Leakage and the Link to Asset Management

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Introduction

When considering leakage, mains renewal is often left out of the picture – not surprising when considered alongside other leakage activities, where the cost of saving water through such as activities as pressure reduction or active leakage control will be a fraction of the cost of saving water through mains renewal. However, mains do not last for ever and correctly identifying the investment needed and targeting the mains to be renewed can ensure that water undertakings get the maximum benefit for their investment. In addition, leakage activities can be incorporated in to a comprehensive asset management plan for the distribution system.

Asset Management Principals

The concept of asset management has become more widespread over the last decade. In the UK, the publishing of PAS 55 and the International Asset Management Manual has greatly raised the profile of asset management and recently the ‘Institute of Asset Management’ was established which is working hard to disseminate best practice.

There has been debate amongst practitioners of asset management as to what its correct definition should be. One recent report, prepared by Leeds University for the Environment Agency, described it as ‘a structured, holistic approach to aligning and managing over time the performance of physical assets as a corporate resource with business objectives and drivers’. The key points in this definition are:

• **Structured and holistic** - the approach should have a clear strategy and guidelines which apply to all asset categories

• **Manage performance over time** - in order to manage performance over time you have to measure the performance at any given point and then track that performance to see how it changes.

• **Corporate resource** - the importance of assets in the delivery of an organisation’s corporate strategy must be understood

• **Aligned to business drivers** - any asset management strategy needs to fit in with the overall business objectives and drivers. For instance, is customer service a priority, are water resources constrained?

The definition could be summarised by answering the following questions for any group of assets:

• How do the assets contribute to the company’s objectives?

• What is their current performance?

• How will that performance change under various strategies? (E.g. maintain or increase current levels of capital investment)

• What is the best strategy for the corporate objectives?

It may be assumed that costs come in to the strategy, and ideally the approach should deliver the minimum whole life cost. In fact the definition given in the International Infrastructure Management Manual defines asset management as ‘The combination of
management, financial, economic, engineering and other practices applied to physical assets with the objective of providing the required level of service in the most cost effective manner. However costs cannot always be considered in isolation. Public sector borrowing requirements and other political or regulatory drivers may direct different options.

The International Infrastructure Management Manual describes two asset management processes or cycles; basic and advanced. These are shown in figures 1 and 2.
Examples of asset management in practice.

As water undertakings rely on expensive assets which may have taken decades to establish, managing those assets to best meet the undertaking’s objectives is key.

Taking the case of a common asset found in water companies, a pumping station, a comprehensive asset management strategy will monitor running and maintenance costs and identify the optimum time to replace any individual pump. On a whole life cost based approach, this will be when the net present value (NPV) of running a pump is more than the cost of installing a new pump. This will entail knowing how the running and maintenance costs of the pump will behave in the future as well as the cost of purchasing and installing a new pump.

Similarly, for a fleet of vehicles, the decision to replace a vehicle will be taken when the NPV for running and maintenance costs amounts to more than the cost of replacing the vehicle.

This can be represented graphically as in figure 3. The interval between replacements may be a few years as in the case of a vehicle or several decades for a pump.
Asset Management is not just a case of balancing the operational and capital investment costs. It should also include ensuring that operational and maintenance policies minimise operating costs. In the case of the pump and the vehicle, a preventative maintenance policy is likely to be adopted as planned preventative maintenance generally costs less and ensures that unplanned breakdowns - with the expense and problems they can bring - are minimised. However, other maintenance policies may be adopted, for instance in the case of a borehole pump, a breakdown approach to maintenance is usually appropriate as removal of the pump is so expensive. However, the decision to replace can still be based on running and breakdown costs with perhaps an element included to take risk and the consequences of failure in to account.

Management of water distribution assets

Water mains and the associated fittings and apparatus should be managed using a similar approach. A distribution system could be considered to consist of a large number of similar assets with leakage detection and repair the reactive maintenance programme. It might be thought that mains replacement could be based on similar approaches to the example with reactive maintenance used above, that of a borehole pump. However, a number of points need to be considered, so it may not be quite so simple.

