ARE RISKS ASSOCIATED WITH ENERGY PIPELINES IN SOUTH AFRICA APPRECIATED?

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ABSTRACT

There has been a rapid worldwide growth in the use of pipelines to transport energy products. Due to the strategic nature of energy products that are transported by pipelines, the importance of risk assessment and management cannot be overemphasized. With the risk of pipeline disruptions increasing globally, energy pipeline organizations are forced to incorporate measures that should help to identify and address areas that can lead to energy pipeline disruptions. Given the strategic importance of energy pipelines, the main purpose of this paper is to ascertain whether the South African energy pipeline sector appreciates the risks associated with energy pipelines. In pursuance to this objective, the paper seeks to establish the risks associated with the physical environment of the country's energy pipelines, the possible impacts of these risks on the business environment surrounding the energy pipeline supply chains and the mitigation processes if any that are used to minimise risks thereof.

1 INTRODUCTION

While pipelines are capable of transporting a variety of products, it is in the distribution of energy products (liquid fuel and gas) where they have gained prominence. Pipeline technology has been in existence for many years and the first commercial pipeline to transport oil was built in 1859 following the successful extraction of oil in Titusville, Pennsylvania in the United States of America (www.pipeline101.com/History/). Since then, there has been a rapid worldwide growth in the use of pipelines to transport energy products particularly in the last few decades as evidenced in a subsequent section on literature review.

Energy products are well sought worldwide, and their shortage has often caused price escalations resulting in economic instability. Due to the strategic nature of energy products that are transported by pipelines, the importance of risk assessment and management cannot be overemphasized. With the risk of pipeline disruptions increasing globally, energy pipeline organizations are forced to incorporate measures that should help to identify and address areas that can lead to energy pipeline disruptions. Pickford (2001:141) pointed out that the minimization of risk to resources is indispensable for success in pipeline operations.

Given the strategic importance of energy pipelines, the main purpose of this paper is to ascertain whether the South African energy pipeline sector appreciates the risks associated with energy pipelines. In pursuance to this objective, the paper seeks to establish the risks associated with the physical environment of the country's energy pipelines, the possible impacts of these risks on the business environment surrounding the

energy pipeline supply chains and the mitigation processes if any that are used to minimise risks thereof. Factors associated with security create uncertainty in any market. Such uncertainty is fundamental to risk and possibly will draw attention to existing or new risks. It is in light of these issues that the paper endeavours to ascertain how the South African pipeline industry perceives the risks associated with energy pipeline.

2 RESEARCH STRATEGY

A comprehensive literature review was conducted in order to gain an understanding of developments in the pipeline industry. The literature review gathered information on the state of the pipeline sector worldwide, and risks associated with energy pipeline supply chains. In the ensuing literature search, it became clear that there is a paucity of literature on the subject related to South Africa.

In order to obtain information on the identification of risks associated with energy pipelines, attitudes and perceptions on risk assessment and management in South Africa, a structured questionnaire was used. The questionnaire was administered to the three companies that operate pipelines. In addition to the structured questionnaire, valuable information was obtained by face to face direct interviews with key and relevant personnel in the industry. The interviewees included inter alias a risk consultant, a risk and fire technician, technical planning officer and a Project Director for the New Multi-Product Pipeline (NMPP).

Information was also sought from those organizations associated with the physical environment surrounding the energy pipeline supply chain in South Africa and these included; a registered Environmental Risk Assessor who previously had worked with the energy pipeline organizations in South Africa, Department of Environment and Tourism (DEAT) which is responsible and mandated to ensure that environmental legislation and regulations are complied with and a senior Environmental Consultant who previously used to undertake Environmental Impact Assessment (EIA) for the construction of the NMPP.

In addition to corporate risk awareness, a household survey was undertaken in a residential area to ascertain the general public awareness on gas pipeline risks. In this residential area, there is a network of gas pipelines and some households are connected to gas supply. The survey was conducted randomly and interviewees included both the household connected and those not connected. As the data analysis could not be accomplished in time for this paper, the results reported in this paper are only indicative.

3 LITERATURE REVIEW

The demand for energy products that are distributed through pipelines has increased markedly in the last few decades. However, the importance of pipelines is hardly recognized, due to the nature of the transportation mode as the majority of pipelines are invisible and buried underground.

Pipelines offer significant benefits to modern supply chains through their economic benefits, reliability and higher levels of safety. Notwithstanding the initial high capital outlay costs, pipelines are extremely efficient due to substantial volumes that can be distributed resulting in greater economies of scale (Liu, 2003:9). Other economic benefits inter alia, include minimal loss of and damage as the movement of the product is covered and protected, lower energy usage when compared to other modes in moving an equivalent

mass of product (Bardi et al (2006:149) and convenience as products can be delivered directly to consumers.

