

CONDITION ASSESSMENT OF PIPELINES THROUGH PROPER PLANNING AND DESIGN



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ABSTRACT

The author has been involved in failure investigations, pipeline performance and condition assessment for more than 25 years. Businesses he has managed have assessed more than 3,500 km of pressure water and wastewater pipelines, in Australia and South-east Asia. During this time he has been involved in Quotation, Design, Implementation and Interpretation of Condition Assessment Projects and Programmes. The success of these programs have largely been determined by the Design and Methodology required to produce a “Useful” outcome.

Design of a Condition Assessment strategy involves the following steps :

1. Identification of Specific Outcomes required from the investigation;
2. Identification of mode of failure of pipeline material;
3. Structured methodology to determine likelihood of failure of pipeline or sections of pipeline;
4. Correct choice of cost-effective technologies for each pipeline material;
5. Estimates of probability of failure of pipelines or sections of pipelines.

Step 1 is essentially determined directly or indirectly by the Regulator, and may differ from one authority to another.

Step 2 is critical as materials perform differently, and although condition may be important, some materials frequently fail with little deterioration of original condition. Also, the frequency or distribution of the failures will not be uniform. In most cases, the pipes exhibiting worst condition will be most likely to fail. These however, will be relatively few in number within a pipeline.

Step 3 uses a multi-stage approach and may require the utilisation of more than one technique.

Step 4 enables the correct choice of technologies. No single technology produces the “whole” picture, but some reveal more than others. In this stage verification and fitness for purpose need to be determined.

Step 5 should ideally match the original requirements of Step 1.

Several examples of projects in Australia and Asia are presented to illustrate the importance of proper planning.

1.0 INTRODUCTION

Since the 1990's the condition assessment of pressure pipelines has become increasingly important in Australia and some of the developed cities of Asia. Indeed, Australia took the lead on this with major contracts in Sydney, Canberra and Newcastle. In recent times, water authorities in United States have embarked on condition assessment of pipelines. To date, the PCA group (formerly part of Tyco Water, and now part of Echologics) has assessed more than 3,500 km of mostly critical water and wastewater mains for customers including Sydney Water Corporation, ACTEW-AGL, Hunter Water Corporation, Singapore Public Utilities Board (PUB) and Water Supply Department (HKSAR).



Figure 1: *DN900 DICL Main Assessed at Admiralty, Hong Kong (2002)*

The Pipeline Condition Assessment group (PCA) began operating as a business in Sydney in 1996, originally, almost exclusively utilising Remote Field Technique (Hydroscope®) to assess smaller diameter grey cast iron and ductile iron mains. As demand increased for assessment of larger diameter mains, the group began to utilise and trial several other techniques, based on the experience of investigated pipe. To date the group has performed Condition Assessment Investigation on more than 25 such techniques as RFT Intelligent Pigging, *SoilCorr* (LPR) soil testing, Pipe Coating Survey (for steel pipelines), RFT Mainscan® and ePulse, mostly in combination with proprietary statistical algorithms.



Figure 2: *DN375 RFT Hydroscope® was first used in Australia (1999)*

2.0 DESIGN OF A STRATEGY

The following diagram depicts the overall design process for a Condition Assessment Strategy for Pressure Pipelines.

