Exploring the Causes of Premature Failures of Water Pipeline Systems in South Africa

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Abstract

Water is a vital commodity for human life. To that end, a pipeline is a critical component to transport water from the source to end-users. The pipeline system is a highly complex network in and of itself. As a result, the dependability of such a component is critical in ensuring the stability and security of an uninterrupted water supply. The purpose of this research is to investigate the causes of premature failures in the South African water pipeline system. To accomplish this goal, this study examines the factors causing premature pipeline failures using existing literature and archival data. According to the findings, the major causes of premature water pipeline system damage include both internal and external corrosion, damage by others (vandalism, sabotage, and theft), miscellaneous, operator error, welding, mechanical damage, equipment, joint leaks, over-pressure and pig traps. It is expected that the findings of this study will help various stakeholders save billions of rand that are spent to replace damaged pipelines.

Keywords
Water distribution, Pipeline system, and Premature failure.

1. Introduction
Water is a crucial commodity for human life (Chaplin, 2001). The water pipeline is a key component that is used to transport water from the source to the end-users (Mcneiill & Edwards, 2001; Marais, et al., 2004). The pipeline system itself is a highly complex network. Therefore, the reliability of its components is critical in ensuring the stability and security of continuous water supply. Around the world, it becomes a great worry for water utilities when the water distribution system deteriorates (Nieuwoudt, et al., 2004). As a result of this deterioration process, pipelines eventually fail and cause the system to transport less water than it is meant to. Another worrying factor is that the water distribution system might get contaminated. With limited resources available to water utilities to repair the pipeline infrastructure, the importance of assessing the current and future state of the water pipeline systems should be emphasized. Currently, approximately 780 million people on the planet do not have access to clean drinking water. This equates to more than two and a half times the total population of the United States of America (Blignaut & Van Heerden, 2009). Every day up to 200 million hours are spent by communities across the entire world gathering water for household use (Deen, 2012). It has been established that every 20 seconds a youngster passes away due to an illness associated with water. Approximately 3.41 million individuals pass away every year as a result of water, sanitation and hygiene-related illnesses (Deen, 2012). It is essential to provide people with clean consumable water. Just like in the United States, there are places where some communities are in danger of getting water-borne illnesses as the water is used before it is thoroughly purified and therefore not suitable for human consumption (Colford, et al., 2006). In most cases, unusual colour, flavour, and odour, bacterial pollution, loss of hydraulic volume and pressure, leaks, breakdowns, and street collapses are regarded as flaws in water distribution (Cosgrove & Loucks, 2015).

Many areas in South Africa have been observed to be water-stressed in recent decades. This water crisis is largely the result of existing water pipeline systems, which in most cases fail before the end of their expected lifespan. To address this issue, the South African government must allocate additional funding to maintain existing infrastructure. However, given the current economic crisis, the government lacks sufficient financial resources. The research problem of this study was that South Africa is experiencing premature failure in its water pipeline systems, with little to no knowledge of the factors causing it.

1.1 Objectives

The overall goal of this study was to educate stakeholders in the South African water pipeline industry on the factors that contribute to the reduction of the lifespan of existing water pipeline systems. To achieve the study's research objective, we attempted to answer the following research questions:

RQ 1. What are the factors limiting the lifespan of the water pipeline systems?

RQ 2. Which areas should be prioritized to address pipeline system issues that are failing to meet consumer expectations?

2. Pipeline system evolution

History reveals that before the start of civilizations, the people in the Stone Age lived in caves and camps which were located near accessible sources of drinking water such as rivers, lakes and springs (Angelakis & Zheng, 2015). However, due to the increase in the number of people and wildlife living in those areas certain illnesses started developing among humans. The places later became so crowded that land for growing crops was no longer available. This forced people to migrate to drier environments (Baus, 2017). A need then arose for people to start establishing a groundwater system. The Romans came up with water distribution solutions (Mays, 2010; Mays, et al., 2007). They collected water from the surface and underneath and stored it in underground vessels made from clay and limestone. These water storage vessels were called cisterns. Water was transported using gravitational flow and it ran through a network of elevated channels which were constructed from stone or brick. One of the first channels was constructed in 312 BC (Mays, 2010). After this, more channels were built with other new water distribution channels like canals. Romans, from there onwards came up with a wider range of water-transport concepts which were used in France, Italy, the Netherlands and Great Britain (Crow, et al., 2008). During the period of 100 to 300 AD, the Romans used lead pipes and channels to convey water to the big houses of the rich people.

