ADVANTICA

FAILURE FREQUENCY ANALYSIS AND THE EFFECTIVENESS OF SAFETY IMPROVING MEASURES FOR HIGH PRESSURE GAS PIPELINES
STAGE 1 TASK 9
FINAL REPORT
FFA-ESM/05/03

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Executive Summary

During 1998 and 1999, an initiative to review and compare the parameters and criteria used in pipeline risk assessment was pursued by a working group of pipeline companies. The review identified four areas where further development could be beneficial. These were:

- Failure frequency

- Effectiveness of safety measures

- Ignition probability

- Behaviour of people

In response to the first two of these, the 'Failure Frequency Analysis and Effectiveness of Safety Improving Measures of High-Pressure Gas Pipelines' (FFA-ESM) project commenced in September 2002. The project addresses the improvement of tools and data available, by providing the means for participating companies to collect and share additional information on pipelines and pipeline damage, and provide techniques to enable companies to adopt a consistent approach to the analysis of the data. In addition, in this project studies will be undertaken on the effectiveness of safety improving measures, to provide information that can be used to estimate their effect on the predicted failure frequencies.

Stage 1 of the FFA-ESM project has recently been completed. This report provides a summary of the work undertaken in Stage 1, the main findings, and recommendations for Stage 2.

The specific objectives of Stage 1 were to:

1. Review current systems used for incident data collection and identify the key parameters that influence failure frequency.
2. Define the requirements for the information to be collected and for the analysis techniques to be employed.
3. Demonstrate how the data collected can be used for failure frequency analysis.
4. Review measures available to companies to mitigate the risk of third party damage and compare the existing techniques used by participating companies to estimate their effectiveness.

In addition to this report, the following deliverables were supplied to participants as result of the work in Stage 1:

1. Report FFA-ESM/04/01, describing the results of Tasks 1 to 3, including a review of existing databases and methods of analysis, identification of the key parameters for failure frequency estimation, and a recommendation of the information that will be requested from participants in order to populate the database.

2. Report FFA-ESM/04/02, describing the results of Tasks 4 and 5, including recommended analysis techniques and worked examples to demonstrate their application, based on existing or fictional data.

3. Report FFA-ESM/04/03, describing the results of Tasks 6 to 8, including a summary of the techniques in use to mitigate against the risk of third party damage, comparison of the techniques available to estimate their effectiveness, and the levels of uncertainty associated with those predictions.

The main findings of the Stage 1 work were:

1. Most companies do have methods to calculate failure frequencies and the different methods for calculating a failure frequency leads to failure frequencies which may differ by more than two orders of magnitude. It is recommended that a multiple regression model should be used when modelling failure frequencies purely based on historical data. However, this means that the corresponding system data should be collected to indicate how many incidents there are and how much experience there is in each combination of classes.

2. Only one test programme has been completed to quantify the effectiveness of physical protective measures used in the pipeline industry. Very little is known about the effectiveness of these surveillance activities. The effectiveness of depth of cover and wall thickness can be quantified using historical data.

Based on the findings from Stage 1, it is recommended that the following work is undertaken:

1. A database is proposed which would contain system data in a combination of classes (e.g. for each diameter the exposure in each wall thickness class would be given). Companies indicated that they would be willing to consider collecting data in the combination of classes in the future but they would need to assess the likely amount of extra effort required to carry this out. Therefore it is recommended that before work on a new database is started, a trial data collection process be carried out in which companies would complete a sample data collection form. Following this companies would then be able to assess the amount of effort required to complete the process and would decide whether to pursue the construction of a new database.

2. Although it was generally agreed that there is a requirement to carry out more tests on physical protective measures, it was not clear from Stage 1 which tests should be carried out. Also it was unclear how many tests would be required in order to obtain a statically meaningful result that could then be used to estimate the reduction in failure frequency associated with different physical protective measures. Therefore, it is recommended that the first part of Stage 2 should be to develop a framework to enable the effectiveness of physical protective measures to be assessed. This framework would then be used to define exactly which tests should be carried out in more detail.

Contents

1 INTRODUCTION

During 1998 and 1999, an initiative to review and compare the parameters and criteria used in pipeline risk assessment was pursued by a working group of pipeline companies. Two workshops were held which were attended by representatives of the companies, based around case studies for a fictitious pipeline.

The review identified four areas where further development could be beneficial. These were as follows:

- Failure frequency

- Effectiveness of safety measures

- Ignition probability

- Behaviour of people

In response to the first two of these areas, the 'Failure Frequency Analysis and Effectiveness of Safety Improving Measures of High-Pressure Gas Pipelines' (FFA-ESM) project commenced in September 2002. The project aims to address the improvement of tools and data available, by providing the means for participating companies to collect and share additional information on pipelines and pipeline damage, and provide techniques to enable companies to adopt a consistent approach to the analysis of the data. In addition, in this project studies will be undertaken on the effectiveness of safety improving measures, to provide information that can be used to estimate their effect on the predicted failure frequencies.

This is the final report of Stage 1 of the FFA-ESM project and gives an overview of the Stage 1 work and recommendations for the work to be undertaken in Stage 2.

