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A NEW ASSET MANAGEMENT APPROACH TO ACHIEVING LONG TERM RELIABILITY AND RISK REDUCTION IN GAS DISTRIBUTION PIPELINES

Dr. Ken Oliphant, P.Eng.
Jana
Aurora, Ontario, Canada

Patrick Vibien, M.Sc., P.Eng.
Jana
Aurora, Ontario, Canada

ABSTRACT

New and formal approaches to Asset Management (AM), such as the PAS-55 and ISO 55000 Asset Management standards have been developed over the past decade. These AM standards can be applied to pipelines and cover all stages of a pipeline's lifecycle - acquisition, operation, maintenance and renewal/disposal and provide guidance and a requirements checklist of good practices in physical asset management. These AM standards include a significant focus on the acquisition phase of an asset as the future system operating capabilities, reliability and risk profile of new or replacement pipelines are largely set in this phase for buried pipelines by the choice of products and the installation practices used in construction. As such, this is a particularly critical phase of a pipeline's lifecycle. Asset Management plans need to, therefore, ensure proper focus on the pipeline acquisition phase to improve long term system risk profile. Utilities have experienced significant maintenance/replaces costs associated with premature failure of pipe and components. These are not easy to combat after the fact or by employing standard methods. A new approach is needed for the industry; this approach is the PAS-55/ISO 55000 compliant JANAcquire55™ process. The implementation of this process for the acquisition phase of a product lifecycle will help utilities to eliminate early pipeline failures and to extend the life of new pipelines past the point of relevance to today's stakeholders. The process is outlined and an example presented.

INTRODUCTION

There is a growing interest by gas utilities to improve their performance through improved their asset management (AM) practices. Whether it is to increase reliability, reduce risk or to make better operating decisions, utilities are adopting formalized AM practices. In evaluating rate cases, some public utility commissions are starting to base decision making on more sophisticated risk evaluations that require comprehensive system knowledge and plans[i]. The required information may only be available with the implementation of the appropriate AM practices and systems.

Two suites of standards for AM have been developed: 1) PAS-55[ii] series and 2) ISO 55000[iii] series. While these standards are generic for physical asset intensive industries (e.g. railways, shipping, real-estate, etc.), they provide a consistent framework for management to identify and implement the appropriate business structures so as to be able to make effective data driven decisions. Organizations can be independently audited and certified to these standards, indicating to the public, shareholders and other stakeholders that they have a structured process to manage their pipeline assets. Most recently, Pacific Gas and Electric (PG&E) gas division was recognized by Lloyd's registration to both PAS-55 and ISO 55000, a first in North America[iv].

ASSET MANAGEMENT

In many industries, Asset Management (AM) has been synonymous with *equipment maintenance.* However, in this context, AM is a holistic approach to managing physical asset intensive organizations in order to optimize the value derived from the asset. Value is dependent on the nature of the organizations activities and the needs and expectations of its stakeholders.

ISO 55000 lays out the benefits of effective AM asiii:

- Improved financial performance
- Informed asset investment decisions
- Managed risk
- Improved services and outputs
- Demonstrated social responsibility
- Demonstrated compliance
- Enhanced reputation
- Improved organizational sustainability
- Improved efficiency and effectiveness

From this list of benefits, it is evident that AM is designed to address the principle concerns of the organization's management and other stakeholders. Implementation of the AM standards starts at the executive level with the establishment of organizational AM policies and objectives and the commitment to establishing the AM management system. The AM system is the set of *interrelated or interacting elements*iii that are used to integrate the organizations disparate activities.

The elements are:

- Context of the organization
- Leadership
- Planning
- Support
- Operation
- Performance Evaluation
- Improvement

All of these elements lead to informed decision making that balance costs, risk, opportunities and performance in alignment with the organizations objectives.

ASSET LIFECYCLE

One of the key aspects of this AM process is in managing the asset lifecycle. The physical asset lifecycle is typically made up of 4 phasesii as shown in Figure 1.