From 1236 AD water was conveyed from the river Thames and some close-by springs to London using pipelines made by the Romans with lead and baked clay materials (Mays, 2010). In 1619, an organisation called New River Company created a water transport system that distributed water to every household in the city of London (Mays, 2010). The concept of pipelines was revolutionized in the 1800s when the first pipes made from cast iron were used. Before cast iron pipes were introduced, a significant number of small-diameter pipes were made using wood (Mays, 2010). In the 1800s cast iron pipes started becoming the preferred pipes over wood and it slowly drove wooden pipes out of the market. Originally the cast-iron pipes were made by casting them vertically inside a pit. In the 1920s the manufacturing method changed and now cast-iron pipes are made using the centrifugally spun method (Mays, 2010). In 1922, there were more developments in cast iron pipes when the pipes were lined with a cement-mortar lining (Donlan, et al., 1994). Further developments in cast iron pipes took place in 1948 when it became known as Ductile iron pipe and it was made from a polyethylene encasement (Donlan, et al., 1994). Steel pipes have been in existence since the 19th century and concrete cylinder pipes were made in the 1940s (Mala-Jetmarova, et al., 2015). Then came an invention of a Bar-wrapped pipe in 1942 with volume manufacturing commencing in 1950 (Mala-Jetmarova, et al., 2015). Thereafter came contemporary piping materials like polyvinyl chloride (PVC), high-density polyethylene pipe (HDPE) and medium density polyethylene pipe (MDPE), glass-reinforced plastic pipe (GRP) and polymer concrete pipe (PC). All these pipe materials have been used around the global market for the past 40 years (Najafi & Gokhale, 2005).

2.1 Pipeline system failures

As illustrated in Figure 1, there are several ways to interpret the pipe failure process. Pipe failures can occur during installation (when a new pipeline is built) or due to corrosion initiation. This type of failure occurs after the pipe has been in operation for some time. The corrosion process begins on the inner or outer (or both) surfaces of the pipe. Other types of failure include partial failure. In the end, manifesting corrosion pits and cracks reduce the remaining strength of the pipe wall, and it becomes weak, resulting in internal or external stresses that eventually result in the pipe wall breaking. This then leads to a leak or burst depending on the magnitude of the break. In certain instances, the magnitude of the failure is not severe enough to be easily detected and leads to later complete failure. For a pipe to completely fail the cause could be a crack, corrosion pit, a leak or burst which has been existing or any other external interferences. When this failure occurs, the water tends to appear on the ground surface or there would be a significant variation in the hydraulic operation of the system. Stress corrosion cracks (SCC) are shown to be active cracks in the future (Wang & Atrens, 2003). The sequential growth of the failure is affected by the type of pipe material (Saegrov, et al., 1999). Steel and ductile iron pipes, for example, are likely to leak before completely breaking. Other ridged materials, such as cast iron and large-diameter pre-stressed concrete pipes, break naturally before they leak. When it comes to plastic and PVC pipes, either breaking or leaking can happen first, depending on the installation and operational conditions. Because plastic pipes have only been on the market for three to four decades, the degrading mechanisms are not well understood.

Overall, the periods in the middle of various stages of pipe deterioration can vary greatly. For smaller iron pipes (Atkinson, et al., 2002) argue that the vital depth of the pit, which resembles the condition when service stress exceeds the residual strength of the pipe material, is equivalent to 30% of the pipe wall thickness (diameter less than 100 mm). The progression of failure is likely to be extremely difficult to predict. When considering third-party interference or external causes, the situation can become even more complicated.