Pipelines are highly reliable because operations are uninterrupted and not easily affected by weather (Liu, 2003:15; Bardi et al, 2006: 199-200) and their ability to function throughout the year enables them to satisfy demand continuously, unlike other forms of transport.

As pipelines are mostly buried underneath the ground, they are not associated with environmental problems such as pollution, accidents, noise and congestion. Although pipeline accidents can result in loss of life, injury and damage to property and/or the environment, these are relatively uncommon. In addition, products distributed by pipelines are less prone to theft in comparison with other modes to transport where the risk is high. Thus, the ability of pipelines to deliver products without interruption provides significant economic and other benefits to business and community.

Globally, there are 124 countries with approximately 1.9 million kilometres of energy pipelines that transport a variety of products which include gas, oil, liquid petroleum gas and refined products (CIA World Factbook 2008). Nearly ninety five percent (95%) of these pipelines carry gas, oil and refined products.

In the USA, which has the largest pipeline network in the world, pipelines transport about two thirds of the petroleum products where they deliver 14 billion barrels of petroleum per year and account for more than 17% of the freight moved nationally, but less than 2% of the national freight cost (Trench, 2001).

In Europe, there has been an unprecedented growth in energy pipelines from 12 800 kilometres carrying 310 million cubic metres in 1971 to 250 crude oil and products pipelines which formed a network of over 30,000 km transporting 672 million cubic metres of oil products by 2000 (Lyons 2002).

While the operations of energy pipelines are relatively safe, there is always a risk that disruptions may occur. According to Ritter et al (2007:85), the word *risk* suggests that there is no certainty that a type of occurrence can or will not take place and that this particular occurrence can have severe implications for the pipeline and the pipeline supply chain if it does occur.

Pipeline organizations are therefore compelled to incorporate measures that would assist in identifying and addressing the risks associated with pipeline operations. Such disruptions range from minor leaks to major disruptions resulting from sabotage. Thus, the management of pipeline risks must be an integral part of any pipeline operation. Vertzberger (1998:19) suggests that the risks associated with pipelines symbolises a complicated interface surrounded by a specific group of actions and outcome probabilities in a specific pipeline area.

Pritchard (2001:1) argued that if risk has to be kept under control, it must be categorized and went on to categorise risks into four groups namely:

- High likelihood of a risk occurring, with a high impact of the business and environment
- High likelihood of a risk occurring, with a low impact on the business and the environment

- Low likelihood of risk occurring, with a high impact on the business and environment and
- Low likelihood of a risk occurring, with a low impact on the business and the environment

4 FINDINGS

This Section focuses on two issues. The first section provides evidence of pipeline supply chain disruptions that occurred worldwide. The Second section analyses the South African situation in respect of views and perceptions on the pipeline operations.

4.1 Evidence of pipeline supply chain disruptions worldwide

Globally, there is evidence of numerous pipeline supply chain disruptions and a selection of a few pipeline disruptions that occurred within the last decade are listed hereunder:

- Leakage on the Trans Alaskan pipeline early January 2011 resulting in a 1% rise in oil prices
- Sabotage of an oil pipeline in Iraq in August 2003
- In Columbia, since 2001, leftists rebels have blown so many holes in a 480 mile pipeline
- Blowing of a pipeline that carries crude from Iraq's northern oil fields to the main AL-Daura refinery in Baghdad
- BAGHDAD, July 5, 2004 – Oil prices rose after Attacks on Iraq's oil lines resulting in a reduction of exports by half in Iraq in July 2004
- Explosion of a gasoline pipeline in December 2006 in Nigeria in the district of Abule Egba killing 260 civilians. It was suspected that the pipeline was ruptured by local bandits who had been tapping the gasoline pipeline for some time.
- Leakage of 20 000 gallons of petrol in Mexico City on 2nd of January 2008, resulting in the evacuation of 10 000 people
- Accidental leakage of an Egoli gas pipeline resulting in an explosion and evacuation of "hundreds of people" on 1 September 2010 in South Africa

From the foregoing, pipeline disruptions are common. There are a number of factors that can cause pipeline disruptions and these include leakages which could be either accidental or resulting from an aging pipeline, accidental damage and sabotage. Clearly, it is important that organizations that operate energy supply chain pipelines should be conscious of the likely occurrence of disruptions. Muhlbauer (2004:14) emphasizes the point and argued that, risk assessment and management must be a fundamental part of pipelines and "not just an exercise whenever the need arises". With the risk of pipeline disruptions increasing globally, energy pipeline organizations are compelled to incorporate measures to identify and address challenges that can lead to energy pipeline disruptions. The primary focus of these measures must be the safeguarding of the energy infrastructure and the protection of the natural environment through which the pipelines pass with the steps that include increasing system redundancy, developing state of the art surveillance equipment, deploying aerial and ground patrols and fortifying pipeline systems against cyber-security breaches (ebcohost.com.ujlink). These measures have been successfully implemented in North America and Europe. As global energy pipelines are continuously threatened, South Africa must have similar risks and therefore need to put in place risk assessment processes in order to secure a continuous supply of energy products.

