline database 'Pipeline database raw data for HSE.xlsx', A Bolsover, DNV GL, 23 July 2014
22. Foundations of statistical natural language processing, Christopher D. Manning and Hinrich Schütze, MIT Press, 1999

ANNEX A
INCIDENT QUESTIONNAIRE

This annex contains details of the incident questionnaire that was issued to pipeline operators in the data collection phase of the PARLOC 2012 study.

Figure A1 in this annex presents a copy of the questionnaire as issued to the pipeline operators. The shaded boxes and codes at the right-hand side of this figure are initial guidance used by DNV GL to categorise the information provided in the returned questionnaires.

Section 2.3 of this report described some the checks made on the returned questionnaires. Some specific checks are summarised in Figure A2.

Pipeline incident questionnaire

Unique ID	Assign 0001A etc
Comment	DNVGL comment space

This questionnaire collects information about releases of hydrocarbons and other fluids from oil and gas industry offshore pipeline in the UKCS
The focus of the questionnaire is on leaks of produced hydrocarbons, but it also allows for reporting of leaks from associated systems.
This questionnaire also collects information about incidents that cause damage to a pipeline and threaten the pipeline integrity, but where no leak occurs.

Use the additional comments to provide any clarifications that may be judged necessary.

Please complete sections A, B, C, D and E

Return the completed questionnaire to …………………………………………….. **no later than 22 November 2013**

A. **Introduction**		**Guidance notes**
A.1 Your name		
A.2 Your contact details		
email:		
tel:		
A.3 Additional comments		
A.4 Incident reference no.		As per column 'No.' in data spreadsheet

Figure A.1: Incident questionnaire

B. Pipeline details			Guidance notes		
				PL no	
B.1 DECC pipeline database no			https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/15653/appendix14.xls (link opens a spreadsheet list of active pipelines)		
B.2 Pipeline type 1	Trunk (export) pipeline		Select the best description	EXPT	EXPT
	Flowline				FLOW
	Riser				RISR
	Jumper				JUMP
	Spool piece				SPOL
	Piggy back				PBAC
	Umbilical				UMBL
	Other				OTHR
	If other, please specify				
B.3 Pipeline type 2	Single steel tubular		Select the best description	SNGL	SNGL
	Flexible				FLEX
	Bundled line				BUND
	Pipe-in-pipe				PIPP
	Other				OTHR
	If other, please specify				
B.4 Pipeline operator				e.g. BP	Short standard version of name
B.5 Pipeline name					Check against pipeline database
B.6 Pipeline diameter			OD for steel. ID for others. Specify units.	6	Check against pipeline database
B.7 From			State: Facility, field, block and sector		
B.8 To			State: Facility, field, block and sector		
B.9 Pipeline length (km)				24	Check against pipeline database
B.10 Pipeline age (y)			Age at time of incident	5	

Figure A.1: Incident questionnaire (continued)

B.11 Contents	Oil	Select the best description Crude etc.	OIL	OIL
	Condensate			COND
	Gas			GAS
	Multiphase hydrocarbon			MULT
	Methanol			METH
	Glycol/TEG/MEG			GLYC
	Chemical	Corrosion inhibitor, anti-scale, hydrates inhibitor, etc.		CHEM
	Other	Other e.g. sea water, etc.		OTHR
	If other, please specify			
	Water content	e.g. Dry gas, unprocessed wet products, % water content, raw/deoxygenated seawater/produced water etc.		
	Solids content	e.g. sand		
B.12 Design pressure		Please specify unit (bar, psi etc)		
B.13 Design temperature (degrees C)				
B.14 Operating pressure		Please specify unit (bar, psi etc) – operating pressure at time/location of incident	20	Units are barg
B.15 Operating temperature (degrees C)		Operating temperature at time of incident	10	Units are degC
B.16 Pipeline protection	Exposed	Pipeline protection at the location of incident	EXPS	EXPS
	Buried			BURD
	Concrete coated			CONC
	Trenched			TRCH
	Rock dumped			ROCK
	Other			OTHR
	If other, please specify			

Figure A.1: Incident questionnaire (continued)