Figure 1. Pipe Deterioration Process

3. Methods
The purpose of this section is to describe the research design, research approach, research strategy, sampling method and data collection adopted for the study. Authors (Greener, 2008; Uma & Roger, 2009; Saunders, et al., 2009) provide different definitions and strategies for conducting research. The subsequent section defines the methods adopted in this study.

3.1 Research Design
Uma and Roger (2009), define research design as either inductive, deductive or a combination of the two. Inductive research is known as theory-building research, whereas deductive research is known as theory-testing research. The deductive approach is found to be very useful in this study because the authors used existing literature and archival data to investigate the factors influencing the causes of premature pipeline failures.

3.2 Research Approach
Scholars (Saunders, et al., 2000), provide various research approaches and applications such as exploratory, descriptive and explanatory. This study takes an exploratory approach to better understand the causes of pipeline failures.

3.3 Research Strategy
The literature (Uma & Roger, 2009; Saunders et al., 2000; Kumar, 2011) describes various research strategies, such as experiments, surveys, case studies, action research, grounded theory and archival research. The use of these research methods varies according to the study objectives or research questions. The operational data from academic sources, the Department of Water and Sanitation and the Association of Pipe Manufacturers were used in this research. Archival research (Saunders et al. 2009), is distinguished by the use of information obtained from administrative records and documents as the primary sources of data. It employs secondary data analysis because it contains data retrieved from administrative records. According to Hakim (2000), such information is derived from day-to-day operational activities and is recorded for statistical purposes rather than for specific research. An archival research strategy caters to studies where information is based on previous events and changes over time to be addressed. A researcher's efforts to address the questions are constrained by the nature of the information obtained. When using the archival research strategy, the researcher should keep in mind that the information obtained may not be sufficient to answer all of the research questions, and some information may not be disclosed due to confidentiality concerns. The researcher may, therefore, have limited control over the available information.

3.4 Population and Sampling
Other authors, such as Bless et al. (2006), define a population as a broad range of objects or people on which the researcher focuses to define specific characteristics about them. According to authors such as De Vos et al. (2002), sampling is the process of selecting a small portion of the total spectrum of items or people that comprise the subject of the study. In this study, the steel pipe was sampled because it represents 73 percent of the entire population of pipelines in South Africa.

3.5 Data Collection
Data is classified as primary or secondary by various authors (Uma and Roger 2009; Greener 2008). Primary data is data collected specifically for research, whereas secondary data is data collected for other purposes. Secondary data from the literature and the Department of Water and Sanitation were used in this study. Interviews, questionnaires, and Delphi techniques are some of the methods used to collect primary data. However, none of these approaches were used in this study. This study drew on information from journal articles, magazines, books, reports, and the Department of Water and Sanitation's statistical data. The section that follows describes the precise procedure used to collect data for the study.

3.5.1 Step-by-step Process for Data Collection
This section explains the step-by-step process adopted to collect data for the study. See Figure2.

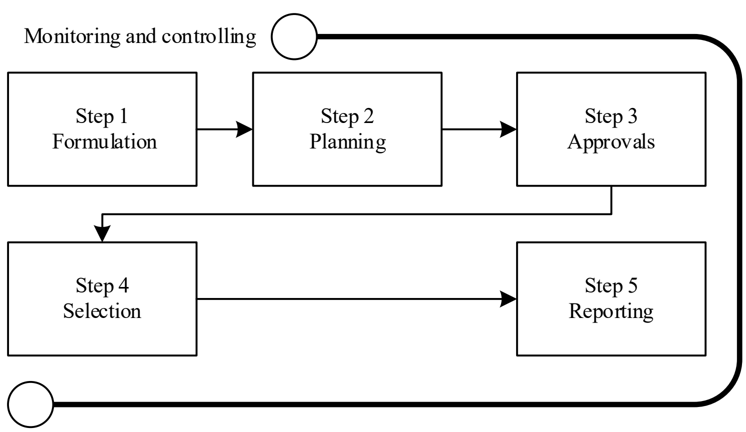

Figure 2. Step-by-step process for data collection

Step 1. Formulation. Reviewing literature about the subject and formulating the theory. Most of the literature for this study was collected from the University of Johannesburg database; Emerald Insight, IEEE Explore, and Science Direct.

