Thesis for the Degree of
Doctor of Philosophy

Ultimate Limit State Assessment of Corroded Subsea Pipelines

August 2014

The Graduate School
Pusan National University

Department of Naval Architecture and Ocean Engineering

Mohd Hairil Bin Mohd

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Mohd Hairil Mohd.

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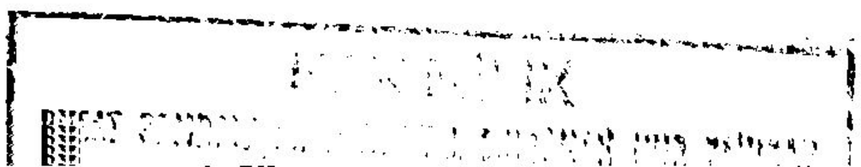

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Thesis Supervisor Prof. Jeom Kee Paik

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by

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Summary

The safety of pipelines is becoming more important nowadays as this issue is strictly related to health, safety, and environment. Special attention and consideration need to be accounted to limit the impacts and consequences due to pipelines failure. Pipelines, which involve a complex engineering system, have been the most practical and economical means of transportation for oil and gas since several decades ago. As the pipelines operate for considerable period, it will be exposed to many types of defects that occasionally decreased the pipelines maximum capacity and lead to undesirable event consequently.

Generally, corrosion decreases the ultimate strength of pipelines. The growth of corrosion in terms of its parameter and quantities are parallel with time (age). Therefore, it can be said that corrosion is a time dependent process. The corrosion process itself is unique and not a straightforward process, hence making pipelines as time-dependent structures and so does their ultimate strength. Corrosion progress in pipelines is influenced proportionally by the surrounding environmental factors, in which their characteristics cannot always be predicted by deterministic methods as in the design standard codes.

By understanding the fact that corrosion cannot be stopped in pipeline systems, the best way to tackle the problem is to critically deal with it. In a reflection to this fact, this thesis aims to identify and examine the suitability of statistical approach on the prediction of pipeline corrosion, as well as oil well tube corrosion. Using the on-site corrosion data (subsea gas pipeline and oil well tube), the formulation of corrosion prediction was developed. In both formulations, the data was carefully analyzed, and the best function which can represent corrosion progress was chosen. As a result, time dependent corrosion wastage model of oil well tube and subsea gas pipeline were produced.

By utilizing the original corrosion data, the ultimate limit strength study was conducted to evaluate the performance of the corroded pipeline against the effect of corrosion. Focus has

been given on the effect of combined internal pressure and bending moment on the remaining ultimate strength capacity of the corroded pipeline. Besides, the proposed formulation on corrosion depth equation was further applied on the prediction of the remaining year in service of particular subsea gas pipeline. Comparisons were made between the effect of linear and non-linear corrosion rates on the maximum burst pressure capacity, as well as its remaining life.

Lastly, the outcomes of this thesis are beneficial to the oil and gas industry in many ways. Not only minimizing the cost, it can also provide valuable knowledge to pipeline operator. For instance, the developed equation on time dependent corrosion wastage models will give a good option for them to calculate the corrosion rate at certain year instead of using uniform corrosion rate throughout the life of pipelines. The application of non-linear corrosion rate will also enhance the accuracy of the analysis compared to uniform corrosion rate as discussed in this thesis. It is hoped that the illustrations and knowledge provided in this thesis can also at least give some impact not only on the oil and gas pipelines structure, but also other engineering structures with similar concerns.