INTEGRITY ASSESSMENT OF CORRODED PIPELINE USING IN-LINE INSPECTION DATA

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A thesis submitted in partial fulfillment of the
requirements for the award of the Degree of
Master of Engineering (Structure)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

JULY 2006

DEDICATION

Special fanatical to my Mother and Father

Puan Puteh Zaliha Binti Yaacob
Encik Mohamed Safian Bin Omar

And

My beloved Brother and Sister in law

Abang Long and Kak Long

No word can describe the gratitude for both of you

Besides

Family in all around Malaysia

Thank for the past or present sustain
And
Shoulder to shoulder support

.....This is for us!!!.....

Unforgettable

Ainul Mardhiah

This thesis is dedicated to you who do not suffer from the uncertainties

ACKNOWLEDGEMENT

Praise to **Allah s.w.t**, the Al Mighty, the Most Merciful for all the blessing and guidance upon me throughout this study.

While the motivation and hard work in pursuing a master's degree must come from within, interactions with others have stimulated and sustained me both professionally and personally during my research career. I want to acknowledge many people whose professionally help and personal support has made it possible for me to complete this thesis. My heart felt deepest gratitude goes to **Associate Professor Dr. Nordin Yahaya**, my thesis supervisor, for all the assistance, knowledge and help during the thesis syllabus.

My special thanks go to **Dr. Norhazilan Bin Md Noor** from Universiti Teknologi Malaysia, Structural Engineering Department, for his support and cooperation during the thesis research. Extended special appreciation to **Mr. Mohd Nazir Bin Haji Mohd Noor** from PETRONAS Gas Berhad for the useful information in the offshore pipeline system. Besides a specific thanks to my fellow master students for their support and great friendship.

Finally, my express is going to my family for their continuous love and support throughout my life.

ABSTRACT

Oil and gas pipeline operation is one of the highest risk systems in the industry. Any failure of the system will cause a huge impact to the environment and economy. The integrity assessment of the oil and gas pipelines in Malaysia has been focused and discussed long time ago. Formerly, the inspection and maintenance work has been made in a certain interval time in order to ensure the integrity of pipelines. Therefore, in this study, the integrity level of the pipelines has been evaluated using the present in-line inspection data (ILI). Present in line inspection data (ILI), gathered from the pipelines operator, has been analyzed by using the statistical approach to obtain the corrosion growth rate. Then using the probabilistic approach is used to predict the future corrosion rate. Finally, the present and predicted data was used in the DNV RP F101 code in order to determine the pipeline integrity. The results show that the pipeline is in a good condition for the next 19 years since from the first inspection. As a conclusion, there is no remedial work suggested to be commenced and as a recommendation the inspection interval can be extended longer in order to reduce the inspection cost.

ABSTRAK

Operasi penyaluran paip minyak dan gas adalah satu sistem berisiko tinggi. Sebarang kegagalan pada sistem tersebut akan memberi impak yang besar kepada alam sekitar dan ekonomi. Penilaian terhadap tahap keutuhan saluran paip minyak dan gas di Malaysia telah mendapat perhatian sejak sekian lama. Secara kebiasaannya, kerja-kerja pemeriksaan dan penyelengaraan dibuat secara berkala bagi memastikan saluran paip yang sedia ada berada di tahap yang optimum semasa beroperasi. Oleh itu, di dalam kajian ini, tahap keutuhan saluran paip minyak tersebut akan dinilai berdasarkan kepada data semasa. Data asas semasa dari alat pemeriksaan dalaman (ILI) yang diperolehi dari operator saluran paip minyak dan gas dianalisa menggunakan konsep statistik bagi mendapatkan kadar pertumbuhan hakisan yang berlaku. Seterusnya berdasarkan data semasa, konsep kebarangkalian digunakan dalam membuat jangkaan kadar hakisan pada masa hadapan. Setelah itu, kadar hakisan semasa dan kadar hakisan jangkaan tersebut dinilai berdasarkan kod DNV RP F101 bagi mengenal pasti tahap keutuhan saluran paip tersebut. Hasil daripada kajian ini menunjukkan bahawa, tahap keutuhan saluran paip tersebut berada di tahap yang baik untuk jangka masa 19 tahun dari tahun pemeriksaan yang pertama dibuat. Sebagai kesimpulan, tiada kerja-kerja penyelengaraan perlu dilaksanakan dan dicadangkan sela masa pemeriksaan boleh dipanjangkan dan secara tidak langsung dapat menjimatkan kos pemeriksaan.