Step 2. Planning. This section included determining the type of data required to answer the research question, identification of stakeholders, and developing high-level risk assessments to improve the chances of obtaining access.

Step 3. Approvals. This section involved writing formal requests to senior management of the Department of Water and Sanitation and other stakeholders to request meetings and access to information required to answer the research questions. The main purpose of the meetings was to clarify any uncertainty regarding the research and to get buy-in from other stakeholders. Out of the meetings the researchers were successful in receiving the right information required to answer the research questions despite the limitation specified by some of the stakeholders which included confidential and classified information.

Step 4. Selection. This step included selecting information specifically needed for the study and removing irrelevant information which was not needed for the study.

Step 5. Reporting. This step involved tabling, grouping and displaying data in a graphical format for the purpose of reporting.

3.6 Data Analysis

There are two types of data analysis: qualitative data analysis and quantitative data analysis (Ritchie and Lewis 2003; Saunders et al. 2009). The qualitative approach involves the use of words, pictures and videos to report on events or occurrences, whereas the quantitative approach involves the use of numerical data to describe events or occurrences. The pipeline failure rates were described and counted using primarily quantitative data analysis in this study.

3.7 Ethical Consideration

The authors of this study followed the University of Johannesburg, the Department of Water and Sanitation, and other relevant rules and regulations imposed by other stakeholders. The following ethical issues were considered. By written agreement, the participants provided informed consent. The researcher informed the participants of the research, its purpose, and the methods by which it would be carried out, as well as their rights. The researcher assured the participants' confidentiality and the extent to which their information would be kept.

4. Results and Discussion

The information presented came from the sources like University of Johannesburg database; Emerald Insight, IEEE Explore, Science Direct, the Department of Water and Sanitation, the Association of Pipe Manufacturers and other stakeholders. The first part of the report highlights the South African pipeline market share. This is followed by the root cause of premature failures, as depicted in the discussion.

Figure 3 illustrates the market share of the South African pipeline systems. The statistics shown were adopted from South African Plastic Pipe Manufacturers Association reports.

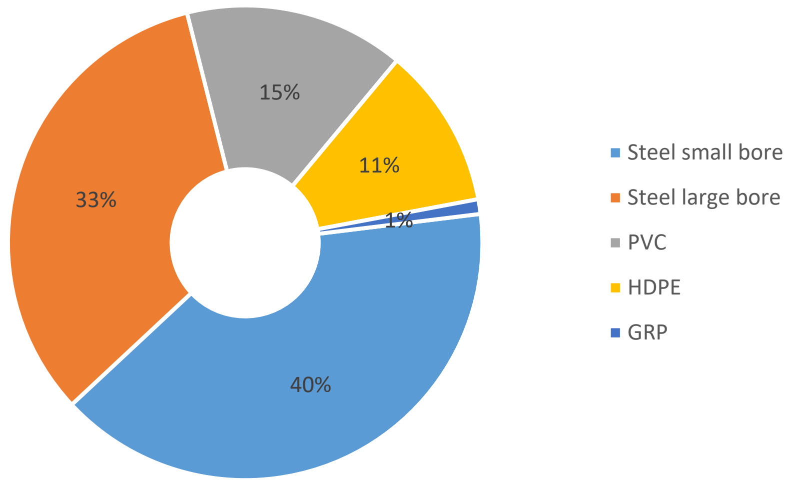

Figure 3. South African Pipeline Market Share (SAPPMA 2013)