2 OVERVIEW OF STAGE 1

2.1 Stage 1 tasks

Stage 1 consisted of nine tasks. The first five tasks were concerned with failure frequency analysis. These tasks were:

1. Review of present methods and databases.

2. Determination and selection of key parameters for failure frequency estimation.

3. Definition of required additional data to be collected from participants.

4. Outline of statistical methodology to be applied.

5. Demonstration of application of statistical methodology.

The work carried out in tasks 1, 2 and 3 has been described in detail in [1] and the work carried out in tasks 4 and 5 has been described in detail [2].

The next three tasks were concerned with the effectiveness of safety improving measures. The tasks examined the:

6. Effect of physical protective measures.

7. Effect of depth of cover and wall thickness.

8. Effect of surveillance

The work carried out in these tasks has been described in detail in [3].

The final task was:

9. Final report and recommendations for Stage 2

The final task is the subject of this report.

2.2 Stage 1 findings

The key findings of the failure frequency analysis part of the project were:

1. Methods for calculating failure frequencies

    - Most companies do have methods to calculate failure frequencies, although most methods are different. Also, most companies use external interference in their failure frequency calculation, but corrosion, ground movement and material/construction defects are often not included.

    - The different methods for calculating a failure frequency leads to failure frequencies which may differ by more than two orders of magnitude.

2. Databases

    - Most of the pipeline operators collect data on their pipeline system and operational faults, including incidents leading to loss of gas and incidents resulting in part wall damage.

    - The most widely used collaborative databases are those of EGIG and the existing basic database established by the participating companies.

    - The only active collaborative pipeline database collecting data on part wall damage, in addition to loss of product, from operational faults is that of UKOPA (in the UK).

3. Key parameters

    - From the questionnaire FFA-ESM/02/04 completed by participants and the sensitivity study for the parameters that influence the failure frequency the following parameters were categorized in the classes "very important" and "relevant" as follows:

Very important	Relevant
Wall thickness	Inspection techniques
Pipeline diameter	Inspection frequency
Material grade	Year of construction
Operating pressure	Pipe type (e.g. longitudinal etc)
Charpy value	Test pressure
Depth of cover	Type of soil/backfill
Area classification	Cathodic protection
Activity type	Mill coating type
Physical protective measures	Coating quality
Surveillance frequency	Stray currents
Surveillance type	Girth weld section
	One call system used
	Internal coating type
	Year of commissioning

4. Statistical methodology

- A multiple regression model should be used when modelling failure frequencies purely based on historical data. This means that the corresponding system data should be collected to indicate how many incidents there are and how much experience there is in each combination of classes. Also, it is recommended that an incident database should store data in a continuous way, rather than collecting incident data in classes.

The key findings of the effectiveness of safety improving measures part of the project were:

- Only one test programme has been completed to quantify the effectiveness of physical protective measures used in the pipeline industry and there is limited information on protective measures used by other buried utility operators.

- The external interference failure frequency can be related to the depth of cover and the population density using a negative exponential function. As some activities turn out to be depth independent, the depth of cover and area classification cannot be treated as two independent parameters.

- Increasing the wall thickness leads to a decrease in the failure frequency. There are two methods of calculating the effectiveness that statistically give the same answers.

- The three most important surveillance activities are walking patrol, car patrol and helicopter patrol, but very little is known about the effectiveness of these surveillance activities. Moreover, the frequencies used by the participating

companies are very different. There are a number of models on surveillance, but they are not validated because of the lack of available data.

3 RECOMMENDATIONS FOR STAGE 2

The findings from Stage 1 show that there are two main areas of work that should be considered for Stage 2. These are described below.

3.1 Database and failure frequency methodology

A database is proposed which would contain system data in a combination of classes (e.g. for each diameter the exposure in each wall thickness class would be given). Companies indicated that they would be willing to consider collecting data in the combination of classes in the future but they would need to assess the likely amount of extra effort required to carry this out. Therefore it is recommended that before work on a new database is started, a trial data collection process be carried out in which companies would complete a sample data collection form. Following this companies would then be able to assess the amount of effort required to complete the process and would decide whether to pursue the construction of a new database.

3.2 Effectiveness of physical protective measures

Although it was generally agreed that there is a requirement to carry out more tests on physical protective measures, it was not clear from Stage 1 which tests should be carried out. Also it was unclear how many tests would be required in order to obtain a statically meaningful result that could then be used to estimate the reduction in failure frequency associated with different physical protective measures. Therefore, it is recommended that the first part of Stage 2 should be to develop a framework to enable the effectiveness of physical protective measures to be assessed. This framework would then be used to define exactly which tests should be carried out in more detail.

4 REFERENCES

[1] FFA-ESM/04/01 "Failure frequency analysis and the effectiveness of safety improving measures for high pressure gas pipelines: Stage 1 Tasks 1, 2 and 3: Failure frequency databases and methods", Gasunie Report RT 03.R.0334, January 2004.

[2] FFA-ESM/04/02 "Failure frequency analysis and the effectiveness of safety improving measures for high pressure gas pipelines: Stage 1 Tasks 4 and 5: Outline and demonstration of statistical methodology", Gasunie Report RT 03.R.0569, January 2004.

[3] FFA-ESM/04/03 "Failure frequency analysis and the effectiveness of safety improving measures for high pressure gas pipelines: Stage 1 Tasks 6, 7 and 8: Effectiveness of safety improving measures", Advantica Report R6447, January 2004.