B.17 Pipeline material grade			e.g. CS X65, CRA Duplex SS (22 %), etc.		x-check against B.3
B.18 Pipeline wall thickness (mm)			Wall thickness in mm	12,5	Units are mm
B.19 Pipeline design code					
B.20 Pipeline coating	External coating		FBE, 3LPP, asphalt enamel etc.	FBE	Establish 'standard' codes after seeing returns
	Internal coating		e.g. flow coating for gas line	NONE	Establish 'standard' codes after seeing returns
B.21 Pipeline piggable?	Yes No		YES NO	YES	
	If yes, date of pigging		Date of last pigging prior to incident		
B.22 Additional comments					

Figure A.1: Incident questionnaire (continued)

C. Incident location		Guidance notes		
C.1 Date of incident		Or date of detection of incident. Specify day, month, year	2008	Year only
C.2 Location where incident occurred				
Riser				RISR
Above sz		If riser, tick either above splash zone, splash zone or subsea		RISR-above
Splash zone				RISR-SZ
Subsea				RISR-subsea
Safety zone		Between riser base and edge of 500 m zone		SFZN
Near		If safety zone, tick either near of far:		
Far		Near = within 100 m of the platform; Far = 100 to 500 m from the platform.		
Mid line		The pipeline on the seabed outside the subsea well and platform safety zones and not in the shore approach		MLNE
Shore zone				
Well				
Land				
SPM				SPM
Other				
If other, please specify				
C.3 Location (UTM coordinates)				

Figure A.1: Incident questionnaire (continued)

C.4 Location (equipment)				
Pipeline body		i.e. leak or damage location. Select the best description	PIPE	PIPE
Flange				FLAN
SSIV				SSIV
ESDV				ESDV
Pig trap				PIGT
Well/xmas tree				WELL
PLEM/PLET				PLEM
Other				OTHR
If other, please specify				
C.5 Water depth (m)		Water depth at incident location in metres	150	Units metres
C.6 Additional comments				

Figure A.1: Incident questionnaire (continued)

D. Incident description		Guidance notes		
D.1 Incident description		Describe the circumstances of the incident		Check against rest of response
D.2 Leak or damage only	Leak	Did the incident result in a leak?	YES	YES or NO
	Damage, but no leak			
D.3 Cause	Anchor damage		ANCH	ANCH
	Trawling damage			TRAW
	Other impact damage			OTHI
	Corrosion – internal			CORI
	Corrosion – external			CORE
	Other material cause			OTHM
	Buckling			BUCK
	Natural hazard			NATH
	Fire/explosion			FEXP
	Incorrect operation			INCO
	Construction			CONS
	Maintenance			MAIN
	Other			OTHR
	If other, please specify			

Figure A.1: Incident questionnaire (continued)

D.4 Object failed	Fitting	ESDV, SSIV, Pig Trap, etc.	FITT	FITT
	Flexible	Flexible pipe or riser		FLEX
	Rigid	Rigid pipe or riser		RIGD
	Other			OTHR
	If other, please specify			
		Amount of release in kg, otherwise please specify the unit		
D.5 Size of release			700	Units kg
			0.2	Units m^3
D.6 Consequences				
D.7 Extent of damage		Describe the extent of damage		
		Describe the consequences of the incident – safety, environmental, production, financial …		
D.8 Dimensions of leak (mm)	Hole diameter	Estimated equivalent diameter in mm	3	Units mm
	Rupture (yes/no)			
D.9 Pipeline status at time of incident		Select one		
	Construction		CONS	CONS
	Commissioning			COMM
	Testing			TEST
	Operating			OPRT
	Other			OTHR
	If other, please specify			
D.10 Additional comments				

Figure A.1: Incident questionnaire (continued)

E. Repair

E.1 Repair works required		Done?	Done?
E.2 Time to repair		75	Units days (30 days per month
E.3 Additional comments			

Please check that all sections have been completed.
Return the questionnaire to ....