Each type of piping material has advantages that make it particularly suitable with regard to certain types of projects. This assists decision-makers to select the right material according to the types of projects. Selecting the material that can last in accordance with the requirements needed for each project is paramount. In light of this, Figure 3 above, clearly shows that steel ranks at the first position with nearly 73% of the market share as the most used material in the construction of pipelines. One possible explanation may be the fact that traditional steel material is perceived as stronger, more reliable and more durable. PVC is in the second position as the most deployed piping material. The reason may be due to its characteristics to resist corrosion while HDPE is the third most used piping material. The explanation is that it can handle higher pressure and provides resistance to corrosion. Lastly, the GRP closes the ranking - the reason may be that is a newly designed material and is in the experimental phase in South Africa.

4.1 Causes of premature failures of the South African water pipeline systems

In this sub-section, we present and analyse the secondary data associated with different causes of premature water pipeline systems failure. In this study, we wanted to use the word "pre-maturely" because a pipeline is normally constructed and expected to last according to its design life. However, due to the causes highlighted below, the pipeline fails before it reaches its expected lifespan. These causes as illustrated in Figure 4 will be explored in depth later on.

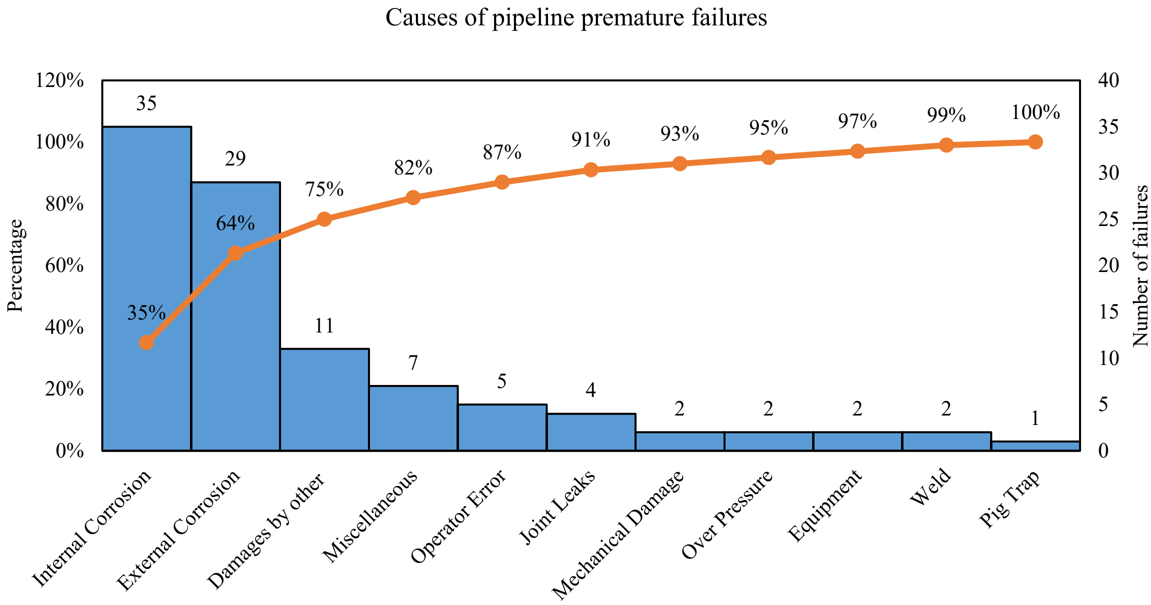

Figure 4. Causes of Premature Pipeline Failures

The information presented in Figure 4 was collected from operational data from the Department of Water and Sanitation, information from the Association of Pipe Manufacturers and other stakeholders.

