Case study in the logistics of liquid waste transfer for storage tank with environmental impact reduction

Gilberto Mourão
Centro Paula Souza– Fatec
gilberto.mourao@fatec.sp.gov.br

Getulio K Akabane
Ceetps
getulio@akabane.adm.br

Hamílton Pozo
Universidade Anhembi-Morumbi
hprbrazil@hotmail.com

Julia Rosa Borges Muniz Barreto
Ceetps
jumunizb@gmail.com

Vicente Miguel Sinkunas Junior
Ceetps
vicente.sinkunas@cpspos.sp.gov.br

Abstract
This article identifies means of reducing the environmental impact with the transfer of liquid contaminants from sump tank to the storage tank. To achieve the objective, bibliographical , documentary research and a proposed solution in the Brazilian industrial were accomplished. Potential impacts to the environment and to worker were mitigated.

Keywords: Environmental Impact, Liquid Hydrocarbon, Green Logistics

Introduction

After its discovery, petroleum, mineral of great importance in the world economy, also started to be transported in the same way, in raw form fields between extraction and processing stations.

A failure in a pipeline can lead to several negative outcomes, and some of these flaws may constitute a serious threat to the environment, to people and assets that are close to the crash site. Several accidents involving the release of toxic or flammable substances have caused many consequences to populations near existing ducts (Viana 2011). This research, which is a case study focused on one step of the operation of liquid hydrocarbon, it aims to respond the following research's question: how to reduce the environmental impact of specific leaks in the pipeline transportation logistics for liquid hydrocarbon?

In order to meet the main objective to identify means of reducing the environmental impact regarding to the liquid waste transfer from a sump tank using pipeline to the storage tank, this study is focused on a liquid hydrocarbon residue in a transfer operation of a pipeline transportation line of liquid hydrocarbon from a Brazilian petrochemical industry. The operation of liquid hydrocarbon in the petrochemical industry is seen as either a high impact in sustainability or the recent term known as green logistics.

Due to this, the present study case focus on the waste transfer from a sump tank – that is the lowest point in a chemical plant, into which flows water from rain, cleaning and contaminants products from maintenance and it is common practice to store flammable or toxic liquids such as gasoline, kerosene, diesel fuel or toxic chemicals.

Sump tank has a product pipeline, extending from the underground storage tank upward and then along the pipeline from one to two kilometers away, then terminating on the storage tank. Outside and on the wall parallel of the storage tank, there is an air valve, as shown in figure 1, which is part of the pipeline transportation and waste storage of the company.

This article aims also to contribute in improving the internal and strategic operations with regard to the pipeline and storage security and process cost reductions.

Figure 1. Storage Tank with air valve in detail
Source: Company

The operational costs and savings achieved with this study were estimated by authors in order to justify and make it viable economically the investments for the technical solution proposed to.

In the end, the idea of implementing a largest and a re-positioned tubing at the outlet of the siphon suction valve to return to tank storage of liquid contaminants was approved by the company. The solution proved to be operationally efficient and effective, bringing positive results for all stakeholders.

Literature review

To answer the research questions and achieve this research's goal, sustainability concepts need to be understood as applied in this case study on leaks in the drainage pipe transporting processed liquid hydrocarbon. Therefore, this section addresses concepts of green logistics and the impact of pipeline models on oil spills and cleaner production.

Green logistics in pipeline transportation

Globalization puts constant pressure on companies to improve their performance on environmental issues. In order to achieve improvements in environmental performance, companies must integrate their environmental management strategies, while maintaining the quality of production, reaching operating cost goals, and operating world-class processes. These goals apply to their supply chain, which includes all stages of the operational life cycle and to services performed by partner companies. Environmental sustainability, according to Silva and Fleury (2000), is "meeting the needs of the present without compromising the ability of future generations to meet their needs."

The term "logistics" was initially used for the task of organizing the supply of weapons, equipment, and food to distant military units (Gozzi and Petraglia 2003). Throughout history, wars have been won and lost through the power of logistics, for example, when World War II logistics played a key role in the invasion of Europe by Allied Forces. While the armed forces have long since understood the important role of logistics, business organizations have only recently recognized the vital impact that logistics management can have on achieving competitive advantage. Consequently, the value of logistics in corporate strategy generates a number of questions related to how companies in the same supply chain are organized to face new challenges (Silva and Fleury 2000). Besides being a contemporary management tool, logistics is also an important economic activity.

With the growing demand for "green" products, logistics systems that offer these products to consumers also need to be "green" (Wu et al. 1994). Green logistics should not be confused with reverse logistics (Lourenco et al. 2002). The reduction of energy and pollution associated with a better organization of transport and the use of less packaging material can be considered part of a green logistics agenda. In contrast, as Lourenco et al. (2002) point out, "If there are no goods or materials moving backwards," the activity is probably not a result of reverse logistics.