For gas distribution, the physical asset is very large and generally buried, hindering access, inspection and maintenance. This makes the asset acquisition phase the most critical as the pipeline components and their installation will largely define the operating risk, utility, longevity and reliability of the asset. Further, the failure rates over time of products, including pipelines, tend to follow a bathtub curve, as illustrated in Figure 2. The 'bathtub curve' comes from the initial flurry of issues associated with a new installation over the first several years of the pipeline until these are completely experienced and stop occurring; then there exists a long period of stability in performance of the pipeline until it approaches the end of its service life when failures begin to occur again and in greater and greater quantity. So, the curve that the pipeline will follow…bathtub or otherwise…is cast upon its installation.

Figure 1: Asset Lifecycle Stages

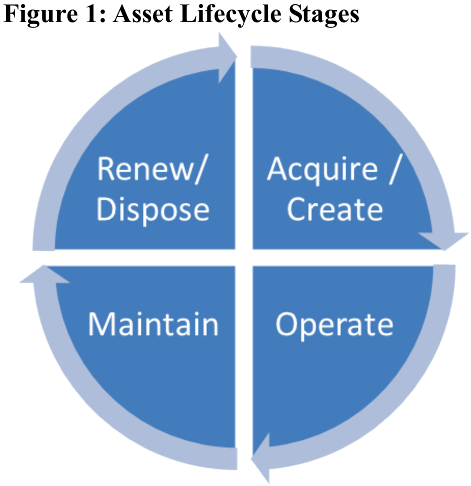
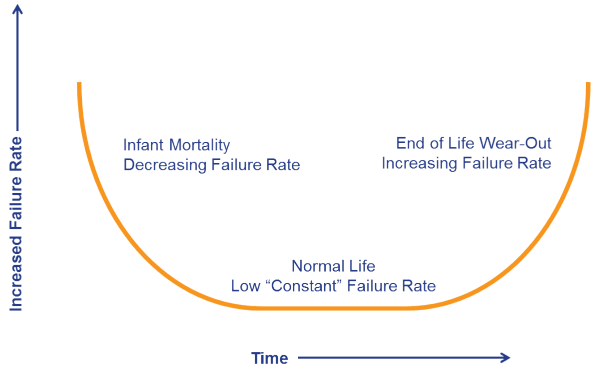


Figure 2: Typical Product Bathtub Failure Rate Curve



LEGACY ISSUES

The gas distribution industry - despite operating for over 100 years - continues to experience issues with the installed asset. These issues are related to poor installation, defective products or early wear out resulting in either replacement or excessive maintenance (e.g. leak surveys). These issues result in leaks that are not only costly to correct but significantly increase the risk of catastrophic consequences to workers and the general public. Distribution Integrity Management Programs (DIMP) have been mandated by federal regulation since 2010[v]. By definition, DIMP is focused on managing the currently installed asset base and the legacy issues within that asset base. Until now, there has been no systematic approach to ensuring the short and long term performance of new gas distribution pipelines.

The legacy issues associated with steel piping and early generation plastic piping (ABS, PVC, PE) are well known[vi] and are being actively addressed by gas distribution companies. DIMP programs do not address other underlying issues that pose the potential of becoming future system threats have been frequently ignored or inadequately addressed.

The potential threats come from:

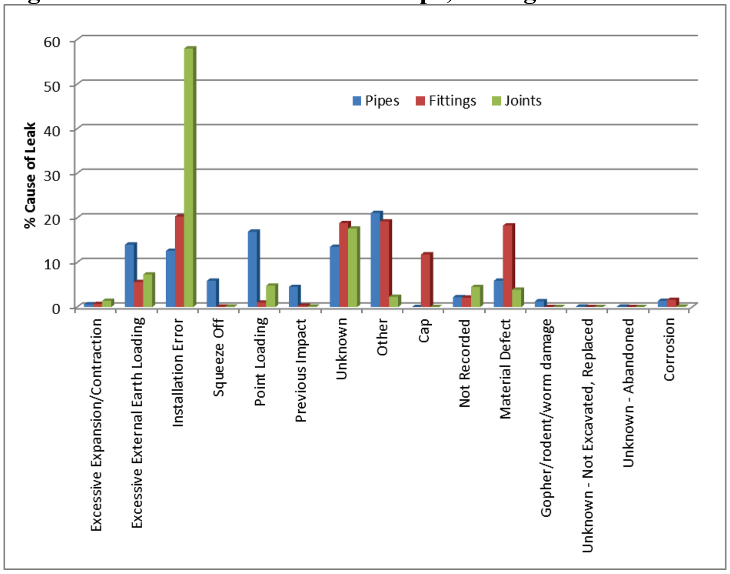
- Design flaws within current, improved or new pipeline components
- Component quality variation
- Inadequate installation practices and controls
- Unintended consequences of other changes
- Interactions of all or some of these items

The American Gas Association (AGA) Plastic Pipe Data Collection (PPDC) findings support that there remain issues with recently installed distribution pipelines[vi]. Of gas distribution pipeline joint leaks experienced within the first 5 years of installation, 58% of leaks are due to installation errors, some 18% of fitting leaks are due to material defects and over 20% of the leaks have unattributed causes (unknown, not recorded or other), as shown in Table 1 and Figure 3. Similarly elevated numbers exist for pipe and fitting leaks. What is not known is how these systems will perform long-term. It is certain that product design and quality issues or poor installation issues can take years to present themselves.

Table 1: Failure/Leak Causes for Pipe, Fittings & Joints within 5 Years of Installationvi

Cause	% of Total Pipe Failures/Leaks	% of Total Fitting Failures/Leaks	% of Total Joint Failures/Leaks
Excessive Expansion/Contraction	0.6	0.7	1.4
Excessive External Earth Loading	14.0	5.6	7.3
Installation Error	12.6	20.3	58.0
Squeeze Off	5.9	0.1	0.1
Point Loading	16.9	1.0	4.8
Previous Impact	4.5	0.3	0.1
Unknown	13.5	18.8	17.6
Other	21.1	19.2	2.3
Cap	0.0	11.8	0.0
Not Recorded	2.2	2.1	4.5
Material Defect	5.9	18.3	3.9
Gopher/rodent/worm damage	1.3	0.0	0.0
Unknown - Not Excavated, Replaced	0.1	0.0	0.0
Unknown - Abandoned	0.1	0.0	0.0
Corrosion	1.4	1.6	0.1
Total	100.0	100.0	100.0

Figure 3: Failure/Leak Causes for Pipe, Fittings & Joints within 5 Years of Installationvi



A NEW APPROACH

With major legacy issues being addressed through DIMP programs, the industry now has the opportunity to focus on how today's pipelines are built. This is about the legacy left to future generations. It is now possible to install a PE gas distribution pipeline that will last well over 100 years and will have no early (infant mortality) failures. To achieve this, however, requires a new way of making a gas pipeline. That way is the JANAcquire55™ process.

Hand in hand with gas utilities, we have developed the JANAcquire55™ approach that specifically addresses the risks through the entire asset lifecycle by ensuring the right decisions, methods and products are employed in the construction of new or replacement pipelines, e.g. the asset acquisition phase.

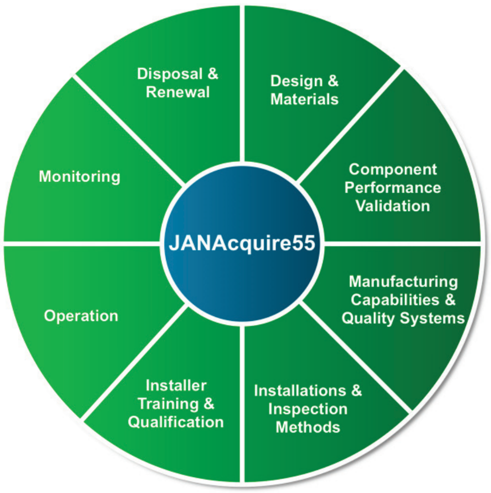
The JANAcquire55™ approach and the resulting 'toolbox' eliminate the causes of infant mortality and prolong the time before the wear-out stage begins. This approach brings together some of the tools and method used in the nuclear, automotive and aerospace industries to address the critical risk areas in those industries. The process has been adapted to address the specific needs and constraints of gas distribution pipelines.