Figure A.1: Incident questionnaire (continued)

Item	Question	Checking process
All checklists	e.g. B.2, pipeline type	e.g. X
B.1	DECC pipeline database no	e.g. PL822
B.2	Pipeline type 1	Add code
B.3	Pipeline type 2	Add code
B.4	Pipeline operator	Add code
B.5	Pipeline name	
B.6	Pipeline diameter	Dimension in inches, just a number, no ". Use ? If not known
B.9	Pipeline length	Units: metres
B.10	Pipeline age	Units: Years (age at date of incident)
B.14	Operating pressure	Units: barg – number only
B.15	Operating temperature (degC)	Units: degC – number only (representative average if necessary)
B.17	Pipeline material grade	Cross-check against other responses e.g. B.3
B.18	Pipeline wall thickness	Units: mm
B.20	Pipeline coating (external)	Add code
B.21	Pipeline coating (internal)	Add code
C.1	Date of incident	Year only
C.2	Location where incident occurred	
C.4	Location (equipment)	Add code
C.5	Water depth	Units metres – number only
D.1	Incident desciption	Cross-check against other responses
D.2	Leak or damage only	YES if leak occurred, otherwise NO
D.3	Cause	Add code
D.4	Object failed	Add code
D.5	Size of release	Units: either kg or m^3 – using appropriate green field. Do not fill both fields.
D.7	Extent of damage	Cross-check against other responses
D.8	Hole diameter	Units mm. If rupture record pipe diameter
D.9	Pipeline status at time of incident	Add code
E.1	Repair works required	Cross-check against other responses e.g. D4, D6
E.2	Time to repair	Units days. Cross-check against other responses e.g. D.6

Figure A.2: Specific checks on the return incident questionnaires

ANNEX B
DESCRIPTION OF INCIDENT DATABASE

The consolidated database is an Excel 2010 spreadsheet containing 206 records. These records comprise 183 records for loss of containment incidents plus records for 23 incidents that did not lead to a loss of containment i.e. near miss incidents. The 183 loss of containment incidents at pipelines and control umbilicals are the main incidents that are relevant to this PARLOC 2012 update. For each incident record, the details of the incident are described by a number of parameters (database fields). Some of the fields contain free text, some contain numbers and others contain codes which are used to categorise the incidents. The contents of the main database fields used in the statistical analysis are summarised in Tables B.1 to B.11. Each table defines the values/codes used in the database and the meaning (definition) of those codes. The tables also show the number of instances of each code / value in the database (numbers are after review by the database analysts). The main reason for presenting these numbers is to provide an indication of the completeness of information in each database field and hence an indication of the confidence in related statistics. The total of the numbers in each table is 183, corresponding to the total number of leak incidents in the database.

It should be noted that most database fields are not fully populated. In many records, there are some fields where the data are marked as not available (NA) indicating that it has not been possible to confidently identify the relevant information for some incidents. Some incident records contain multiple instances of NA data.

Table B.1: Database field: type

Code	Description	Number
UMBL	Control umbilicals	15
STEE	Single steel tubulars and other rigid steel pipelines	89
FLEX	Flexible pipelines	59
NA	Not available i.e. not identified from available information	20

Table B.2: Values and codes in database field: diameter

Code/value	Description	Number
<number>	Diameter in inches	137
NA	Not available i.e. not identified from available information	46

Table B.3: Values and codes in database field: length
(continues overleaf)

Code/value	Description	Number
<number>	Length in km	142

Table B.3: Values and codes in database field: length (continued)

Code/value	Description	Number
NA	Not available i.e. not identified from available information	41

The length of the pipeline is based on the length as reported by operator. In some cases different databases quote different lengths, but these differences are usually small. Larger differences were seen in some operator responses in a few cases e.g. where the leak occurred from a riser that was directly connected to a longer pipeline. Where large differences were identified, DNV GL endeavoured to identify the specific pipeline in the preferred pipeline population database and ensure that the length corresponded to that database.

Table B.4: Values and codes in database field: age

Code/value	Description	Number
<number>	Age of pipeline at date of incident in years (rounded to whole number)	183

Table B.5: Values and codes in database field: fluid

Code/value	Description	Number
OIL	Crude oil	45
COND	Condensate	1
GAS	Gas	23
MULT	Multiphase hydrocarbon	48
METH	Methanol	17
GLYC	Glycol/TEG/MEG	10
CHEM	Corrosion inhibitor, anti-scale, hydrates inhibitor, etc.	12
WATR	Water	25
OTHR	Other	1
NA	Not available i.e. not identified from available information	1

Operators were asked to select the best description for the relevant contents of the pipeline.