For petrochemical companies, the concept of sustainability is most appropriately used in evaluating their business strategies. The goal of sustainability is not only focused on reducing negative impacts on the natural environment through operations but also on investing in business practices that promote policies that broaden the scope of progress toward sustainable development. In industry, the operations of petrochemical companies are analyzed according to their impact on the surrounding environment, during any given period.

In order to distinguish between sustainability, as described above, and environmentally friendly operations, the latter are referred to as "green operations." Green operations are not necessarily sustainable in the long term, but they consciously minimize the negative environmental impact of operational processes. Petrochemical company operations deal with the energy consumption required for the operation of their facilities and emissions and waste processes. Meanwhile, the sustainability of products must deal with their liquid hydrocarbon products, such as naphtha and fossil fuels.

In this context, green logistics is defined as the effort to find ways to reduce the burden of external logistics associated with climate change, air pollution, noise, vibrations, and accidents—in order to achieve a sustainable balance between economic, environmental, and social factors. Therefore, all efforts are ultimately directed towards green logistics, and these help ensure sustainability (Ittmann 2011).

In this context, pipeline transportation proves important because it can provide both economic and environmental benefits (Coleti 2013). In the proposed model, fixed costs are higher because improvements include construction and maintenance; however, these are offset by lower variable costs, with lower demand for labor in operations (Viana 2011).

According to Santos et al. (2009), pipelines are a clean alternative form of transportation not subject to traffic congestion and a relatively inexpensive means of transportation for liquid hydrocarbons and safer derivatives worldwide. Nevertheless, operating pipelines represents significant risks to the environment. Several accidents, in Brazil and around the world, involving the release of toxic or flammable substances have had a serious environmental impact on flora and fauna, as well as deaths and damage to the health of populations in the vicinity of pipelines. This has led the countries involved to increase environmental requirements relating to the operation and maintenance of pipelines transporting hydrocarbons.

Impact on the environment and workers' health arising from leaks of liquid hydrocarbons in the petrochemical industry

The petrochemical industry, at all stages of its production process, has the potential to have an impact on the environment and the health of people in surrounding areas—in particular, their workers, depending on specific risks in their workplace (Augusto 1991). Because hydrocarbons are a complex mixture of organic compounds—predominantly hydrocarbons and smaller percentages of sulfur, nitrogen, oxygen, and metals such as vanadium, nickel, sodium, calcium, copper, and uranium—they can be used in numerous syntheses (Vieira et al. 2004).

Refineries and petrochemicals derived from human activities are a major potential pollutant since they produce large amounts of liquid discharges and release many harmful gases into the atmosphere, resulting in difficult waste treatment and disposal processes. Due to these facts, petrochemical industries are often large contributors to degrading environments: they have the potential to affect the air, water, soil, and consequently all the biotic environments in their surroundings (Mariano 2001).

Environmental damage results from the installation and operation of petrochemical refineries, which provide both raw materials and their derivatives through refining. These have an impact due to the wide variety of processes and operations used in the extraction of fractions. Many of the compounds used and generated in refineries come out of the processing units in the form of air emissions and solid waste effluent. Atmospheric emissions include fugitive emissions of volatile compounds present in crude oil and its fractions contained in processing units and generated by burning fuels during production. Typically generated pollutants include volatile hydrocarbons, carbon monoxide, sulfur oxides, nitrogen oxides, particulate matter, ammonia, hydrogen sulfide, metals, acids, and exhausted toxic organic compounds (FADE Environmental Impact Report 2006, cited in Do Monte Gurgel et al. 2009).

Human exposure can be occupational or environmental, as these compounds are released through leaks, fugitive emissions, improper disposal of waste, or accidents. Among the related health impacts introduced into the landscape by petrochemical refining are increased risk of cancer and development of neurological and psychological disorders, as well as diseases of the skin, liver, and cardiovascular and respiratory systems, among others. These affect community environments, where the local population lives at risk—vulnerable to exposure to chemical pollutants (Augusto 1991).

Regarding accidents in petrochemical plants, these can occur in engineering and maintenance processes, with both typical industrial accidents and larger chemical accidents often generated by explosions, leaks, improper waste disposal, and transportation of hazardous materials (Sevá Filho 2010; Souza and Freitas 2002).