The JANAcquire55™ process involves:

1. Identification of the component or operational process to be assessed
2. Collection and review of all related information
3. Detailed analysis of all the potential causes of root failure
4. Mapping of all current mitigations via a fault tree analysis
5. Risk assessment of failure rate and mitigation effectiveness
6. Gap analysis to identify where additional risk is required
7. Development of appropriate corrective action to reduce risk

The data collection and analysis of the component/process is exhaustive. For a component, it examines all the steps in the lifecycle of the component including, as shown in Figure 4.

Figure 4: JANAcquire55 Asset Lifecycle Considerations



The root cause analysis is conducted in the form of a Fault Tree, as illustrated in Figure 5 and Figure 6 for an electrofusion tee. The Fault Tree analysis is exhaustive and, as such, it ensures that possible causes of failure are not overlooked.

Figure 5: Illustration of Top 2 Levels of Fault Tree

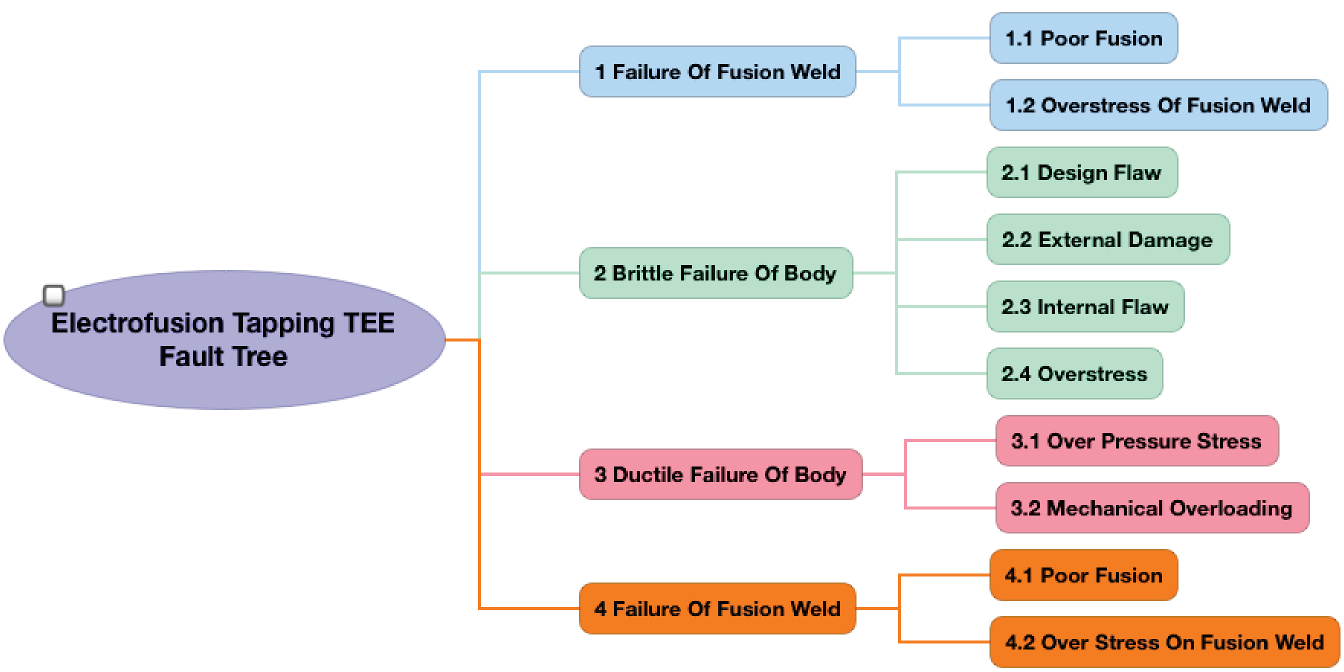
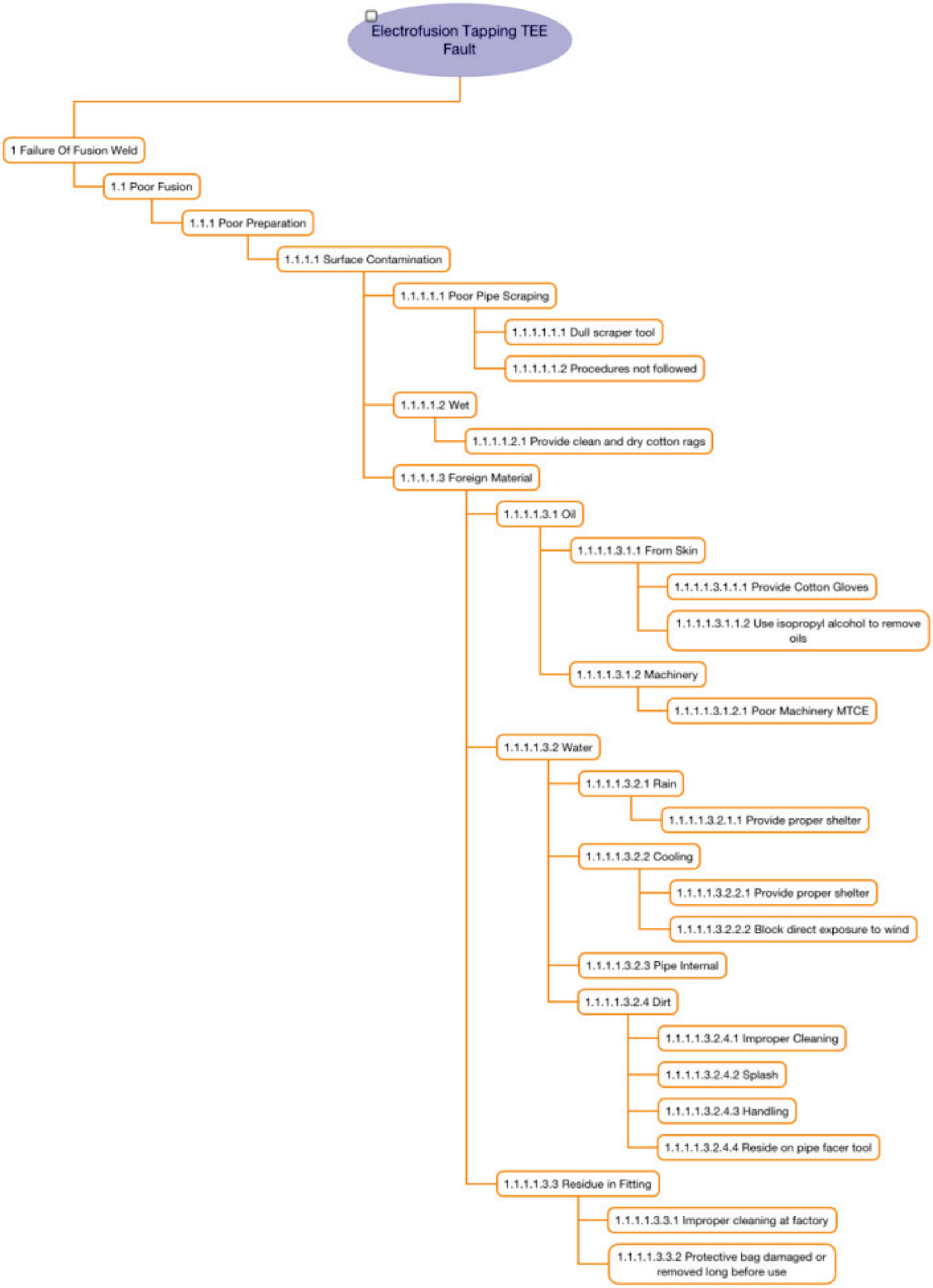