4.2 Risk awareness of South African pipeline operators

4.2.1 Overview

In South Africa, the country has an extensive network of pipelines that transport crude oil, refined products and gas. There are 931 kilometers of crude-oil pipelines, 322 kilometers of natural gas pipelines, and 1,748 kilometers of pipelines for other petroleum products make up this network (The World Factbook 2008) and the network continues to expand. Three companies, namely, Transnet, Egoli gas and Sasol are responsible for the operation of the pipeline energy network. All three companies operate steel pipes. A detailed account of each company operations is outside the scope of this paper.

Bredell (2004:12) raises pertinent questions in respect of South Africa energy pipelines; to what extent the South African energy pipeline operators will be able *firstly,* to identify risks associated with the energy pipelines and, *secondly,* to what extent South African energy pipeline operators will be able to manage risks such as pipeline pilferage, third party damage, leaks and corrosion. According to one senior interviewee of a pipeline company; pipeline risks in South Africa are very remote and the industry by and large has had a good safety record. However, the question to ask is "What if it does?", as the possibility is always there. Interestingly, a few months after conducting the interview, a huge pipeline gas explosion occurred on 1 September 2010 in Johannesburg. Thus, pipeline operators in South Africa need to acknowledge that there is always a possibility of risk occurrence that need to be identified, assessed and managed. As Slay et al, (2006:32) quite rightly pointed out, the concept of risk is broader and refers to an ordinary happening in which is hidden a small probability that can preclude a business from accomplishing its goals.

Consensus from the industry is that legislation in South Africa does not provide a clear legal framework in regard to quantified risk criteria in comparison with European Union and North America legislation. When risk criteria are applied, various alternatives exist which will be able to assist the pipeline risk assessors in formulating an informed opinion.

4.2.2 Views and perception of industry

In order to ascertain the appreciation of risks associated with pipelines, data was collected from companies that operate energy pipelines using a structured questionnaire. Two of the companies (A and B) were able to provide detailed information while the third, Company C was not able to provide any information. The information sought revolved around four questions which are highlighted below:

- What risk factors are the energy pipeline supply chains mostly exposed to?
- Which risk assessment model/process does the company use for their energy supply chains? Risk assessment has never been done.
- What type of pipeline inspection and protection measures does the company use for their energy pipeline supply chains?
- What is the frequency of pipeline supply chains?

In respect of risk factors that energy supply chains are mostly exposed to, the factors that the two companies cited were categorized into six areas. Table 1 hereunder shows the perceived level of risk exposure in respect of six factors that are deemed as likely to occur in energy pipeline supply chains.

Table 1: Perceived level of risk exposure

Factor	Rating in order of importance (%)	
	Company A	Company B
Environmental factors	8%	6%
Pipe leaks	9%	19%
Pipe erosion	16%	26%
Pipe design	17%	9%
Pipe sabotage	1%	2%
Third-party damage	49%	38%

From the above figures, there is consistency in regard to the factors that energy pipeline companies are exposed to in South Africa. Companies perceive third-party damage as posing the highest exposure to risk. Third-party damage entails accidental damage that can be caused to the pipeline. The Egoli gas pipeline explosion cited earlier is an example of third-party damage that was caused by workers who unintentionally struck the pipeline with an excavator when carrying out routine maintenance. The second highest perceived factor to risk exposure is pipe erosion. Pipe erosion is of concern to the companies as some of these pipelines were erected several decades ago and there is therefore a realization that they are susceptible to damage. The least perceived exposure is sabotage. With political stability in the country, sabotage is perceived as a remote occurrence. Interestingly, sabotage features highly in other parts of the world as evidenced by oil pipeline disruptions cited earlier that occurred within the last decade.

Environmental factors are lowly perceived, whereas in the developed world such issues would feature prominently. Thus, South African companies are aware of the various risks they are exposed to in energy pipeline operations.