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NOMENCLATURES

G	=	limit state function.
S	=	load,
R	=	resistance/demand.
P	=	probability.
P_f	=	failure probability.
xi	=	random variables
μx	=	mean value
n	=	number of observation
$Var(x)$	=	variance
σx	=	standard deviation
COV	=	coefficient of variation
Φ	=	standard Normal probability
y	=	dependent variable
x	=	independent variable
m	=	slope
c	=	y-axis intercept
y	=	$\phi^{-1}F(x)$
x	=	x
m	=	$1/\sigma$
c	=	$-\mu/\sigma_x$
i	=	failure order (counted from 1 to the largest order)
N	=	sample sizes
r_i	=	random number
a, c, m	=	non-negative integers
k	=	largest non-negative integer
$F(x)$	=	Cumulative Distribution Function (CDF)

u	=	generated pseudo random variables (0,1)
Sp	=	hoop stress level at failure (MPa)
Sf	=	flow stress of the materials (Mpa)
Ao	=	original cross sectional area of the pipe at the defect, (Ao = Lt) (mm2)
A	=	projected area of the defect in the longitudinal plane through the wall thickness represented by a parabola, (2/3 Ld) (mm2)
M	=	Folias or bulging factor, accounting for the effect of stress concentration at notch
L	=	defect length of metal defect along the axis of the pipe
t	=	nominal pipeline thickness
$SMYS$	=	Specified Minimum Yield Strength
D	=	Outer Diameter
F	=	factor of safety (always taken as 0.72)
$SMTS$	=	Specified Minimum Tensile Strength
x	=	0.9, 1.0 and 1.1
$\left(\frac{d}{t}\right)meas$	=	measured relatives corrosion depth
γm	=	partial safety factor for prediction model and safety class
γd	=	partial safety factor for corrosion depth
εd	=	factor for defining a fractile value for the corrosion depth
$Pmao$	=	maximum allowable operating pressure
$StD\left[\frac{d}{t}\right]$	=	standard deviation for measurement (d/t) ratio (based on the specification of the inspection tool)
$SMTS$	=	specified minimum tensile strength
$\Delta dist$	=	difference of relative distance
$dist_{prev}$	=	sampling distance of previous inspection data
$dist_{next}$	=	sampling distance of next inspection data
$\Delta orie$	=	difference of orientation
$dist_{prev}$	=	orientation of previous inspection data
$dist_{next}$	=	orientation of next inspection data

CR	=	corrosion rate
d_{T1}	=	corrosion depth in year T_1
d_{T2}	=	corrosion depth in year T_2
T_1	=	years of inspection T1
T_2	=	years of inspection T2
a	=	number of bin/class
n	=	number of observation
d_{T2}	=	corrosion depth in year T_2
L_{T2}	=	corrosion length in year T_2
d_{pre}	=	predicted corrosion depth
d_{act}	=	actual corrosion depth
L_{pre}	=	predicted corrosion length
L_{act}	=	actual corrosion length
$Std\ [d/t]_0$	=	Standard deviation of inspection tool in first year assessment.
$Std\ [d/t]_T$	=	Standard deviation of inspection tool in the future.
$Std\ [d/t]$	=	Standard deviation of corrosion rate.
T	=	prediction interval in year.

CHAPTER I

INTRODUCTION

1.0 GENERAL

Offshore pipeline transport enormous quantities of oil and gas vital to the economic of virtually all nations. Therefore the exploration and production of oil and gases form adverse or hostile environments and from marginal field is becoming increasing important to ensure a continuous and independent energy supply. Production of oil and gas from sea bottoms, performed from stationary platform has gained wide development. Most of the sub sea oil and gas fields that been developed, or are under development, are marginal with a production life time between 5 and 15 years (Martinussen, E. 1995).

