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IN HYDROCARBON PIPELINE
(CASE STUDY OF Ø914.4MM PIPELINE)Academic Session: 20072008-3

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EXTREME GROWTH BEHAVIOUR OF CORROSION PIT IN
HYDROCARBON PIPELINE (CASE STUDY OF Ø914.4MM PIPELINE)


CHUAH CHONG KEAT

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Civil - Structure)

Faculty of Civil Engineering
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JUNE 2008

I declare that this thesis entitled "Extreme Growth Behaviour of Corrosion Pit in Hydrocarbon Pipeline (Case Study of Ø914.4MM Pipeline)" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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To my beloved family

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ABSTRACT

The prediction of pipeline integrity in the early stage is important in order to provide assessment for future inspection, repair and replacement activities since the failure of hydrocarbon pipelines contributes to economic implications and cause serious hazards to the environment. The main objective of this research is to study the effects of extreme growth behaviour of corrosion pit in hydrocarbon pipeline using statistical and probability methods. The linear model is deployed due to its simplicity and flexibility to project the corrosion dimension in the future. The research methodology consists of three main stages, which are statistical analysis, probabilistic analysis and reliability analysis using Monte Carlo simulation. The information of pipeline internal condition provided by the in-line inspection tools called pig has numerous uncertainties. It is more realistic to concern a group of data that has already exceeded a certain level of corrosion severity rather than considering the large volume of detected data provided by the intelligent pig inspections. Instead, the peak depth of corrosion defects is most likely to cause the failure of hydrocarbon pipeline. Thus, peaks-over-threshold method and extreme value statistics have been adopted. Based on the result, higher threshold value will lead to earlier time to failure. Both peaks-over-threshold method and extreme value statistics can be combined to produce a reliable prediction. With the results from both methods, we can compare and make a reliable prediction. The results are important for pipeline operators to assist their planning program of inspection, repairing and replacement activities in the future.

ABSTRAK

Ramalan keupayaan semasa pada peringkat awalan struktur talian paip minyak adalah penting untuk menyediakan penilaian awal bagi tujuan pemeriksaan, penyelenggaraan dan penggantian pada masa hadapan kerana kegagalan struktur talian paip minyak akan menyebabkan implikasi kepada ekonomi dan mendatangkan bahaya kepada alam sekitar. Objektif utama bagi penyelidikan ini adalah untuk mengkaji kesan-kesan daripada sifat pertumbuhan pengaratan dalaman yang ekstrem dalam paip minyak menggunakan pendekatan statistik dan kebarangkalian. Model linear digunakan kerana sifatnya yang ringkas dan fleksibel untuk meramal dimensi karat pada masa hadapan. Metodologi penyelidikan mengandungi tiga bahagian utama iaitu analisis statistik, analisis kebarangkalian dan simulasi keboleharapan struktur dengan menggunakan prosedur Monte Carlo. Maklumat keadaan dalaman paip diperolehi melalui peralatan pemeriksaan yang dikenali sebagai *pig* mengandungi banyak ketaktentuan. Adalah lebih realistik untuk mempertimbangkan sekumpulan data yang telah melebihi sesuatu tahap pengaratan daripada mempertimbangkan data yang banyak yang diperolehi daripada pemeriksaan *Ipig*. Biasanya, pengaratan yang dalam sekali akan menyebabkan kegagalan paip minyak. Oleh itu, metode nilai atas batasan dan statistic nilai ekstrem telah digunakan. Keputusan menunjukkan semakin tinggi nilai batasan, semakin cepat paip minyak akan gagal. Kedua-dua metode nilai atas batasan dan statistic nilai ekstrem boleh digabungkan untuk menghasilkan ramalan yang dapat dipercayai. Dengan adanya keputusan daripada kedua-dua metode, kita boleh berbanding sesama metode lalu membuat ramalan yang dapat dipercayai. Keputusan kajian sangat penting bagi pengendali paip minyak untuk merancang aktiviti pemeriksaan, penyelenggaraan dan penggantian pada masa hadapan.

