The Pennsylvania State University

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# QUANTITATIVE ANALYSIS OF RISK FACTORS AFFECTING TRANSPORTATION OF NATURAL GAS USING PIPELINES

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by

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## ABSTRACT

In the United States today, there are thousands of miles, long grids and networks of pipelines conveying natural gas across the nation. Recent pipeline leaks and explosions in various regions have challenged the industry to re-evaluate on-going efforts aimed at aggressive pursuit of preventive strategies. Considering that safety and environmental risk has become a major issue in the United States and around the world, particularly in cases where oil, gases and other hazardous wastes are involved, an important point in the gas pipeline industry that represents both social and competitive issue is the pipeline accidental risk. In this paper, I compared the failure data from various pipelines to observe the trend regarding failure rates, causes of failure, aging characteristics and failure rate dependence on pipeline parameters.

Statistical tools were used to develop an effective risk reduction strategy based on the need to reduce pipeline incident and failure rates. Five main safety risk factors: pipeline age, maximum allowable operating pressure (MAOP), time dependent factors (corrosion and material degradation) and time independent factors (third party damage, incorrect operation, material defect) were highlighted and statistically analyzed to demonstrate their effects on pipeline failure rate. An inverse transformation analysis of variance results for the failure rate model showed four risk factors A: Age (0.0001), B: MAOP (0.0003), D: Time Independent (0.0191) and E: Time Dependent (0.0022) to be significant since their obtained p-values was less than 0.05. From this I inferred that Factors A: Age, B: MAOP, D: Time Independent and E: Time Dependent are major contributing factors in the pipeline failure rates, with $R^2$ value – 0.83, prediction error sum of squares (PRESS) – 32.95 and coefficient of variance (CV) – 21.82. Relative scoring index approach and an aggregated weighting technique was applied to sort the grouped factors. The statistically developed safety plots showed that the effect on failure frequency of factors such as pipeline age, MAOP, corrosion (internal &external), and how the failure rates for pipelines above four decades of installation were affected by corrosion damage.

This research identified the need for the urgent assessment of aging pipelines due to the high risk of corrosion and cracking. The model was validated using various case studies from history to demonstrate that the resulting interactions were similar to the hypothetical failure rate curve. The results of the interactions of the risk factors could provide risk and hazard prevention personnel with a better understanding of gas pipeline maintenance activities.

**Keywords:** Quantitative risk analysis, risk-based management, gas pipelines, pipeline corrosion, failure control, third party damage, operational damage, analysis of variance.