Due to the effort of providing an over all energy supply, more oil and gas pipelines for the primary energy were supplies. Thus several damages occurred in such pipelines, caused by the formation of cracks extending over long distances. Any failure to ensure safe and continuous operation of these pipelines can have serious economic implications, possibly damage the environment and cause fatalities. A prerequisite to pipeline safe operation is to ensure their structural integrity to a high level of reliability throughout their operational lives.

1.1 PROBLEM STATEMENT

Cross-country of submarine pipelines are the most energy-efficient, safe, environmentally friendly, and economic way to ship hydrocarbons (gas, crude oil, and finished products) over long distances, either within the geographical boundary of a country or beyond it. A significant portion of many nations' energy requirements is now transported through pipelines. The economies of many countries depend on the smooth and uninterrupted operation of these lines, so it is increasingly important to ensure the safe and failure-free operation of pipelines.

While pipelines are one of the safest modes of transporting bulk energy, and have failure rates much lower than the railroads or highway transportation, failures do occur, and sometimes with catastrophic consequences. A number of pipelines have failed in the recent past, with tragic consequences. In 1993, in Venezuela, 51 people were burnt to death when a gas pipeline failed and the escaping gas ignited. Again in 1994, a 36-inch (914 mm) pipeline in New Jersey failed, resulting in the death of one person and more than 50 injuries. Similar failures also have occurred in the UK, Russia, Canada, Pakistan, and India (Hopkins, 1994). While pipeline failure rarely causes fatalities, disruptions in operation lead to large business losses. Failures can be very expensive and cause considerable damage to the environment.

In practice, various techniques are routinely used to monitor the status of a pipeline. Any deterioration in the line may cause a leak or rupture. Modern methodologies can ensure the structural integrity of an operating pipeline without taking it out of service (Jamieson, 1986). The existing inspection and maintenance practices commonly followed by most pipeline operators are formulated mainly on the basis of experience. However, operators are developing an organized maintenance policy based on data analysis and other in-house studies to replace rule-of-thumb based policies. The primary reasons for this are stringent environmental protection laws (US Department of Transportation, 1995), scarce resources, and excessive inspection costs. Existing policies are not sharply focused from the point of view of the greatest damage/defect risk to a pipeline. The basis for selecting health monitoring and inspection techniques is not very clear to many operators. In many cases, a survey is conducted over an entire pipeline or on a particular segment, when another segment needs it more. Avoidable expenditures are thus incurred.

A strong reason exists, therefore, to derive a technique that will help pipeline operators select the right type of inspection/monitoring technique for segments that need it. A more clearly focused inspection and maintenance policy that has a low investment-to-benefit ratio should be formulated. The purpose of this study is to highlight the pipeline integrity assessment process in order to maintain safe pipelines operations.

The existing method of pipeline health monitoring, which requires an entire pipeline to be inspected periodically, is both time-wasting and expensive. A risk-based model that reduces the amount of time spent on inspection has been presented. This model not only reduces the cost of maintaining petroleum pipelines, but also suggests efficient operation philosophy, construction methodology and logical insurances plans. Besides, use of probabilistic approaches to evaluate the integrity of corroding pipelines is beneficial because the uncertainties associated with in-line-inspection tools, corrosion rate, pipeline geometry, material properties, and operating pressure can be modelled and considered over any chosen time period.

1.2 OBJECTIVES OF THE STUDY

The objectives of this study are as follows: -

1. To estimate the corrosion rate (Cr) from the in-line inspection (ILI) data.

2. To evaluate the current and future integrity of corroded pipelines by using a probabilistic simulation approach.

1.3 SCOPE OF STUDY

The scope of study will be using the ILI data for the corroded pipeline provided by the pipeline operator. The corrosion rate has been determined by using statistical and probability analysis method and for the integrity assessment the provided ILI data has been analyzing by using the DNV RP F101 code.

1.4 STUDY METHODOLOGY

To support the study, a comprehensive literature review has been done on the corroded pipeline including the corrosion process, in line inspection tools and the assessment method. Besides, the DNV RP F101 code has been focus in detail study in order to achieve the objectives.