The code OTHR (“other”) is used here and in other database fields to indicate data that does readily correspond to one of the defined categories.

Table B.6: Values and codes in database field: location

Code/value	Description	Number
RISR-above	Riser – above splash zone	10
RISR-SZ	Riser – at splash zone (This category is not reported in tables in the main body of this report because none of the questionnaires returned by operators identified failures occurring in this category)	0
RISR-subsea	Riser – below splash zone	31
RISR	Riser – unknown location	2
SFZ-Near	Between riser base and edge of 500 m zone, within 100 m of platform	15
SFZ-Far	Between riser base and edge of 500 m zone, beyond 100 m of platform	10
SFZ	Within 500 m zone, but distance from platform not known	4
MLNE	Midline – outside all safety zones and not on shore approach	25
SHOR	Shore zone	0
LAND	On land section of pipeline	0
WELL	Within well safety zone	20
SPM	Single point mooring	2
OTHR	Other	32
NA	Not available i.e. not identified from available information	32

Table B.7: Values and codes in database field: equipment

Code/value	Description	Number
PIPE	Leak from pipeline body (or umbilical body)	85
FLAN	Leak from flange or other connection/end fitting	28
SSIV	Leak from SSIV	1
ESDV	Leak from ESDV	4
VALV	Leak from other valve	4
PIGT	Leak from pig trap/launcher	3
WELL	Leak from line at well, or other equipment in the subsea well area	10
PLEM	Leak from pipeline end manifold/pipeline end termination	3
CLAM	Leak from failed clamp	1
OTHR	Other (including cut/open for removal/maintenance)	17
NA	Not available i.e. not identified from available information	27

Table B.8: Values and codes in database field: cause

Code/value	Description	Number
ANCH	Anchor damage	1
TRAW	Trawling damage	7
OTHI	Other impact damage	1
CORI	Corrosion – internal	29
CORE	Corrosion – external	1
OTHM	Other material cause	24
BUCK	Buckling	1
NATH	Natural hazard	7
FEXP	Fire/explosion	0
INCO	Incorrect operation	5
CONS	Construction	10
MAIN	Maintenance	10
OTHR	Other	23
NA	Not available i.e. not identified from available information	64

It should be noted that the database codes generally correspond to a single primary cause as identified in the incident questionnaires. Many incidents have several contributing causes that might be identified through a more detailed study of the questionnaire responses.

Table B.9: Values and codes in database field: size of release

Code/value	Description	Number
<number>	Amount of release in kg	128
<number>	Amount of release in m^3. (The questionnaire asked for the size of release in kg, but some responses were only able to quote a volume)	4
NA	Not available i.e. not identified from available information	51

Table B.10: Values and codes in database field: hole diameter

Code/value	Description	Number
<number>	Estimated equivalent hole diameter in mm. The questionnaire also asked operators to indicate if the failure was a rupture. For ruptures, the hole diameter was limited to the relevant pipeline diameter	42
NA	Not available i.e. not identified from available information	141

Table B.11: Values and codes in database field: status

Code/value	Description	Number
CONS	Incident occurred during construction	0
COMM	Incident occurred during commissioning	2
TEST	Incident occurred during test	8
OPRT	Incident occurred during operation	148
REMO	Incident occurred during removal (or maintenance on open line)	13
OTHR	Other	12
NA	Not available i.e. not identified from available information	0

ANNEX C
PIPELINE POPULATION DATA SOURCES

This annex contains supplementary data on the pipeline population data sources.

C.1 DECC PIPELINE DATA

DECC has publicly published a list of pipelines (reference 6) that are operated by offshore oil and gas industry on the UKCS. This online DECC database is evidently incomplete since it lists a relatively small number of pipelines (only 433 items). The database is also not up-to-date. When reviewed in mid-2013, it was found to have been last updated in February 2012 and included two items marked as “to be laid April/May 2012”.

The main fields in this database are shown in Table C.1.