According to Do Monte Gurgel et al. (2009), the wastewater produced during the operation phases involving hydrocarbons and their derivatives can affect workers' health through cancer and the problems previously described caused by hydrocarbons. Toxic substances include benzene (e.g., benzene poisoning, hematological changes, signs of neurological abnormalities, and chromosomal abnormalities), toluene (e.g., skin and upper airway irritation, anemia, central nervous system (CNS) depression, psychiatric disorders, and neurological diseases), and xylene (e.g., skin and mucous membranes irritation, eye and liver damage, anemia, and CNS problems). With regard to the environment, the effects on living things include: reducing the amount of sunlight available; reduction in the rate of photosynthesis; death of certain organisms (e.g., plankton); adherence of oil on the bodies of animals (e.g., mammals, fish, birds, and crustaceans), which causes damage to their health or death; and narcosis in aquatic animals. In addition, wastewater leads to the production of bad odors; pollution of surface water by entrainment or infiltration of debris into water bodies; release of toxic gases; air pollution; and toxic chemicals in the soil (e.g., impacts on biota and damage to human health and other living organisms).

Da Silva et al. (2013) presented the results of their analysis of sustainable development and occupational health in the context of environmental impact studies of petrochemical plants in Brazil. These indicate the need for inclusion of basic health indicators for workers, at the minimum, to be included in the licensing process of these industries.

Minimization and reuse of waste through methods of cleaner production

Cleaner production (CP) means a strategic focus on reducing environmental impacts throughout the product life cycle and, therefore, considers techniques to conserve energy and raw materials, eliminate toxic materials in processes, and reduce the quantity and toxicity of all emissions and wastes. It can be achieved by technological improvements and changes in attitude (Medeiros et al. 2007).

Therefore, CP is a set of actions aimed at the prevention of waste generation and wastage and even the reuse of waste from production processes. These can be applied at various stages of transformation processes and already be provided for when planning products and processes to encourage the proper disposal and return of waste.

Methodology

The method used was a case study in a petrochemical industry in the state of São Paulo. The choice of carrying out a case study was justified by the fact that the overall objective of the research involved operational issues that needed to be investigated over time, rather than being seen as isolated events or incidents. Furthermore, a case study is the most recommended strategy when examining contemporary events and when doing research that cannot handle all the relevant behaviors to be studied or ignore the context in which they occurred (Yin 2005).

In the first step, a literature search was done in order to identify theoretical approaches to possible environmental impacts of the operation and maintenance of the pipeline model of transportation and good practices related to green logistics. For this reason, a case study that would enable us to identify ways of reducing the impacts highlighted in the literature survey was conducted. Case studies, which are characterized by the profound and exhaustive study of one or a few items, allow researchers to gain both broad and detailed knowledge of the items, an almost impossible task when other research designs are considered (Gil 1989).

The present study case focused on the waste transfer from a sump tank. This tank had a product pipeline, extending from the underground storage tank upward and then along the pipeline from one to two kilometers away, then terminating on the storage tank. Outside and on the wall parallel of the storage tank, there was an air valve, which was part of the pipeline transportation and waste storage of the company.

Analyses and results

The company used standards for drainage of lines without pumps as a reference for the maintenance of ducts and their equipment and accessories. In this case study, the maintenance process required the drainage of the liquid hydrocarbon line to exchange the control valve connected to the drain valve. To implement these services, it is mandatory to use personal protective equipment: gloves of leather or a suitable plastic material, safety shoes or boots, a PVC safety helmet and goggles, and a filter mask for organic vapors.

Furthermore, attention needs to be paid to the fact that hydrocarbons and alcohols can cause irritation. To prevent these chemicals from coming into contact with skin during activities, workers must use uniform with long sleeves, avoiding the exposure of body parts without proper protection.

Usually aligned through valves, the line drains into a sump tank, which is a collector box that receives waste from draining lines and is the environment for later reprocessing. To the extent that the level of the liquid waste tank reaches a pre-set time in order to prevent the overflow of the waste tank, the level sensor activates the multi-stage vertical centrifugal pump, which transfers the waste through duct line for the liquid waste storage tank.

Important to note that, along its stream, the liquid waste duct runs substantially in the horizontal direction winning small level differences and a few obstacles such as gate valves and leads, before reaching the side of the storage tank, where in there is a vertical pipeline that directs the waste by "climbing" to the top of the storage tank and the air valve.

Air valve as shown in figure 2, in pipeline systems serve two primary functions. The first is the release of accumulated air that comes out of solution within a pressurized pipeline. This air will result in bubble formation, which will gather at localized high points along the pipeline profile. This air accumulation will occur when the bubble’s buoyancy is greater than the energy to convey the bubble with the liquid. The second function of an air valve is to admit air into the system when the internal pressure of the pipeline drops below atmospheric pressures. By admitting air into the pipeline as the internal vacuum condition develops, the magnitude of the vacuum pressure can be reduced and as a result help prevent the pipeline from experiencing excessive deflection and/or collapse as well as help prevent the formation of a full vacuum condition in which vapor cavities may form from the fluid vaporizing.