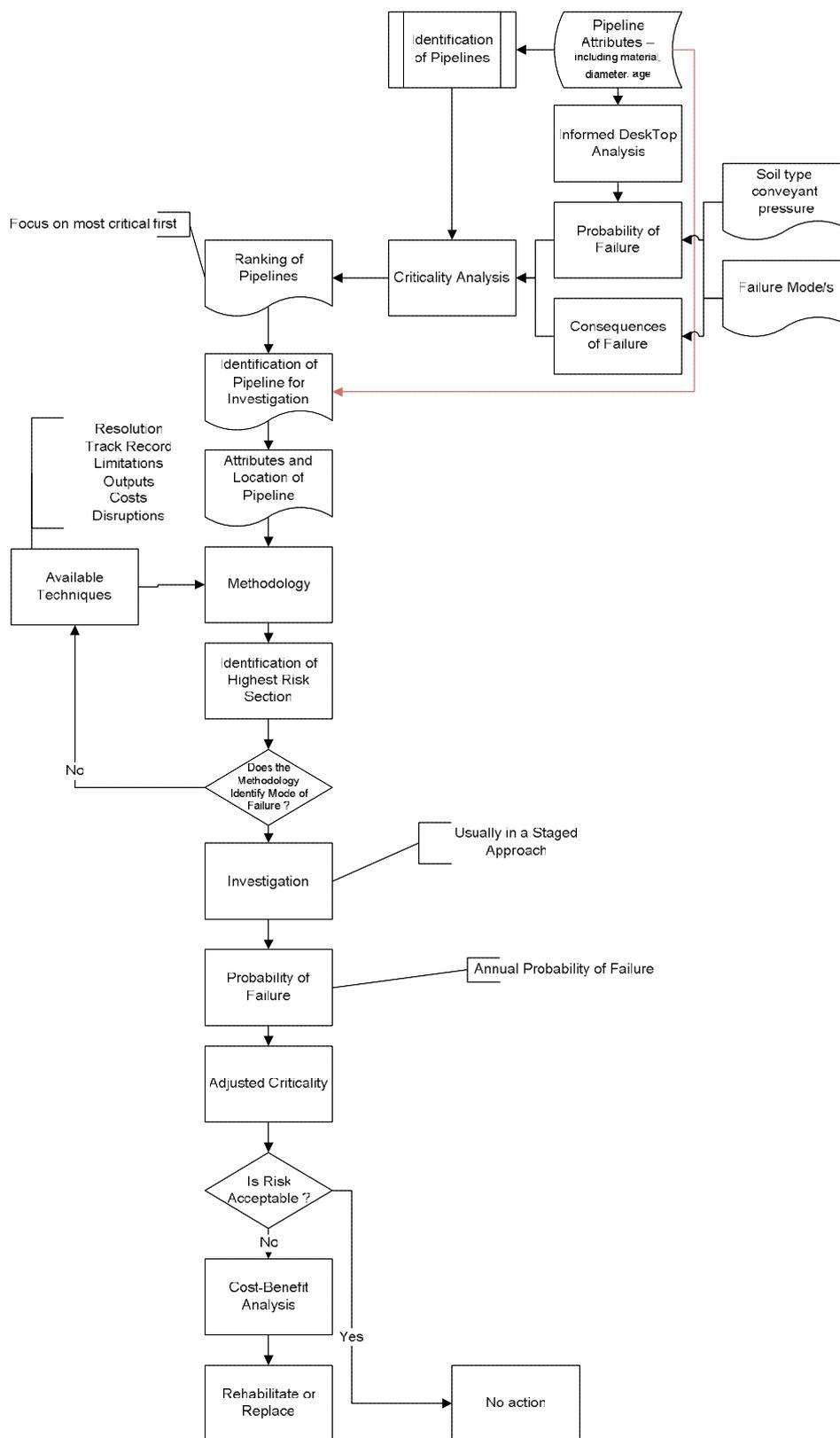


Figure 3: Overall Strategy

2.1 Outcomes

The ultimate Outcome from a Condition Assessment Programme is usually determined by the Regulator or Owner, and is quite often Lowering of Risk.

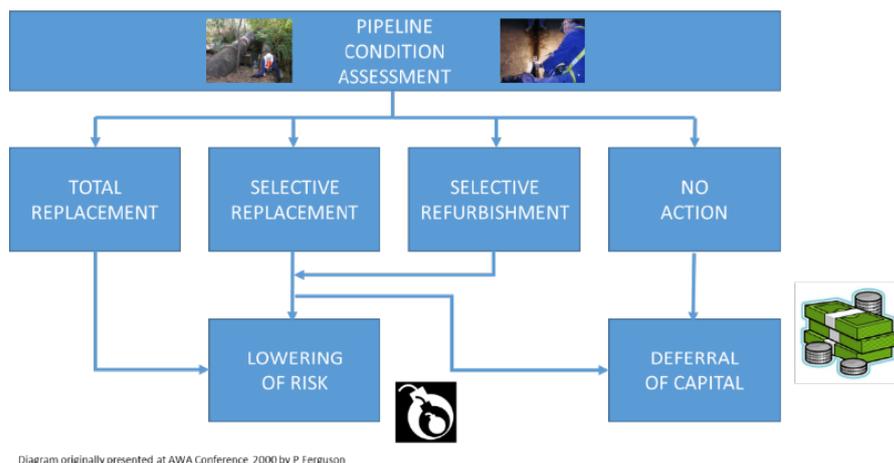


Figure 4: *Driver for Pipeline Condition Assessment (2000)*

2.2 Mode of Failure of Pipelines

From consideration of the distribution of failed pipes along inspections using RFT pigging, extensive pipe excavations and consideration of failures, it became apparent that with a pipeline, there is a distribution of individual pipe conditions, and accordingly a large variation of condition. The following figure depicts the variation of condition of 122 individual pipe lengths along 450m pipeline. The condition of the individual pipe length is determined by the minimum remaining wall thickness of the individual pipe.