Table C.1: Field in the DECC database of pipelines

Database field	Comment
PL no	Unique pipeline identifier number
From	Name of platform/terminal/well, manifold, median line at international border, onshore facility etc.
To	As above
Length	Length in km
Diameter	Diameter in mm
Material conveyed	Descriptive text e.g. gas, crude oil, condensate, gas lift, chemical/hydraulic fluids, control signals, control lines, corrosion inhibitors, etc.
Operator	Name of operator
Year commissioned/approved	Year

Total length of pipelines in the DECC database is 15,729 km.

C.2 CDA PIPELINE DATA

Three sets of related pipeline data have been identified held by CDA/Oil & Gas UK.

C.2.1 Modified PARLOC database

The modified PARLOC database contains tables of pipeline and riser population data. It is termed modified PARLOC to distinguish it from the database that was used in the 2001 PARLOC update. (The original PARLOC 2001 pipeline database could not be located.) The modified PARLOC database is understood to be a composite of the pipeline database used in the PARLOC 2001 update and the FishSafe database.

The modified PARLOC database contains 49 database fields, but many of these fields are sparsely populated: 14 fields contain no data and a further 12 are less than 10 % populated.

A review of this database in 2013 identified 57 duplicate entries with identical identification numbers and descriptions.

Table C.2: Selected fields in the modified PARLOC database

Field	Comment	Complete
PIPELINE_DTINO	Cross reference to DTI/DECC identification number	99.6%
PIPELINE_NAME	Descriptive name	100%
OPERATOR	Name of operator	100%
LENGTH_KM	Length (km)	98.4%
SERVICE_TRANS	e.g. oil, gas, chemical, etc.	60.3%
INST_TYPE	e.g. umbilical, pipeline, riser, power, telecom etc.	100%
INST_DATE	Defined to day month and year	70.5%
COMMISSION_DATE		17.5%
END_DATE		4.3%
STATUS	e.g. active, not in use, pre-commission, proposed etc.	100%
MAT_TRANS	e.g. flexible, rigid, rigid – carbon steel X60 etc.	23.3%
SYSTEM_TRANS	e.g. infield line, trunk line, flowline etc.	25.6%
CONFIGURATION	e.g. PGYLIN, PPINBL, PPINPP	7.7%
PROT_TRANS	e.g. buried, rock dumped, on seabed, etc.	21.5%
PROT_DEPTH_TRNCHD	Units not specified – possibly a mixture of units	5.2%
OUTER_DIAM	Units are apparently a mixture of inches and mm (values range from 0.5 to 1,085)	59.8%
WALL_THCKNSS	Apparently a mixture of units (values range from 0.02 to 13.5)	20.6%
CORROSION_COAT	e.g. CONC, MONEL, EPDM etc.	17.1%
MAOP	Apparently a mixture of units	23.9%
HYDROTEST_PRESSURE	Apparently a mixture of units	9.0%
PRESSURE_UNITS	e.g. bar	61.8%
MAX_WATER_DEPTH	In metres	22.7%
FLANGES	It is not clear what this parameter represents	4.2%
TEES	No of tees	2.1%
WYES	No of wyes	2.4%
DATA_SOURCE	e.g. PARLOC 2001 or SEAFISH (sic)	64.2%

The modified PARLOC database was therefore considered to be unsuitable as a basis for defining the PARLOC 2012 pipelines database.

The review also noted that the modified PARLOC database also contains records that are not relevant to the PARLOC update such as power lines, telecommunications and anchoring cables. These non-relevant items are clearly identified in the database.

This database contains 2,247 records but only approximately 1,873 records are relevant to PARLOC.

The total length of relevant pipelines in this database is approximately 23,466 km.

C.2.2 CDA database

The main CDA database contains data provided by pipeline operators but contains no length data or field names. Work done by Infield to cross-reference PL numbers to the Infield database also suggests that the CDA pipeline dataset does not update the names of operators during changes in ownership.