TABLE OF CONTENTS

CHAPTER	SUBJECT	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRACK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xi
	LIST OF FIGURES	xii
	LIST OF SYMBOLS	xiii
	LIST OF APPENDICES	xv
CHAPTER 1	INTRODUCTION	1
	1.1 Introduction	1
	1.2 Problem Statement	2
	1.3 Objectives of Study	2
	1.4 Scope of Study	3
	1.5 Importance of Study	4
CHAPTER 2	LITERATURE REVIEW	5
	2.1 Corrosion	5
	2.1.1 Corrosion Mechanisms in Oil and Gas Industry	6
	2.1.1.1 Electrochemical Corrosion	6

2.1.1.2	Chemical Corrosion	7
2.1.1.3	Mechanical and Mechanical/Corrosive Effect	8
2.2	In-line Inspection Activities	9
2.2.1	Metal Loss Detection Tools	10
2.2.1.1	Magnetic Flux Leakage Tools	10
2.2.1.2	Ultrasonic Tools	10
2.3	Peaks-Over-Threshold Method	11
2.4	Extreme Value Statistics	11
CHAPTER 3	METHODOLOGY	13
3.1	Overview	13
3.2	Histogram	13
3.3	Continuous Probability Distribution	14
3.3.1	Normal Distribution	14
3.3.2	Lognormal Distribution	15
3.3.3	Exponential Distribution	16
3.3.4	Weibull Distribution	17
3.4	Parameter Estimation Using Probability Plotting	18
3.5	Goodness-Of-Fit Test	19
3.5.1	Chi-Square Test	19
3.5.2	Graphical Test	20
3.6	Peaks-Over-Threshold Method	21
3.7	Extreme Value Statistic	21
3.7.1	Extreme Value Distribution	22
3.8	Monte Carlo Simulation	22
3.8.1	Monte Carlo Simulation Procedure	23
CHAPTER 4	DATA ANALYSIS	27
4.1	Overview	27
4.2	Pipeline Corrosion Data (Pigging Data)	27
4.3	Corrosion Dimension Analysis	28

4.4	Corrosion Growth Analysis	29
4.5	Probability Analysis	31
4.5.1	Construction of Histogram	31
4.5.2	Parameter Estimation	33
4.5.3	Parameter Verification	36
4.6	Correction of Verified Corrosion Rate	37
4.6.1	Z-score Correction Method	37
4.7	Corrosion Growth Model	38
4.7.1	Random Consistent Model	39
4.7.2	Random Inconsistent Model	39
CHAPTER 5	RESULTS	41
5.1	Overview	41
5.2	Simple Simulation	41
5.3	Results of Simple Simulation	42
5.4	Monte Carlo Simulation	42
5.4.1	Statistical Parameters	43
5.4.1.1	Peaks-Over-Threshold Method	44
5.4.1.2	Extreme Value Theory	45
5.4.2	Failure Model	45
5.4.3	Limit State Function	46
5.4.4	Target Probability Failure	46
5.4.5	Simulation Cycles	47
5.4.6	Random Value Equation	48
5.5	Results of Monte Carlo Simulation	48
CHAPTER 6	CONCLUSIONS AND RECOMMENDATIONS	51
6.1	Discussion on Monte Carlo Simulation	51
6.2	Discussion on Peaks-Over-Threshold Method	51
6.3	Discussion on Error of Pigging Data	52
6.4	Conclusions	53

6.5 Recommendations	53
REFERENCES	54
APPENDICES	56

LIST OF TABLES

TABLE NO.	TITLE	PAGE
1.1	Summary of the inspection data	3
4.1	Summary of inspection data of Pipeline B	28
4.2	Average and standard deviation for sample of corrosion depth	29
4.3	Average and standard deviation for sample of corrosion length	29
4.4	Corrosion growth rate for depth	30
4.5	Corrosion growth rate for length	31
4.6	Frequency table of corrosion depth, d_{95} (%wt)	32
4.7	Estimated Exponential parameter for length data (1995)	33
4.8	Estimated Weibull parameters for depth data (1995)	34
4.9	Estimated Normal parameters for corrosion rate data (1995)	34
4.10	Computation of chi-square value for corrosion depth, d_{95}	36
4.11	Verified Exponential parameter for length data (1995)	36
4.12	Verified Weibull parameters for depth data (1995)	37
4.13	Verified Normal parameters for corrosion rate data (1995)	37
4.14	Corrected corrosion rate	38
5.1	Simple simulation results	42
5.2	Statistical value of material properties for pipeline	43
5.3	Statistical value of product flow properties for pipeline	44
5.4	Corrosion defect properties for pipeline	44
5.5	Suggested annual target failure probability for offshore pipelines (After DNV, 1999)	47

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
3.1	Normal distribution (Noor, 2002)	24
3.2	Lognormal distribution (Noor, 2002)	24
3.3	Exponential distribution (Noor, 2002)	25
3.4	Weibull distribution (Dodson, 1994)	25
3.5	Different extreme Normal distribution (Noor, 2002)	26
4.1	Histogram for corrosion depth, d_{95} (%wt)	32
4.2	Histogram for corrosion length, L_{95} (mm)	32
4.3	Histogram for corrosion rate, CR_{95} (%wt)	33
4.4	Exponential probability plot for corrosion length, L_{95} (mm)	34
4.5	Weibull probability plot for corrosion depth, $d_{95(\text{all data})}$ (mm)	35
4.6	Normal probability plot for corrosion rate, CR_{92-95} (mm)	35
5.1	Probability of failure versus time for 10000 cycles and 100000 cycles	48
5.2	Probability of failure versus time (non extreme case)	49
5.3	Probability of failure versus time (extreme case)	50

