EM&I – low cost solution for reducing piping integrity risk

By using probability theory, we can get an indication of the level of risk of a piping system failure with higher accuracy and far fewer measurements than the traditional method. We talked to EM&I

Probability theory is a well-known statistical technique where you expect a distribution of anything in the real world to follow a bell curve (technical name is the Gaussian distribution).

Bell curves do not all have the same shape – some are more condensed than others. The challenge is working out the shape of the bell curve, with the minimum number of data points so that the probable minimum wall thickness and an understanding of the internal condition of the piping system can be assessed much more quickly and at lower cost.

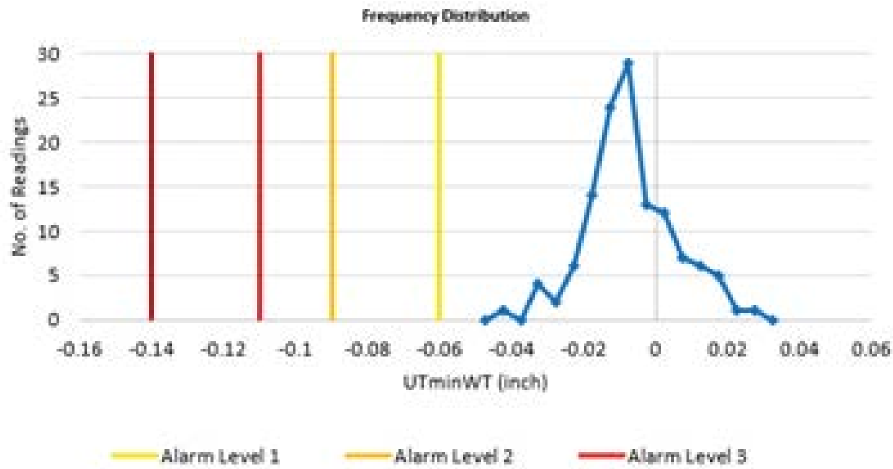
This is a technique which we could readily understand if applied to the task of – say – finding out the chances of having a person weighing above 115kg in a certain group of people, without actually finding a person who weighed 115kg. We can take enough readings to see what the rough distribution looks like and extrapolate it.

But this technique has not been much applied to tasks with big risks attached to them, like assessing the likelihood of a piping pressure system failure. People may be sceptical that data analysed through probability theory is as reliable and informative than data you directly measure.

However, data you directly measure involves challenges, for example, where it is difficult or uneconomic to measure everything, such as with seabed pipelines, or extensive piping systems. In these cases, the probability theory results can be more reliable and give insights such as the probable minimum with a known confidence level, and the type of corrosion that is occurring.

Asset integrity consultancy EM&I is applying probability-based risk assessment on 14 assets currently and is running pilot programs with a number of oil majors. The company believes this is the first time that an effective probability theory has been applied to asset integrity management. It calls the system "ANALYSE™".

EM&I says it has achieved greater than 60 per cent reduction in maintenance costs, while improving integrity assurance. Less maintenance work also means fewer people exposed to risk and of course lower costs and lower carbon emissions.



Blue line: you have a frequency distribution of pipeline thickness readings, showing deviation from the norm (zero). But what are your chances of having a reading which reaches alarm levels 1, 2 or 3?

The same method can be applied to thickness measurements or pitting in steel structures, or anywhere there is corrosion, to help determine the risk of a possible leak or structural failure.

The background is that asset integrity management companies like EM&I have spent a great deal of time taking readings on piping and pressure vessels over the past decades. 'Much of this data was never used for any modelling, just used for an immediate determination of minimum recorded wall thickness at the time of the inspection' says Danny Constantinis, executive chairman of EM&I.

For one client, as an experiment, EM&I took all the data it had collected for them over a 5-year period and tried, using conventional methods to look for useful trends – and found it was unable to do so.

This triggered efforts to look for a solution in a new direction which analysed all the data rather than minimum readings and point to point trends. The top statistical brains in various universities were consulted and in collaboration with in-house experts in corrosion and integrity management came up with the ANALYSE solution.

This had to be tested on real data and after extensive trials the system was introduced to a major client with a pilot programme which was successful and led to the system being implemented on 14 assets fleetwide.

Standard RBI methods

The standard way to plan an inspection program for pipelines is "Risk Based Inspection" (RBI), where you try to determine which piping systems might be most risky and survey those. Perhaps for each piping system you would gather corrosion data at susceptible points, around T connections, for example.

A first problem with trying to directly measure corrosion is that the inspection tools do not have enough resolution. You may have corrosion rates of 0.1mm per year, and equipment which is accurate to +/- 1mm – so it may take many years of reading in the same spot to notice any real change.

It is not therefore usually possible, using conventional methods, to calculate the safe operating life by calculating the corrosion rate.