C.2.3 Oil & Gas UK decommissioning data

This database was developed by Oil & Gas UK during 2012 as part of an exercise to identify subsea infrastructure and establish a baseline and requirements for decommissioning in the North Sea, west of Shetland and in the Irish Sea. Oil & Gas UK incorporated information from a variety of sources including: online DECC data, CDA database, publicly available decommissioning plans, Atkins' pipeline JIP, GIS data (for pipeline lengths), together with information from NPD and SoDM. The database includes pipelines, control umbilicals and other items that are not relevant to PARLOC but are present in the CDA database such as anchor cables, mooring lines and power cables.

Work to develop this database focused on larger pipelines since these would drive decommissioning costs; it is expected to have omitted some of the smaller pipelines on the seabed. The database used GIS data to estimate pipeline lengths and this was matched to the PL numbers. Bundles were included as single records in the database.

Oil & Gas UK is relatively confident in the quality of the "from/to" descriptions, pipeline lengths and diameters where these have been identified (reference 21). The duplicated PL numbers in the modified PARLOC database were almost fully eliminated from this decommissioning database, but there are some records where the PL is not identified.

While performing this work, Oil & Gas UK had identified conflicts between data for pipeline status and commissioning dates (e.g. pipeline marked as PRECOMMISSION, but also showing a commissioning date of 2006). Oil & Gas UK also noted the lack of precise definition in some of the terms used to describe the line status (e.g. confusion in the distinction between the meanings of terms such as not in use, abandoned, decommissioned and removed). Some other fields have a low level of completeness.

Oil & Gas UK judged this database to be the best information that could be achieved in 2012 as a basis for defining requirements for decommissioning.

A notable feature of this database is the large number of control umbilicals that are identified.

C.3 INFIELD PIPELINE DATA

DNV GL received a version of the Infield database (Excel file, dated 21 June 2013) in connection with a PARLOC pre-project performed for BP. The database as provided also included various database keys relating to data that were not supplied by Infield. The database as provided contained details of 3,353 pipelines but of these, some were considered to be not relevant to PARLOC 2012 (e.g. marked as cancelled, deferred, pre-commission, or with lay-dates after 2012). When these were excluded, the total number of pipelines relevant to PARLOC was reduced to 2,660.

Review of the Infield database showed that it contains details of pipelines that are omitted from the modified PARLOC and DECC databases. In particular, it includes many shorter pipelines that are apparently absent from the other databases. The total length of the relevant pipelines in the Infield database is about 21,300 km (about 9 % less than the modified PARLOC database). The distribution of stated years in which the pipelines were laid is plausible although there seems to be a disproportionally large number installed in 1998. This result may be due to inaccuracies in the database, but further investigation shows that there were a few large fields being installed around 1998 and this appears to account for the larger number installed that year. There was also a lack of information regarding the decommissioning year for those pipes that are no longer in operation. Of the various sources of pipeline data reviewed, the Infield database appears to be the most complete.

Some apparent omissions from this database were identified although it became clear that these were omitted because of the UK scope of the database, and these omitted pipelines did not start in the UK. These omissions were: the UK section of the Langeled pipeline (540 km length), the Irish Interconnectors, and a pipeline between the UK and the Netherlands. These pipelines are in any case out of scope of the PARLOC 2012 update.

Table C.3 shows the main fields in the Infield database that are relevant to the PARLOC update. All fields in the Infield database are fully populated.

Table C.3: Fields in Infield database

Field	Comment/example entry
Operator name	Full name of company e.g. Total E&P UK Plc
Operator	Brief name – typically one word e.g. Total
Pipeline name	e.g. Alwyn North NAB – Ninian Central
Status	e.g. operational, decommissioned, removed, abandoned
Diameter	In inches
Length	In metres
Lay type	e.g. trenched, buried, surface
Product	e.g. gas, oil, condensate, oil/condensate, water injection
Date laid	Typically accurate to year
Water depth	In metres
Type	e.g. steel, flexible, stainless steel
Type 2	e.g. single tubular, piggy-back, jumper
Weight coat	Yes or No
Vessel type	e.g. lay, reel
From-structure	e.g. platform, subsea unit,
To-structure	e.g. platform, single point mooring, pipeline, terminal

The Infield database was judged to be the preferred listing of pipelines available for use in the PARLOC 2012 update. This preference was largely because of the relative completeness of the Infield database (all data fields were fully populated), but it is noted that none of the sources of pipeline data are considered to be ideal as a basis for the PARLOC 2012 update.