First of all, what is the asset life? There are many factors which affect pipe failure including soil conditions, surface loading and weather. This is further complicated when one considers the question ‘what is the end of the asset life?’ A pipe may still continue to convey water even when it suffers from a large number of leaks or repeated bursts. Leaks are used here to indicate escapes of water which do not severely affect performance of the pipe, whilst a burst is used to indicate a failure which is so severe that the pipe cannot continue to convey water.

One approach might be to consider the cost of repairs over a period of time against the cost of replacement. However, what period of time should be chosen? Even where quite long periods have been chosen it can be difficult to justify the substantial costs of mains replacement on cost alone as a policy of reactive repair will continue to be more effective until very high mains leakage and burst rates are experienced. These rates may be substantially higher that those which are acceptable to customers or politicians.
An additional complication is the question of what costs should be included. In the UK there has been more focus recently on the so called 'social' or 'indirect' costs of repairs – such as the cost of traffic delays, additional pollution, degradation of the road surface etc. However, a recent study by the UK based research consultants WRc showed that even when such indirect costs are included, an approach of reactive repair and maintenance is the economic solution unless the remaining life of the pipe is taken to be around 50 years or more.

All this would seem to indicate that mains replacement initiatives should be kept to a bare minimum. However, without some sort of regular replacement programme it is possible that the situation experienced by some UK water companies could be repeated. In these companies the extensive network of ferrous mains laid in the nineteenth century has now deteriorated to such an extent that, even with an extensive leakage control programme, maintaining acceptable levels of leakage is virtually impossible. There is some evidence that ferrous mains have relatively low failure rates until a critical point when leakage and/or bursts start to increase at a rapid rate as shown in figure 4. In the later stages of the pipe's life there may also be the problem that the pipe has deteriorated so far, typically by corrosion, that when a pipe suffers the disturbance required to repair the pipe – isolation, draining down and recharging, this in itself can initiate more leaks than previously existed.

The trick would appear to be to identify the critical point at which the failure rate is just starting to increase rapidly. However, this may not be so easy. Additional variables which are not continuous such weather effects and operational problems may make it difficult to identify the underlying rate of deterioration.

An alternative approach is to consider the whole pipe stock and maintain the current level of risk, or change it if this can be justified on a cost and/or social basis. Ideally the rate of capital investment should be such that the cost of capital expenditure and operational expenditure are minimised. A graph which should be familiar to many leakage experts can be applied to the rate of capital investment. As capital investment rates (capex) fall operational expenditure (opex) rises. (figure 5) Asset management information should allow an undertaking to identify the minimum whole life cost.
The UK approach

In the UK the issue of how much money should be allocated to replacement of ageing assets has been a topic of discussion for a number of years. In most water companies at least a third of their stock is over 100 years old and in some companies over 80% is over 50 years old. Although other asset categories also require major investment, the deterioration of water mains and high levels of leakage, in spite of extensive active leakage control programmes, mean that replacement of water mains is a major issue for some companies.

The debate regarding the appropriate levels of asset maintenance investment emerged in the late 1990’s as substantial discrepancies occurred between the levels of investment which companies claimed they required to maintain their assets and the money which the financial regulator, OFWAT, agreed should be made available during the periodic price reviews. This tended to be disruptive to investment programmes as well as leading to protracted and expensive debates companies and the regulator. In 2002 UK Water Industry Research (UKWIR) published the results of a research project to develop an approach to creating asset management plans which would be accepted by all parties concerned. The initiative was unusual in that all the regulators participated in the project and the result was ‘The Common Framework for Capital Maintenance Planning’. Figure 6 details the approach, which requires a detailed analysis of past asset performance based on well considered observations of those records. From this, models should be developed to identify future performance.
This approach may be summarised by a four step approach:

- Identify current and past performance
- Predict future failure rates with current investment approaches
- Predict future failure rates with alternative investment approaches
- Determine the economic level of maintenance as in figure 5

Thus not only can the economic level of leakage be ascertained, but the economic level of mains replacement can also be established.

In order to support the development of failure analysis for water mains, a national mains failure data base was established which to date has over 200,000 records. All companies contribute with a national standard established for the collection of mains failure data. This sets minimum standards for data collection as well identifying possible enhancements for companies who wish to improve their asset records. With such a large stock of data it is possible to start to identify trends affecting failure rates and work is now
in progress to investigate those trends nationally, although some companies have
developed their own models.