The second issue pertained to the types of risk assessment models that the companies used for their energy supply chains. This is an important area of risk assessment as no one can argue with certainty the occurrence of an event especially with pipeline supply chains. There are a number of risk assessment models, which include inter alia, Matrix model, Probabilistic model, Index model, Phast system and ATMOS leak detection system.

Company A, uses the Phast Risk assessment model which is ideal for monitoring high pressure gas pipes. According to a senior official of company A, this control system ensures safe and effective gas flow protecting humans, animals and property from fatal and destructive gas accidents. The system is designed in accordance with company requirements and it is continuously updated ensuring accuracy of information. The benefits that accrue to Company A for using the system are:

- Facilitation of cost reductions in terms of losses and insurance
- Risk ranking and hazard zone identification for guidance concerning possible mitigation measures, including operating, emergency response or land use planning
- Providing traceability and consistency for energy pipeline calculations
- Providing gas flow reports with user-defined acceptance criteria
- Incorporating the consequence modelling of the Phast process hazard analysis.

Company B uses Probabilistic model and ATMOS leak detection system. The former model is the most challenging and complicated risk assessment methodology. Probabilistic risk assessment is a highly mathematical and statistical tool (therefore data intensive) that

is dependent on historic data. It is an advanced tool that requires more trained operators to achieve a thorough risk assessment.

ATMOS leak detection system, which is also used by Company B, is extensively used worldwide. According to a senior Company B official, the system monitors the pipeline energy supply chain and the information regarding flow rate, pipeline pressure, temperature and density is instantly made available. The benefits for Company B of using this system are:

- Collection of flow, pressure, temperature and valve data at 30-second intervals
- Validation of the above data so that faulty instruments are diagnosed and incorrect data rejected
- Detection of leaks under different operational conditions
- Estimation of leak size and location
- Record of historical data and events.

The third question in ascertaining risk awareness sought responses on types of inspection and frequency measures used on pipeline supply chain risks. Company A use measures such as foot patrols, computer monitoring and inspection with an aircraft. Company B employs CCTV for pump stations and terminals, inspection by helicopter, computer monitoring, vehicle as well as foot patrols. The fact that a variety of inspection and protection measures are employed is indicative of the awareness of risks that are likely to occur to energy supply chains.

Both companies conduct regular protection measures; on a daily basis, once a month six times a year and when an incident takes place. The intensity of inspections increases with longer time intervals.

Notwithstanding the argument by Valsamakis et al (2005:7), that risk management surrounding the business energy pipelines environment in South Africa is still at an embryonic stage, the industry is certainly aware of the risks involved in pipeline operations. What may be amiss is the level of sophistication in risk assessment and management when compared with countries in the developed world.

4.2.3 Public awareness

In respect of public awareness of gas pipeline risks, the crude results of a household survey revealed that a good proportion of households with gas connections were not aware of the risks associated with gas pipelines. Interestingly, some were not even aware of the actual location of the pipeline albeit located at the back of their houses. Households who were aware of risks associated with pipelines cited leakages as the most common risk. This was not surprising as most residence were aware of a leakage that had been going intermittently for over 18 months. Other potential risks cited were rust and explosions. On precautionary measures to take in order to minimize the risks, the majority of households were ignorant. A few cited the need for regular maintenance as a measure to address the possible risks.

5 Towards a risk management process for energy pipeline supply chain industry

Muhlbauer (2004) has identified a number of risk management processes that are ideal in energy pipeline supply chains. Such a process is ideal to South African organizations that operate pipelines. The steps are depicted in Figure 1 (developed by authors).

