# VIBRATION INDUCED FATIGUE FAILURE IN PIPING SYSTEM

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To my beloved wife and parents

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Thank You.

## ABSTRACT

Vibration induced fatigue failure in piping system is a critical yet common problem in the petrochemical industry. Root cause identification and severity assessment of these problems usually require specialist input. The objective of this study is to develop a spreadsheet based approach using guidelines published by Energy Institute to identify the likelihood of failure in a piping system. Test case for a Malaysian offshore was undertaken for the validation of the developed software. Such software allows vibration induced fatigue failure to be screened in the design of a new plant or modification of an existing plant. This software can also be used to analyze pipeline used in other industry.

# ABSTRAK

Getaran menyebabkan kegagalan lesu teraruh dalam sistem paip adalah satu masalah yang kritikal tetapi umum dalam industri petrokimia. Pengenalpastian punca dan penilaian masalah ini memerlukan kepakaran khas. Tujuan kajian ini adalah untuk menjana perisian berasaskan hamparan elektronik merujuk kepada garis panduan yang diterbitkan oleh *Energy Institute* untuk mengenal pasti kemungkinan kegagalan dalam satu sistem paip. Perisian ini diuji untuk sebuah pelantar luar pantai. Dengan penggunaan perisian ini kegagalan lesu teraruh oleh getaran perlu sentiasa diambil kira semasa reka bentuk logi baru. Hamparan elektronik ini boleh digunakan untuk analisis sistem paip tumbuhan dalam industri lain.

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## LIST OF SYMBOLS

| | | |
|---|---|---|
| D | - | Pipe diameter |
| L | - | Distance |
| $M_w$ | - | Molecular weight |
| PWL | - | Sound power level |
| P | - | Pressure |
| T | - | Pipe thickness |
| $T_e$ | - | Temperature |
| V | - | Velocity |
| W | - | Mass flow rate |
| $\rho$ | - | Density |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Research Background

Failure in piping system as failure due to fatigue which may lead to plant shut down is a concern in industry. There are 3 basic for vibration: mechanical induced vibration, flow induced vibration and acoustic induced vibration. Vibration could cause piping system to fret, fatigue or even transfer the vibration to the structure. Figure 1.1 and 1.2 below show examples of pipe fretting due to vibration.

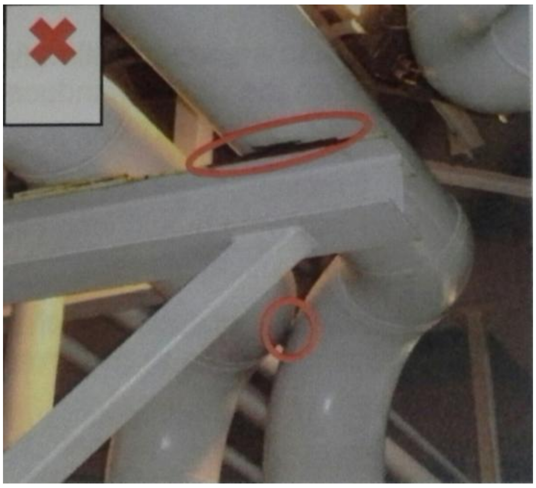

**Figure 1.1** Pipe fretting due to vibration and no reinforcement plate at rest support (Energy Institute, 2008)

**Figure 1.2** Fretting damage caused by clash between pipes (Energy Institute, 2008)

Several standards had been developed. The Norwegian petroleum industry for example had developed NORSOK standard L-002 to prevent major failure and reduce the downtime of the process plant. In year 2000, Marine Technology Directorate had published Guidelines for the Avoidance of Vibration Induced Fatigue in Process Pipework as a guideline to pipeline design. This had been adopted by the Energy Institute in 2004 for a similar guideline. The American Petroleum Institute (API) developed API 579 standard in January 2000 to define the fitness for services of pressurized equipment. Other than standards developed by the industry, finite element method is also frequently used to assess vibration problem by consultants.

These guidelines provided methodology to predict and assess the likelihood of failure of a pipe system. Whenever a likelihood of failure is predicted, additional supports such as shown in figure 1.3 shall be added to brace the pipe structure or viscous damper such as figure 1.4 shall be added to reduce the vibration level. The industry uses these standards as a basis for safeguard of piping from suffering from damages. Continuous work should however be done to improve the accuracy of these standards and to prevent any tragic incident from happening.

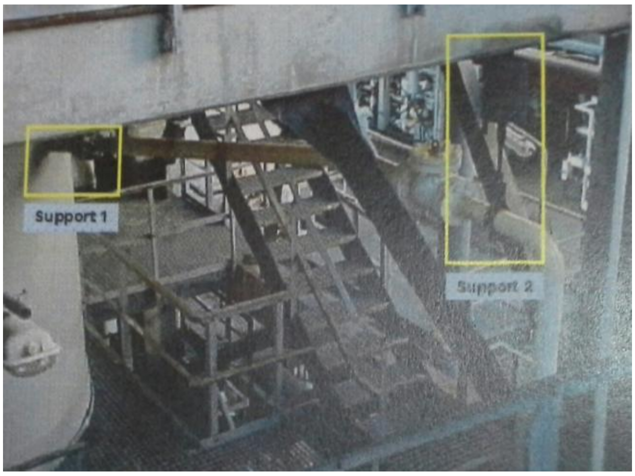


**Figure 1.3** Additional support in piping system to brace the piping structure (Energy Institute, 2008)

**Figure 1.4** Viscous damper added to reduce the vibration level of piping system (Energy Institute, 2008)

## 1.2 Objective of Study

The objective of this work was to review empirical predictions for the likelihood of fatigue failure in piping systems involving case studies of actual installations, and to develop a software routine for use of vibration fatigue failure screening.

## 1.3 Problem Statement

Flow and acoustics induced vibrations are common occurrence in industrial piping systems used in petrochemical and power generation industry. These vibrations often result in fatigue failures. Root cause identifications and severity assessments are often based on elaborate computation methods involving finite element analysis, computational fluid dynamics and acoustic analysis. These methods are however not readily available to the non-specialist in the plant. The Energy Institute formulated technical guidelines based on empirical and approximations for screening and risk assessment for likelihood of failures.

This work involved developing a spreadsheet based software using the Energy Institute methods and included case studies from the industry.

## 1.4 Organization of Thesis

Chapter 1 introduction consists of background of the research, the objective of this work, the reason conducting this work, and the hypothesis of the result of the study work. Chapter 2 literature review describes the theory used in this work. Chapter 3 methodology describes on how this work was done. Including flowchart, identification of research variable, algorithm, collection and analysis of data, and how the accuracy and correctness of this research is checked. Chapter 4 results and discussion shows the results held by this work using technical guidelines followed by discussion on the results observed from the case study and mitigation measures are suggested for high likelihood of failure pipelines.

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