One issue with these records, however, which is difficult to eliminate is the effect of
leakage policy on the numbers of failure records. It is not difficult to see that a company
with robust leakage detection procedures might well identify more failures than a company
where leakage monitoring was carried out on a more hit and miss basis. Similarly any
changes in leakage strategy or technology within a company, such as large scale
investment in noise loggers, may lead to an apparent increase in failure rates. Therefore it
is preferable to consider leakage levels when looking at failure rates at a company level to
identify any factors which might affect the failure rate. This is not possible with the UK
national data base where the data given by the companies has been carefully processed
to be completely anonymous before including the database.

A further factor which needs to be taken into account is the requirement for mains to
perform on water quality as well as quantity. A mains asset management programme
needs to take other parameters into account, such as dirty water problems, when
developing a mains renewal programme. However, various systems to optimise
investment to take these multiple demands into account are being developed, although
there is still much work to be done.

Starting from scratch

Not all organisations have a robust asset information system. However, much of the
information they will need can be collected and may already be available through, for
instance, their leakage or repairs system.

Good records of the mains system in the ground is the first step. The availability of this
information may be dependent on earlier operational policies. If there are gaps in the
information it is essential to mobilise all employees and contractors working on the system
to collect information at every opportunity. Other utilities may also be able to help.
Whenever a water man is exposed there is an opportunity to check the material, age, soil
surround and exact location. This will help improve the database.

When repairs are made, it is important to collect as much information about the repair
as possible. How the need for a repair was identified should be captured as this may
indicate whether the leak developed rapidly or slowly over time. The time of identification
may not be the exact time when the failure occurred, but when dealing with pipe lifetimes
of decades the inaccuracies are generally not important. Information about the failure
mode should also be collected and simple charts to explain what type of failure, e.g. ring
fracture, failure of a ferrule etc. may help field staff. Pipe cut outs should be collected at
every opportunity – when connections are made as well as repairs. Soil samples collected
at the same time can help provide information about factors affecting the pipe condition.
Both pipe and soil sample collection can be encouraged by providing plastic bags with
labels ready attached which just need details of the date and location of the work.

Leakage levels can also provide an indicator. However, this is more difficult to allocate
to a specific location unless the system is subdivided into smaller units such as district
metered areas (DMA’s). If leakage is being maintained at a constant level, the total repair
numbers required to maintain this level this can give an idea of whether the overall pipe
stock is deteriorating, although climate variations may affect this. If the rate of rise is
known this can indicate the state of the pipe stock.

Where DMA’s have been established they can provide a useful unit for comparison.
Repair levels, leakage levels, rate of rise and, if available on a DMA basis, costs per DMA
can provide a simple basis for prioritisation of areas for renovation and replacement.
Other factors such as water quality problems can also be taken into account.
The Future

It is widely accepted that asset management which considers current and future asset performance under different strategies should be based on well thought out asset performance measurement. However, even where there is a well developed system for capturing data such as mains failure details and leakage levels, there is still a problem predicting which mains will fail.

Research is needed to develop better understanding of pipe deterioration and what initiates a failure. There is evidence for instance that where mains in some clay soils had, to all intents and purposes, completed rotted away water was still being conveyed effectively along what was really a clay conduit. It was only when extreme weather conditions altered the properties of the clay soil that major leakage occurred. Should the main have been replaced earlier when the functionality of the buried asset was not impaired? In the UK the concept of serviceability has been adopted which is the assets ability to carry out its function, which may not be directly related to the assets deterioration rate. Data collected through active leakage programmes can help inform that understanding within companies and it is hoped that leakage forums will extend the debate further.

Conclusions

Leakage activity should not be seen as a separate activity but as part of an overall asset management strategy for the group of assets that comprise a water undertaking’s distribution system. If leakage data, including information about what pipes have failed when and how is collected, this can help develop models to predict future failure rates and ensure that investment levels in mains renewal programmes are set at an appropriate level and that capital investment delivers the optimum benefit.

References

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