None of the deficiencies in the Infield database prevents its use in the PARLOC 2012 update. These deficiencies do however relate to uncertainties in the population of pipelines and risers that must be recognised because these affect the uncertainties in the best estimate loss of containment frequencies.

The Infield database as provided contains no information on PL numbers. Infield was requested to attempt to assign PL numbers to the records in the Infield database using available information. Infield was able to identify good matches to PL numbers for many records and tentative matches for other records. Of the 1,517 records supplied from the CDA database, Infield was able to match the PL numbers to its in-house database in 598 cases, possible matches in 402 cases and no matches in 480 cases. (The remaining 37 records were control lines which are not included in the Infield database.) Table C.4 shows the extent to which Infield was able to match the records. In this table "match" corresponds to 90 %+ confidence on the pipeline match, and "possible match" corresponds to 60 %+ confidence on the pipeline match.

Table C.4: Matching of CDA database records to the Infield database

Match status	Number of matched records
Match	598
No match	480
Possible match	252
Possible match-date	96
Possible match-diameter	16
Possible match-line status	25
Possible match-line type	2
Possible match-product	8
Possible match-status	2
Possible match-length	1
Control line	37
Total	1,517

The estimation of leak frequencies for specific categories of pipelines requires that these categories can be identified in both the incident data and the pipeline population data. The categories in the incident data and population data did not generally match, so it was necessary to recategorise some fields in either the questionnaire or the pipeline database. Table C.5 is an example of this work, showing how the Infield pipeline product categories were mapped onto the incident codes used to describe pipeline fluids.

Table C.5: Pipeline fluids listed by Infield and corresponding PARLOC categories

Infield pipeline product descriptions	Code/value in PARLOC database
Oil	OIL
Fuel Oil	OIL
Oil/TFL	OIL
Condensate	COND
Chemical inj./gas lift	GAS
Fuel gas	GAS
Gas	GAS
Gas lift	GAS
Injection gas	GAS
Gas lift/kill/ann.mon	GAS
Vent gas	GAS
Gas/condensate	MULT
LPG/gas	MULT
Oil/condensate	MULT
Oil/gas	MULT
Oil/gas/condensate	MULT
Methanol	METH
Glycol	GLYC
TEG	GLYC
Chemical injection	CHEM
Corrosion inhibitor oil	CHEM
Water	WATR
Water injection	WATR
Water injection/TFL	WATR
Water ballast	WATR
Annulus monitor	OTHR
Service	OTHR
TEST	OTHR
Test/kill	OTHR
Carrier	XXX

Some pipelines are identified as having multiple product uses e.g. chemical injection/gas lift. The proportion of operating experience with each product is not known for these pipelines, and they are counted as having a single product e.g. "GAS" in the analysis of the pipeline population. The number of pipelines having multiple product uses is relatively small; it is judged that any uncertainty introduced will be small.

ANNEX D
GLOSSARY

DECC	Department of Energy and Climate Change
DMA	dead man anchor
DTI	Department of Trade and Industry
ESDV	emergency shutdown valve
FPSO	floating, processing, storage and offloading vessel
GIS	Geographic Information Systems
HCRD	Hydrocarbon Releases Database
HSE	Health and Safety Executive
JIP	Joint Industry Project
LOC	loss of containment
MAOP	maximum allowable operating pressure
MAR	missing at random
MIC	microbial induced corrosion
MNAR	missing not at random
NA	not available
NPD	Norwegian Petroleum Directorate
NPS	nominal pipe size
NRV	non return valve
NUI	normally unmanned installation
PARLOC	pipeline and riser loss of containment
PL	prefix for unique pipeline identifiers assigned by DECC/DTI
PLEM	pipeline end manifold
PLET	pipeline end termination
PON	Petroleum Operations Notice
PWC	preferential weld corrosion
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrence Regulations
ROV	remotely operated vehicle (subsea vehicle)
SoDM	Staatstozicht op de Mijnen (Dutch regulator)
SPM	single point mooring
SSIV	subsea isolation valve
UKCS	UK continental shelf

Other abbreviations used as data categories in the incident database are listed in Annex B.