4.1.1 Corrosion

Figure 4 shows that both internal and external corrosion ranks first with 35% of internal corrosion and 29% of external corrosion. This is the highest incidence in the water supply system and can negatively affect its structural integrity. Corrosion causes pipes to leak and rupture. Another explanation would be that the probability of a pipeline failing over time gets escalated by the process of corrosion of the pipeline material. From the operational perspective and that of pipeline operators, failures caused by corrosion are considered the biggest problem. In the US, the cost due to failures caused by corrosion is estimated to be between $5.4 billion and $8.6 billion per year. Annual costs incurred due to corrosion on operations and maintenance are estimated to be 15 percent of the total operation and maintenance costs. The process of corrosion is the damage or degradation of a material caused by the reaction with its environment, meaning that corrosion is considered to be the chemical or electrochemical oxidation of metals when it comes together with an oxidant. Corrosion starts to occur either from the inside or the outside of the pipeline material. Various factors influence corrosion, for instance, internal corrosion is formed when corrosive fluids are transported through pipelines. To be more precise, internal corrosion relies on the quantity of water content in the natural gas and chemical components of gas such as carbon dioxide (CO_2), hydrogen sulphide (H_2S), oxygen (O_2), flow velocity, density, temperature, surface condition of the steel, and the number of bacteria in the natural gas. Uniform corrosion, pitting or crevice corrosion, erosion-corrosion, and microbiologically influenced corrosion (MIC), which are the types of internal corrosion, are developed through such factors. External corrosion mainly takes place as a result of soil environment (types, moisture, level of salts, or bacteria), degradation of the external coating or mechanical damage of the external coatings, insufficient cathodic protection (CP), and alternating current or direct current interventions. One of the greatest challenges is that corrosion cannot be completely regulated because pipelines relate to their environment which naturally induces corrosion to take place. Currently, the only way of combating corrosion is by applying the correct strategies to prevent corrosion, and these strategies include the models that articulate the calculated number of failures in the future. Pipelines which are underground or above ground and not protected, exposed to atmospheric conditions or in contact with water, are vulnerable to corrosion. If the pipelines are not maintained in the right way, they deteriorate in the end. One of the dangers of corrosion is that it weakens the structural strength of the pipeline and increases the risk of failure of the entire pipeline system. Nevertheless, using the modern and right maintenance principles, the structural life of the pipeline can be extended for much longer.

4.1.2 Damage by Others

Figure 4 indicates that damage by others (vandalism, sabotage, and theft) is second in the ranking with 11% as the cause of premature pipeline failure. One possible explanation for this is that pipelines are prone to be attacked by people who vandalize, and they can be targets for others who would want to steal them. These tendencies are common, for instance, the drilling of the pipeline and illegally obtaining water from it. Most first-world countries are not to a great extent affected by such problems, even though that could quickly turn around if any acts of terrorism take place. When some of these acts occur, pipeline operators are usually the ones who are left with an engineering challenge on how to restore the pipeline system. They usually institute emergency measures to restore the pipeline and environment. Depending on the magnitude of the damage, the pipeline can usually be quickly repaired to its functional mode. However, illegal acts on pipelines vary.

4.1.3 Miscellaneous

From Figure 4 it is seen that miscellaneous factors are in the third position with 7% as a cause of pipeline premature failure. Here we refer to miscellaneous as one of the elements that could hinder the quality and the lifecycle of the pipeline or make it fail prematurely. It is when proper procedures are not adhered to by the contractor in installing the pipeline or if the contractor is less skilled and inexperienced to execute the task. This factor could be attributed to a lack of good governance or corruption among people within the procurement value chain who are tasked to apply the correct adjudication procedures and based on the selection of the best possible contractor. In South Africa, one of the main selection criteria of a contractor is to use as many resources coming from the local community as possible where the pipeline will be installed. As much as this is a good gesture for empowering the local communities, this process tends to be manipulated by various parties who have certain interests other than the quality of the pipeline system.

4.1.4 Operator error

In this study, an operator is referred to as a contractor who is responsible for the installation of the pipeline. In South Africa, research has shown that the contractor skill levels differ per geographical area, and this could have a significant impact in terms of the lifespan of the pipeline. Any error resulting from not following the correct pipeline installation procedure or any mishandling of the pipeline material will compromise the quality of the system.