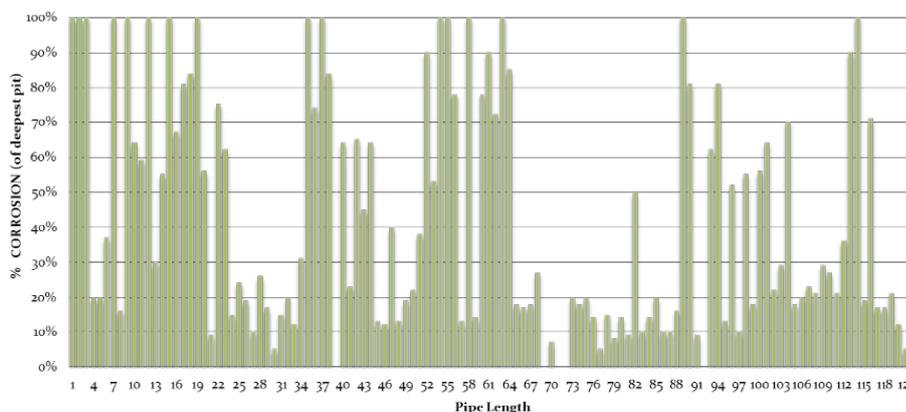


Figure 5: *Variability of Condition of Individual Pipes along a Pipeline (1999)*

The variability of condition is determined by such factors as variation in soil corrosivity (both natural and man-influenced), presence and condition of external coatings, material properties and original wall thickness. Statisticians refer to some of these influences as Stratem – which refers to commonality within a sample of pipes. An example of two different strata is above and below ground pipes, which will behave differently due to different environments. Another is coated and uncoated pipes.

With brittle materials, such as asbestos cement and grey cast iron pipe, loading and rates of loading will significantly influence the occurrence and probability of failures.

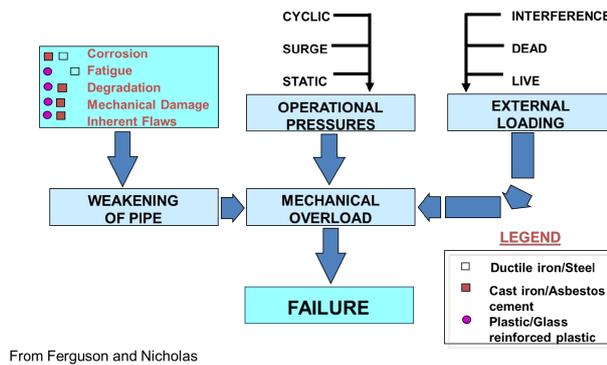


Figure 6: *Failure Sequence of Pipes (1992)*

2.3 Methodology

Technically, the Methodology must be able to identify those factors which will determine pipe failures. From a condition perspective, this means identifying those pipes, or sections of pipes, which contain the pipes in “worst” condition, and a quantitative assessment of the worst condition. Accordingly, the Methodology identifies those technologies which are capable of detecting “defects” or change in condition for the specific material. Additionally, it must contain the means to consider the principal modes of failure.

2.4 Choosing Technologies

There are some basic evaluations that should be conducted before a technology is chosen:

1. Does the technique produce a Quantitative Output? This is important as it allows verification and extrapolation;
2. Can results be extrapolated along the entire pipeline and into the past and future ?
3. Has it already been used successfully?
4. What are the limitations of the technique?
5. Does the service provider fully understand the behaviour of pipes and how the technology will be utilised; and
6. Is the technology cost-effective?

It must be realised that all technologies require some assumptions to be made, and that they each have “incomplete” information concerning the condition of the entire pipeline. An example is shown below of a “poor” technology, as it doesn’t reveal aspects of the “important feature”. Technologies can broadly be divided into “spot” or “continuous” (with recent introduction of some acoustic techniques which are a combination of these). The former require statistical techniques and require recognition of the sample space.

2.5 Probability of Failure as an Outcome

Based on the condition (likely worst case) and the operational environment (static and surge pressure) the outcome should be the Annual Probability of Failure, with a corresponding estimate of Failure Regime. This allows verification of the methodology, and provides input into

- a. A revised Criticality Ranking;
- b. Cost-benefit analysis for timeliness of replacement or rehabilitation, and
- c. Capital Expenditure Programming.

3.0 CASE HISTORIES

Some Case Histories will be presented to demonstrate how proper outcomes can be achieved.

4.0 CONCLUSIONS

1. There is an increasing need for Condition Assessment within the Water Industry;
2. There are techniques available that provide valuable information into the condition of pipes/pipelines;
3. There is a large variation of condition of pipes along a pipeline;
4. This variation can be ascertained by two different methodologies – “spot” measurement or “continual” measurement;
5. Each technique has its own strengths and limitations;
6. The effects of measurement techniques/methodologies of material type and “type” of water need to be identified;
7. An important outcome of the assessment is a quantitative **Probability of Failure** of the
8. ‘weakest links’ and other sections.

5.0 ACKNOWLEDGEMENTS

The author wishes to thank the co-authors of papers referenced in this paper. Most are still actively involved in the Water Industry.

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