Also the column break the waste prevents reaching the maximum level of the storage tank can return by gravity to the sump tank causing it to overflow. Note that the residue resulting from leakage is essential function of the suction valve, i.e., to eliminate the air contained in the duct line, just possibly indicating a sudden increase in pressure may be the result of a phenomenon known as water hammer, which entails the elimination of air mixed with the initial volume of the residue through a jet or spray of liquid waste storage tank and the plating sump. Added to the fact that the gasket responsible for the automatic closing of the vent valve windy, it worked partly due to the accumulation of waste in your body and spring-float set.

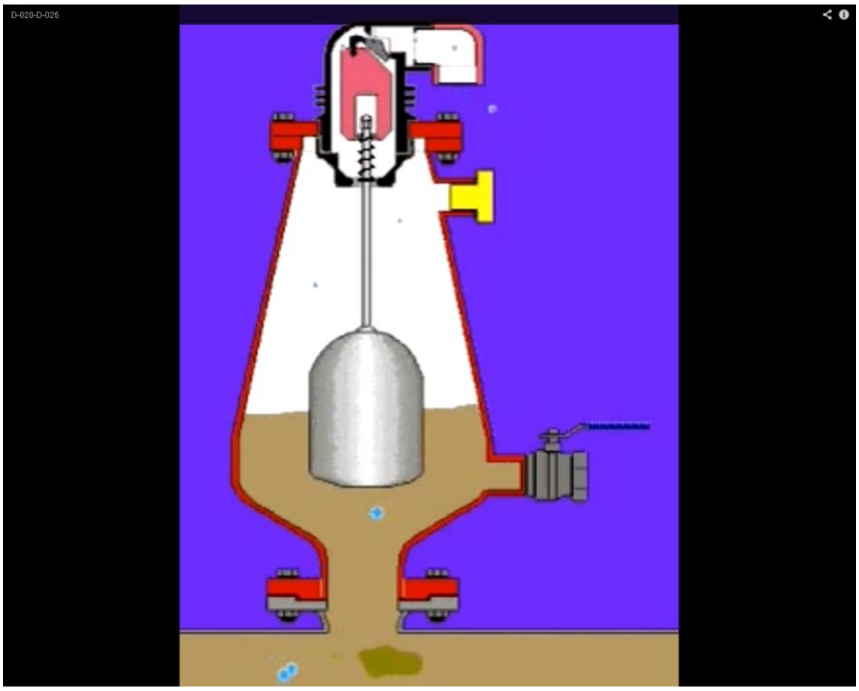

Figure 2 – Air valve
Source: Company

The calculated volume of sprayed line and residue poured onto the side of the storage tank and the sump tank is 4.8 liters. Table 1 provides details of major losses and the costs involved for each item. Also shows the investment and annual cost reduction generated with technical suggestion that team studied to apply after analysis.

Table 1 – Cost estimate

Item	**Volume (L)**	**Number of similar incidents per year**	**Value per incident (US$/incident)**	**Valuel US$**
Contaminants onto the side of the tank	4.8	80	0	0
Cost of drainage and cleaning after contaminants leakage	4.8	80	15	1,200
Cost of auxiliary pipe accessories plus installation services				- 200
Savings in the 1st year				**1,000**

Source: Authors

In this case, we studied to apply an additional pipeline in the discharge outlet of the air valve to deflect and direct the volume of waste liquid sprayed into the storage tank. Implementing this solution will avoid leakage of liquid contaminants out of the storage tank. This technical solution was developed from the query to the air valve manufacturer's website. We might be searching for different applications of the air valve and one of them; we see the capture of the product to a manifold mounted in different product pipelines as shown in figure 3.

Figure 3 – Air valve
Source: Company

The results show that in despite of the minimum savings achieved with the technical solution implemented on storage tank, completely eliminated the leak reducing any environmental damage. With that it applies an economically viable action for a sustainable environmental practice operation.

Conclusion

The transfer of liquid contaminants from the sump tank to the storage tank, as part of the terrestrial pipeline transportation logistics of these contaminants that uses air valve has huge potential to produce gases and vapors that may cause potential environmental hazards, and waste products that could end without large technology investments, be transferred to a later reuse, helping to develop best practices for cleaner production (CP) and green logistics covering the following aspects of the product life cycle: production, storage, transport, use, maintenance, disposal, resource and energy saving, handling hazardous materials, recycling and reuse.