Current inspection methods will provide the minimum thickness detected but do not calculate the probable minimum with a known level of confidence as does the statistical method, EM&I says.

Probability theory and pipelines

To explain the probability theory method in more depth, consider if we wanted to work out the chance of a young person dying in the next decade. The chances are low but not zero. But since not many young people die, calculating the chances by dividing the number of young people who die by the number of young people does not give a very useful answer.

But we can get a better sense by looking for other parts of the curve – for example if we can get a more realistic sense of the chances of dying for people in their 40s and 50s, when death rates are higher, we could draw a curve and extrapolate it for people in their 20s.

A similar process can be used if we want to estimate the chance of a section of piping leaking (= thickness reducing by 100 per cent). It is quite rare for a pipe to leak, so we can't use the number of pipe leaks to calculate the odds of this specific pipeline leaking. But we may have data for a component of the same pipe which has reduced its thickness by 40 per cent, 50 per cent or 60 per cent, which we can use to draw a curve.

Consider that if you take thickness measurements of a new piece of piping where the walls are supposed to be 10mm thick. You will see that all the thicknesses are close to 10mm, and the average thickness will be slightly more than 10mm, to ensure the piping passes a quality control test.

There will be a range of thicknesses on a curve. You cannot guarantee that the smallest thickness you measured is the thinnest section of pipe, unless you measure the entire pipe.

But if you put your readings through a probability model, it can tell you that the thinnest part anywhere is (for example) 8.5mm – and what confidence you can have in that number.

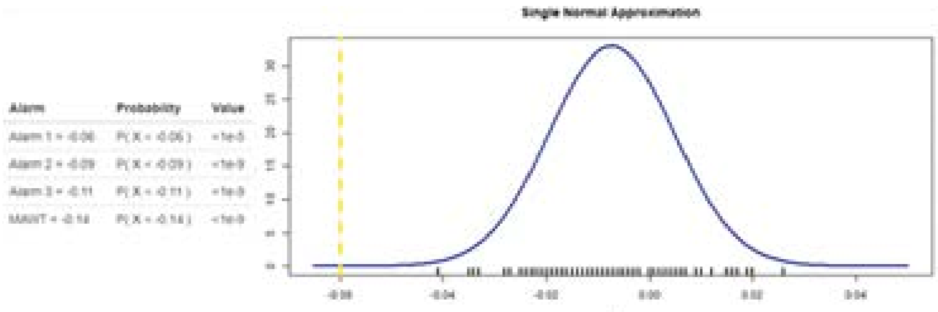
Then with statistics, you can calculate how sure you are of this. In one pipeline example, it said that the chances of having steel which leaks (= 0 thickness) is 1 in 1 x 10 to the power 12 (12 zeros).

The adequate level of risk is an engineering judgement based on what the consequences of an accident would be. If it is a pipe carrying seawater, and the only risk would be a seawater leak, 1 in 100,000 may be fine. If it is a high-pressure gas pipeline which goes past a potential ignition source, you may want at least 1 in a million.

You can calculate the number of readings that you need to take, to get the desired accuracy level. This may mean you need fewer readings than you would normally take on a normal risk-based inspection.

The owner of the asset can determine the risk level they want to live with, and the service provider can deliver an inspection scope that meets that risk level.

"We can find we can 'lose' 50 per cent of the data randomly and still end up with an excellent prediction," Mr Constantinis says.



The 'normal' distribution ' what you would expect anything in the real world to follow – and the probability of finding an extreme value

Enough data?

In terms of the statistical modelling, the method is not just about calculating the curve from the data available, it is about determining if there is enough data to calculate a curve with an adequate reliability level. In other words, whether you have made enough inspections and have enough data points, or where it would be useful to make more inspections.

The probability theory algorithm can run inside the handheld computers or tablets carried by inspectors, and continually tries to compute the risk levels from the readings they are taking – and also let them know if there are enough readings or if any alarm levels have been reached.

There is a colour coded advice showing green when sufficient thickness readings have been taken, and they can move onto the next task. Amber when more readings or further investigation is required, and red when immediate action is required.

The data might be sent to an engineer to look at in more depth, who might recommend shutting the line down while more analysis is done, or reducing the pressure of flow through it. If the asset owner resists the idea of shutting the plant down because of money which will be lost, it is possible to immediately send a photo of the area of concern of the pipe, to justify the reasoning.

It is possible that the analysis will calculate that you have a very high chance of a breach – although you have not yet actually measured any specific section of the pipeline which is close to being breached.

If the analysis shows you are taking more readings than you need, then it does not matter which readings you remove – you can choose them randomly, but in practice the system chooses higher risk points such as T's and bends.

This kind of statistical modelling does need high levels of statistical expertise. For this project, E&MI worked together with statistics experts at a well-known London science and technology university, together with an oil major. E&MI does not have authorisation to release their names at this stage.

Taking baseline pipeline measurements on Asia's first deepwater FPSO