4.1.5 Weld

Within the pipe structure, defects in the material are not usually the reason for the pipeline to fail, as the pipes go through rigorous testing processes and eye screening and the defects are usually discovered even prior to the pipe being placed in service. Welding is used as it is the most cost-effective way of constructing steel pipelines. The two common techniques are submerged arc welding (SAW) and electrical resistance welding (ERW). During the welding process the flux is heated by the arc and as it melts it generates a layer of molten flux that then reacts in a certain way to prevent any spattering and avoid reaction with any atmospheric gases to the arc and the weld pool and that enhances the properties of the weld joint. Any deviation from the standard procedure or poorly executed weld can in time lead to a leak or rupture.

4.1.6 Mechanical Damage

Mechanical damage to a pipeline occurs when a localized pipe material gets damaged as a result of the pipe getting in contact with another object. “Localized” refers to the damage limited to some area of the pipe cross-section or the area alongside the length of the pipe. The mechanical damage can eventually have a short-term or long-term effect on the failure of a pipeline, with most of the failures taking place as the impact occurs. Instant pipeline failure would normally take place when construction equipment pinholes the pipe as it gets into contact with it and a leak is sprung. Localized mechanical damage can become a point where a crack starts to form, and it eventually fails.

Mechanical damage cannot only be described in one form. The damage to the pipe as a result of different types of equipment or certain conditions may end up in a wide range of impacts on the pipe. The damage can have different physical characteristics measured in length, depth, width, orientation, and surface appearance – therefore it varies greatly. The severity of the mechanical damage is highly reliant on defect geometry, the type of steel pipe material, together with the level of stress under which the pipeline functions. Having said this, the occurrence of mechanical damage would usually go undetected as the event of the damage is not normally seen or reported. Furthermore, the properties of certain types of damage to pipeline integrity cannot completely be comprehended from a scientific point of view.

4.1.7 Overpressure

Pipelines must be designed to operate under specific conditions and be able to withstand a certain amount of surge pressure. Pipeline surge pressure is one of the biggest risks. Failures due to this pressure normally have a catastrophic effect. That is why several sequential actions are needed to regulate the pressure surge and to keep the pipeline protected from damage. A sudden increase in pressure which is caused by a rapid change in the velocity of the fluid being transported is the main reason why the pressure surge occurs. Most often when designing a pipeline, the flow of the fluid is aligned to the static head calculation and the friction head losses, while applying the maximum allowable pressure and safety factor. Nevertheless, for any system to function, the flow of the fluid needs to commence and be stopped by a pump or a valve, and this process can create transient pressure flow which exceeds steady state pressures. Therefore, events like the closing of the pump station, malfunctioning controls pressure surges occur due to the events such as shutting down of a pumping station or pumping unit, unstable controls, fluctuation in tank levels, the sudden closing of a valve, or perhaps any other rapid restriction to fluid flow. These pressure surges usually happen in all pipeline systems and can cause pipeline fatigue and result in failure.

4.1.8 Pig Trap

Pipeline “pigs” are devices usually used at the time of pre-commissioning of the pipelines to assist with performing hydraulic testing on a section of an installed pipeline. Furthermore, pigs are used to take away construction remains that may have built up during the construction stage of the pipeline. Pigs are considered to be the most cost-effective solution for removing any contaminants rather than using expensive chemicals. Operators and contractors of pipelines have been applying pigs effectively for many years. However, multi-diameter pipelines are increasingly becoming common and now the risks come into play when a pig device gets stuck or causes extensive mechanical damage to the pipeline which could also lead to failures of seals in the pipeline.

4.1.9 Joint Leaks

It is said that any joint in a pipeline is a potential leak point. When a pipeline is designed and constructed, the model is that it would transport a certain amount of water from one point and effectively deliver it to the next point and the system should not incur any losses in the process due to leaks. In 2012, South African Water Commission released statistics indicating that the amount of water lost due to pipeline leaks amounted to about 37% which cost the state an estimated R7.2 billion per annum. Most of the pipelines are joined using mechanical couplings which use rubber seals to ensure that there are no leaks in the joint.