Figure 6: Illustration of an Expanded Branch of the Fault Tree



BENEFITS

With comprehensive knowledge related to the product or process, current mitigations are mapped to each branch of the Fault Tree. Assignments of probability of failure from each root cause and the current effectiveness of each mitigation can be made using utility specific data, industry data and subject matter experts.

Employing detailed and novel statistical techniques, the risks can be quantified and areas of high residual risk identified. Corrective action in the form of improvements in current mitigation or the addition of new mitigation approaches can be specifically targeted to reduce this residual risk to an acceptable level. Business decisions can be made regarding the risk profile of the new pipeline as a cost-benefit analysis of the corrective action is conducted given that the risk has been quantified.

As an illustration of the benefits of the approach**,** a recent analysis for a utility was conducted on electrofusion fittings. The use of electrofusion fittings, already ubiquitous in Europe, is gaining ground in North America. Utilities and installers may assume that these fittings are a solution to high defect rates in jointing of PE gas pipelines. In fact, these fittings can have a high installed defect rate[vii] that may not become evident for many years. Ensuring the product is of high quality and the entire installation procedure is robust will help to avoid embedded issues in the future. A detailed JANAcquire55™ analysis was performed on this element of concern for the utility. The following corrective actions resulted:

- A revised product specification
- Formalized product performance validation requirements
- A product specific manufacturer audit checklist
- A revised, detailed installation procedure
- A controlled critical tool and supplies list
- A detailed installer training curriculum

When this type of analysis is completed and the resulting corrective actions implemented systematically through the list of critical distribution system components, a complete understanding of the risks and the role of current mitigations throughout the pipeline is achieved. The work is extensive and can take several years but it has long term benefits that can transform the risk profile of a company. Further, managing risk into the future is also transformed as the process results is a fully documented fault and risk map of all the critical components and mitigation processes. These maps can be used to inform and verify the impact of changes to products or processes. Further, they capture the organization's knowledge and experience which can be used to train future generations of engineers and specifically manages the issue of personnel change in terms of integrity management. The maps can be used very effectively in root cause analysis associated with operating events to determine the root cause as well as potential impact of those events.

CONCLUSION

In conclusion, the industry is dealing with the legacy distribution system threats via DIMP processes. Now, the industry can proactively examine its current practices in installation of new pipelines to ensure a proud legacy for future generations. JANAcquire55™ provides the tools and processes to do just that.

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[i] Order Instituting Rulemaking to Develop a Risk-Based Decision-Making Framework to Evaluate Safety and Reliability Improvements and Revise the General Rate Case Plan for Energy Utilities R-13-11-006, California Public Utilities Commission, November 2013.

[ii] PAS-55:2008 series, Specification for the Optimized Management of Physical Assets, BSI, September 2008.

[iii] BSI ISO 55000:2014 series, Asset Management Overview, Principles and terminology, BSI, March 2014.

[iv] PRNews, PG&E Earns Two Prestigious International Safety-Focused Asset Management Certifications For Gas Operations, San Francisco, May 23, 2014

[v] Pipeline Safety: Integrity Management Program for Gas Distribution Pipelines, United States Federal Register, 49 CFR 192, Vol. 74, No. 232, 2009.

[vi] Plastic Pipe Data Committee, Plastic Piping Data Collective Initiative Status Report, December 12, 2013.

[vii] Ingham, E., Wheeler, M., Leakage from PE Pipe Systems, Report Ref. No 10/WM/08/43, UK Water Industry Research Limited, 2011.