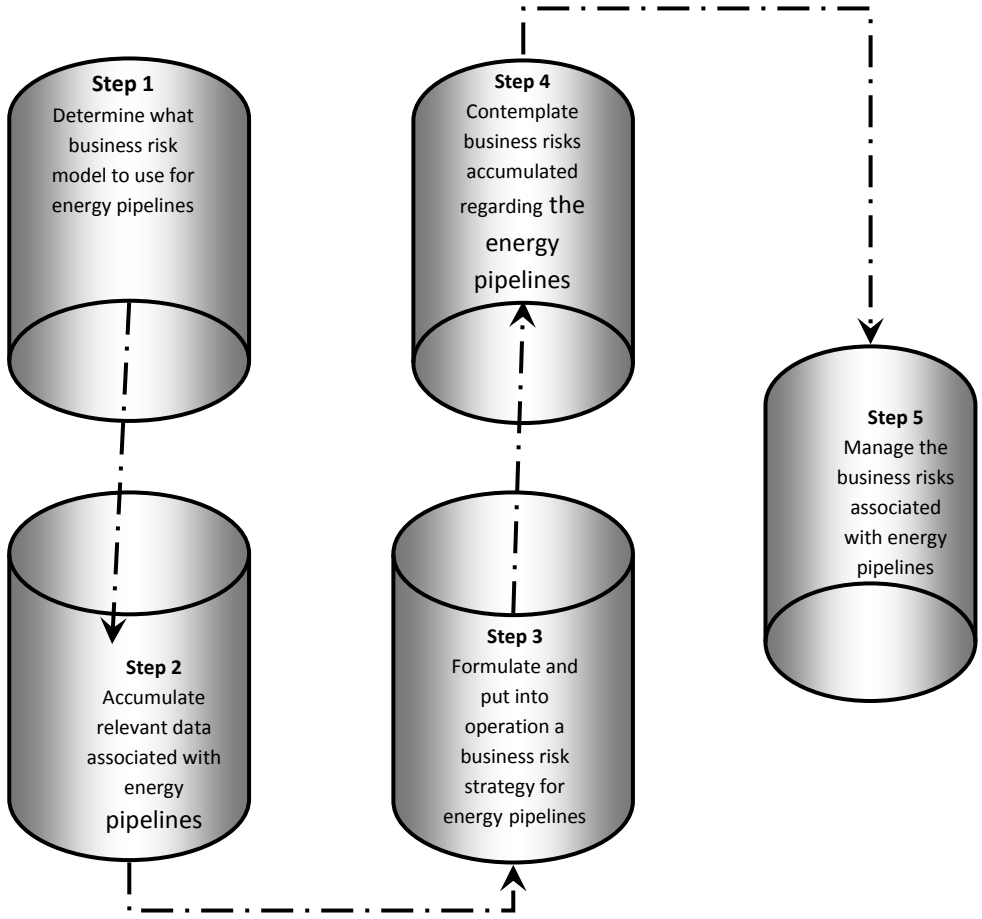

Figure 1: Business risk management process
Source: Developed by authors

The first step involves the determination of business risk model to use for energy pipelines. As already discussed, there are different assessment models that are available for the risk evaluation process. Companies in South Africa can modify an existing model to tailor it specifically for an individual organisation's business environment. The second step requires the collection of relevant data. According to Ritter et al (2007:83) the more well-founded information one has at his/her disposal, the more certain one can be of an outcome. The data can come from a variety of sources which include workshops, brainstorming sessions, lessons of history and benchmarking with other organizations among others. The formulation and putting in operation a business risk strategy is the third step of the risk management process. While pipelines are considered to be the safest mode of transport, it is imperative that the operational side has to be managed in a continuous manner by crafting a business risk strategy. The fourth step entails the consideration of all business risks accumulated in regard to energy pipelines. Vertzberger (1998:23) suggests the use of statistics from previous years as a guideline for the prediction of forthcoming risk associated with pipelines. Another way recommended by

Ritter et al (2007:96) is to categorise the possible risks into four groups, namely catastrophical, critical, marginal and negligible. The final step is the actual execution of the business risk management process which involves bringing together all the concepts and ideas identified and highlighted the four steps discussed above. The objective for managing business risks associated with energy pipelines according to Young (2006:34) is to make certain that energy pipeline risk model, methods and processes are operating effectively and resourcefully. Thus, it becomes imperative that the process adopted should continuously monitor the risks identified and related to the business environment of energy pipelines. Finally, as the energy business environment changes from time to time, risk management methods have to be reviewed as well.

6 CONCLUSION

Pipeline risk management is increasingly becoming a major concern as disruptions can adversely impact the provision of energy products resulting in price escalation. Consequently, risks associated with energy pipeline supply chains have to be identified, managed and controlled if energy pipeline organizations have to operate effectively. Energy pipeline supply organizations in South Africa need to realise that supply chain risks are increasing as the business environment comes under pressure from global competitors. Albeit, the local industry being aware of supply chain risks, success in managing risks is hinged on implementation of a long term risk management strategy which includes dissemination of relevant information to stakeholders and the general public. The paucity of risk management literature in the pipeline sector in the country is evident and this is one limitation that needs to be addressed.

In view of the paucity of literature in this area of pipelines it is recommended that an examination be conducted with the view of embarking an undergraduate programme in conjunction with the South African energy pipeline supply chain organizations. Exposure to this field of study would greatly assist the energy pipeline supply chain organizations to properly educate their company personnel regarding the various risks to which their operations are exposed. In addition, such a programme would also enhance public awareness of the importance of pipeline transport.

Finally, the lack of risk awareness by members of the households warrants a need to raise public awareness on risks associated with energy pipelines. Notwithstanding a good safety record that the country has sustained without a major pipeline disaster, the question remains, *What if it happens?*

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