4.1.10 Equipment

In this study, the equipment refers to tools used in handling the pipe material and ensuring that the pipeline gets constructed effectively in accordance with its design installation guidelines. During the pipeline installation, the pipe material goes through different stages of handling and using the correct risk assessment guidelines, the correct tools have to be used and proper procedures are followed to ensure that there is no mechanical damage inflicted on the pipes. If there was any mechanical damage to the pipe which goes undetected due to procedures not followed, that area could become a potential area for the pipeline to fail prematurely.

4.2 Proposed Improvements

The increasing failures of the water pipeline infrastructure systems generate a need for more research to discover the failure patterns of the water pipeline systems and propose ways of reducing these failures. The water pipeline systems are an asset that enormously contributes to the economy and the development of every region. The functioning of water pipelines has a major impact on community health standards. The increase in water pipeline failure is of great concern to water utilities across the globe. More and unplanned resources from the water utilities are being channelled towards repairing and maintaining a deteriorating pipeline. In pipelines that are considered critical, there are certain technologies like trenchless technology (where a pipeline is installed without actually digging a trench) that could be applied to combat vandalism and theft which mostly affect urban areas more than the ones in rural areas. It has been discovered that vandalism and theft occur where there was actual visibility of the pipeline components installed above ground and therefore the trenchless technology method reduces the opportunity for such acts to occur. A budget for regular maintenance needs to be allocated to ensure that pipelines are maintained when they need to be.

5. Validation

According to Maree and Fraser (2004), a study is said to have longevity if the same methodological process was applied again under the same conditions and produced the same results. The ability of tools, processes and techniques to produce consistent results under specified conditions is referred to as reliability (Uma and Roger 2009). To ensure the study's reliability, the authors created a folder containing all communications, information and documentation related to it and detailed the study's step-by-step process for data collection and analysis. The authors employed two types of validation methods in this study: face validity and content validity. Drost (2011), characterizes face validity as a personal judgment on the operationalization of a concept. The author uses an example that one might look at a measure of reading ability, go through the content, and immediately make a judgment based on knowledge and expertise that the reading ability looks like a good measure, whereas to others the validation method may not be substantial.

Content validity can be characterized as a qualitative technique of guaranteeing that the results achieved dwell on the importance of the concept applied as defined by Drost (2011). The author goes on to say that content validity can be assessed in two ways: firstly, by the number of questions regarding the test and secondly, by getting inputs from experts in the field. According to Rossiter (2011), among all types of validities, content validity is the most trustworthy technique for validating a measure.

6. Conclusion

Around the world, it becomes a great worry for water utilities when the water pipeline distribution systems deteriorate and fail before they reach their expected lifespan. As a result of this deterioration process, pipelines eventually fail and therefore cause the system to transport less water than it was designed for. Another worrying factor is that the water distribution system might get contaminated. With limited resources available to water utilities for repairing the pipeline infrastructure, it outlines the importance of assessing the current and future state of the water pipeline systems. To this end, over the last decades, it has been observed that many areas in South Africa are facing a serious water crisis. This water crisis is largely attributed to the existing water pipeline systems, which in most cases are failing before they reach their expected lifespan. To resolve this problem, the South African government is required to allocate additional funding to sustain existing infrastructure. However, with the current economic crisis, the government does not have sufficient financial resources. Therefore, the research objective of this study was to explore the causes of premature failures of the current water pipeline systems. The findings revealed that the major causes damaging the water pipeline system prematurely include both internal and external corrosion, damage by others (vandalism, sabotage and theft), miscellaneous, operator error, weld, mechanical damage, equipment, joint leaks, over-pressure and pig traps. It is, therefore, believed that the outcome of this study would assist decision-makers in the South African water utility to save billions of rand that are often allocated to replace damaged pipelines.

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