A healthy environment is essential for efficient transport through its ability to promote economic growth and opportunities which is essential for effective and lasting environmental management markets.

With the implementation of the proposed pipeline in the discharge outlet of the air valve to deflect and direct the volume of waste liquid sprayed into the storage tank, an engineering change was established. This solution avoids leakage of contaminants out of the storage tank also established a new standard of operational waste that reinforces the need for management control drainage, contributing to the reduction of scales of toxicity and concentration of gases and noxious fumes, risk of undesirable changes and effects on the ecosystem in the vicinity of the premises, especially those aspects related to the adverse professionals who deal and are exposed to the product drained effects.

In addition, the company can respect its principles of operational excellence, avoiding costs of draining and cleaning after leakage and generating annual savings of $ 1,000.

Moreover, in directing liquid hydrocarbon contaminants act directly on operational quality, reducing impacts on the environment and worker health and organizational climate, aligned with the strategy of sustainability policy and respect the interests of stakeholders in the industry.

Bibliography

Augusto, L. G. S., ed. 2009. *Saúde do Trabalhador no Desenvolvimento Humano Local: Ensaios em Pernambuco*. Editora Universitária UFPE, Recife.

Augusto, L. G. S. 1991. *Estudo das Alterações Morfológicas (Medula Ossea) em Portadores de Neutropenia Secundária à Exposição ao Benzeno* (dissertation). Universidade de Campinas, Campinas.

Coleti, J. C. 2013. *Nova Logística de Etanol para o Abastecimento do Mercado Interno* (dissertation). Esalq-Log Universidade de São Paulo, Piracicaba, Brazil.

Da Silva, J. M. et al. 2013. Desenvolvimento sustentável e saúde do trabalhador nos estudos de impacto ambiental de refinarias no Brasil. *Saúde e Sociedade* **22**(3): 687–700.

Do Monte Gurgel, A. et al. 2009. Framework dos cenários de risco no contexto da implantação de uma refinaria de petróleo em Pernambuco. *Ciência & Saúde Coletiva* **14**(6): 2027–2038.

Gil, A. C. 1989. *Métodos e Técnicas de Pesquisa Social*. Atlas, São Paulo.

Gozzi, S., J. Petragalia. 2003. *A Evolução da Logística no Setor Petroquímico em Busca da Vantagem Competitiva*.

Ittmann, H. W. 2011. *Green Supply Chains – A New Priority for Supply Chain Managers*.

Lourenço, H. R., J. P. Soto. 2002. *A Recoverable Production Planning Model* (working paper) Grup de Recerca en Logistica Empresarial, Barcelona.

Mariano, J. B. 2001. *Impactos Ambientais do Refino de Petróleo* (dissertation). Universidade Federal do Rio de Janeiro, Brazil.

Medeiros, D. D., F. A. Calabria, G. C. S. Silva, J. C. G. Silva Filho. 2007. Aplicação da Produção mais limpa em uma empresa como ferramenta de melhoria contínua. *Revista Produção* **17**(1): 109–128.

Santos, J. C. D., A. Santos, A. R. Berto. 2009. Logística: Evolução e perspectiva. *Revista de Ciências Empresariais* **2**(4): 1–14.

Sevá Filho, A. O. 2010. Problemas intrínsecos e graves da expansão mineral, metalúrgica, petrolífera e hidroelétrica nas Amazônias. Zhouri, A., K. Laschefski, eds. *Desenvolvimento e Conflitos Ambientais*. UFMG, Belo Horizonte, 114–147.

Silva, C. R. L, P. F. Fleury. 2000. Avaliação da organização logística em empresas da cadeia de suprimento de alimentos: Industria e comércio. *Revista de Administração Contemporânea* **4**(1): 47–67.

Souza, C. A. V., C. M. Freitas. 2002. Perfil dos acidentes de trabalho em refinaria de petróleo. *Revista de Saúde Pública* **36**(5): 576–583.

Viana, V. C. 2011. *Desenvolvimento de Metodologia de Análise Quantitativa de Risco para Dutovias de Petróleo e Derivados* (dissertation). Recife.

Vieira, F. C. D. S. et al. 2004. *Toxicidade de Hidrocarbonetos Monoaromáticos do Petróleo sobre Metamysidopsis Elongata Atlântica (Crustácea: Mysidacea).*

Wu, H.-J., S. C. Dunn. 1995. Environmentally responsible logistics systems. *International Journal of Physical Distribution & Logistics Management*.

Yin, R. K. 2005. *Estudo de Caso: Planejamento e Métodos*. Bookman, Porto Alegre, Brazil.