LIST OF SYMBOLS

Δ	-	Interval width
r	-	Range of the data
N	-	Number of data points
μ_x	-	Mean
σ_x	-	Standard deviation
λ_x	-	Lognormal parameter
ξ_x	-	Lognormal parameter
λ	-	Exponential parameter or known as failure rate
x_o	-	An offset, which is assumed to be known a priori (the smallest value)
β	-	Shape parameter ($0 < \beta < \infty$)
θ	-	Scale parameter ($0 < \theta < \infty$)
δ	-	Location parameter ($-\infty < \delta < \infty$)
\hat{x}	-	Independent variable
m	-	Slope
c	-	y-axis intercept
O	-	Observed frequency
E	-	Expected frequency
χ^2	-	Chi-square
d	-	Degree of freedom
k	-	Number of classes
r^2	-	Determination coefficient
CR	-	Corrosion rate
SMTS	-	Specified minimum yield stress

d	-	Corrosion depth
t	-	Pipe thickness
D	-	Pipe diameter
P_p	-	Applied fluid pressure
P_a	-	Calculated allowable pressure using failure model equation

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Table of Chi-Square Distribution	57
B	Table of Standard Normal Distribution	58

CHAPTER 1

INTRODUCTION

1.1 Introduction

Hydrocarbon pipelines are one of the important elements in oil and gas industry. They are mainly used to transport oil and gas. When pipelines aged, it is necessary that their safety, environmental and economical interests are preserved.

The internal environments of hydrocarbon pipelines can be extremely corrosive. Corrosion has become a major cause of the loss of strength in hydrocarbon pipelines resulting in failures. Due to leakage, the failure of hydrocarbon pipelines contributes to economic implications and cause serious hazards to the environment. Therefore, the prediction of pipeline integrity in the early stage is important in order to provide assessment for future inspection, repair and replacement activities.

This study is solely focused on the effects of extreme growth behaviour of corrosion pit in hydrocarbon pipeline using statistical and probability methods.

1.2 Problem Statement

An intelligent pig inspection will provide a huge amount of defects on pipeline even very shallow defects. It is more realistic to concern a group of data that has already exceeded a certain level of corrosion severity. Instead, the peak depth of corrosion defects is most likely to cause the failure of hydrocarbon pipeline. In this case, peaks-over-threshold method and extreme value statistics have been adopted.

1.3 Objectives of Study

The main goal of the research is to study the effects of extreme growth behaviour of corrosion pit in hydrocarbon pipeline using statistical and probability methods. To achieve this goal, the following plans were identified:

- a) To analyse real inspection data using statistical and probability methods.
- b) To model extreme growth behaviour of corrosion pit base on the metal loss volume of the hydrocarbon pipeline obtained from inspection data.
- c) To determine the most suitable peaks-over-threshold range of corrosion data.
- d) To predict the probability distribution of extreme growth behaviour of corrosion pit and the remaining life of corroding pipeline at the time of inspection and in the future using Monte Carlo simulation.

1.4 Scope of Study

The scope of study will include the statistical study on the inspection data gathered from oil and gas producer and inspection vendor. In this study, there are no dependency on the weather, environmental properties, material properties and operation conditions. The extreme growth behaviour of corrosion pit is modelled base on solely the metal loss volume of the hydrocarbon pipeline obtained from the inspection data. The summary of the inspection data is presented in Table 1.1 below. All parameters are presented as the statistical probability distributions. With different peaks-over-threshold value, the probability distribution of the extreme growth behaviour of corrosion pit will be predicted. To calculate the probability of failure, Monte Carlo simulation procedure will be used.

Table 1.1 : Summary of the inspection data

INFORMATION	PIPELINE B
Diameter (mm)	914.4
Inspected Distance (km)	150
Wall Thickness (mm)	22.2
Year of Inspection	1990,1992,1995
Year of Installation	1967
No. of Data (All Sets)	7009

1.5 Importance of Study

The study shows the systematic procedure in modeling the extreme growth behaviour of corrosion pit in hydrocarbon pipeline based on the in-line inspection data. Statistical and probability methods used in this study increase the accuracy in analyzing the data. The peak depth of corrosion defects is most likely to cause the failure of hydrocarbon pipeline. Therefore, the findings of this study are able to assist the pipeline operator in providing assessment for future inspection, repair and replacement activities.