# TABLE OF CONTENTS


LIST OF FIGURES……………………………………………………………………………..viii

LIST OF TABLES ……………………………………………………………………………ix

ACKNOWLEDGEMENTS ……………………………………………………………..…...x

Chapter 1 INTRODUCTION ………………………………………………………..……1

1.1 History of the Natural gas pipeline……………………………………….…….1

1.2 Objectives of the Study……………………………………………..……..5

1.3 Problems Encountered……………………………………………….…....7

1.4 Aging Natural Gas pipeline infrastructure in the United States……………..……9

1.5 Consequences of Age on Natural Gas pipelines…………………………………12

1.6 Need for Natural Gas pipeline assessment..……………………………………...14

Chapter 2 BACKGROUNDS……………………………………………………….…...18

2.1 Pipeline system safety……………………………………………………..…...18

2.2 Hazard/Threat Assessment…………………………………………………..18

2.3 Natural Gas Pipeline Risk Management……………………………………….….19

2.3.1 Risk Identification……………………………………………………..21

2.3.2 Risk Assessment……………………………..………………………22

2.3.3 Risk Reduction……………….………….…..………..…………….……..….22

2.3.4 Risk Mitigation……………………………………………………..….23

Chapter 3 LITERATURE REVIEW………………………………………….……….23

3.1 Factors leading to an accident…………………………………………….....24

3.1.1 Third party damage……………………………….………………...25

3.1.2 Corrosion Damage..……………………………………………..26

3.1.3 Mechanical Damage……………………………………………….……..30

3.1.4 Operational Damage………………………………………………..31

3.1.5 Equipment Damage…………………………………………………31

3.2 Risk Assessment techniques currently used in the Pipeline Industry………..…......32

3.3 Current Approach to Risk Assessment in the pipeline Industry……………………33

3.4 Pipeline Data Analysis…………………………………………………………...34

Chapter 4 METHODOLOGY AND RESEARCH DESIGN ……………………………………35

4.1 Data Source and Analysis technique……………………………………...….35

4.2 Experimental Design procedure……………………………………………...36

Chapter 5 ANALYSIS AND RESULTS ………………………………………………………..41

5.1 Analysis of Variance……………………………………………………………41

5.2 Transformation Analysis and Normality…………………………….……....50

5.2.1 Square Root Transformation………………………………………..51

5.2.2 Natural Log Transformation………………………………………...54

5.2.3 Base 10 Log Transformation………………………………………..57

5.2.4 Inverse Square Root Transformation……………………………….60

5.2.5 Inverse Transformation……………………………….………….63

Chapter 6 DISCUSSION……….……………………………….…………………….……61

6.1 The Failure Rate Model…………………………….………………..66

6.2 Factor Interaction using Plots/Graphs……………………………………….….68

6.3 Model Validation………………………………………………………………72

6.3.1 Data collection Methodology………………………………………….73

Chapter 7 CONCLUSIONS…………………………………………………………...….75

7.1 Recommendations………………………………………………...…………….…....76

7.2 Limitation of Study…………………………………………………………………..77

7.3 Suggestions for Future Work…….…………………………………………….…….78

REFERENCES ……………………………………………………………………………….79

Appendix: DATA SORTING FORM……….…………………………………………..…......83

## LIST OF FIGURES

Figure 1.1 United States Natural Gas Pipeline Compressor Stations…………………………..……3

Figure 1.2 Natural Gas consumption in the United States………..…………………………….…...3

Figure 1.3 Natural Gas consumption in the United States ……… …………………………..…...4

Figure 1.4 Damage record on the transmission lines in the United States …………………...…..6

Figure 1.5 The Hypothetical Failure Rate Curve (Dennis J. Wilkins 2002)…………………….…...7

Figure 1.6 Pipeline Installation Dates for United States Transmission and Distribution Lines…..8

Figure 1.7 Chart of Age of pipe line and miles covered in the United States …….……………....10

Figure 1.8 Chart of gas pipeline incidents in the United States ………………………….……..14

Figure 2.1 The Risk Management Process, Modified from MOSHAB………………………….20

Figure 5.1 Schematic diagram of the analytical process…………………………………………42

Figure 5.2 show statistical analysis Model………………………………………………………41

Figure 5.3 Positive and Negative effects for the various risk factors and their interactions…….43

Figure 5.4 Normal plots of residuals for the failure rate model…………………………….…48

Figure 5.5 Normal plots of residuals for the square root transformation………………………...53

Figure 5.6 Normal plots of residuals for the square root transformation………………………...56

Figure 5.7 Normal plots of residuals for the Base 10 Log transformation………………………59

Figure 5.8 Normal plots of residuals for the inverse square root transformation…….……….62

Figure 5.9 Normal plots of residuals for the inverse transformation……………………………65

Figure 6.1 Interactions between Factors A and D……………………………………………..68

Figure 6.2 Interactions between Factors A and C…………………………………………......69

Figure 6.3 Interactions between Factors B and C…………………………..…………………69

Figure 6.4 Interactions between Factors D and E…………………………………………......70

Figure 6.5 Interactions between Factors A and E…………………………………………......70

Figure 6.6 Behavior of MAOP over time (AGE)………………….……………………………71

Figure 6.7 Major Incidents Causes vs. Gas Pipeline Age in United States (Validation Run)…...74

Figure 6.8 Comparison of Validation run with Hypothetical failure rate curve…………………74

## LIST OF TABLES

Table 1.1 Age of onshore NG transmission pipelines and miles covered in the United States…...9

Table 3.1 Outside force as the leading cause of Distribution pipeline failure 2002-2003……….25

Table 3.2 Corrosion as the leading cause of transmission pipeline failure 2002-2003……….…30

Table 4.1 Grouping and weighting of Factor A……………………………………………….36

Table 4.2 Grouping and weighting of Factor B……………………………………………….37

Table 4.3 Grouping and weighting of Factor C……………………………………………….37

Table 4.4 Grouping and weighting of Factor D……………………………………………….38

Table 4.5 Grouping and weighting of Factor E……………………………………………….39

Table 5.1a Ranks and t-values for risk factors and factor interactions………………………….45

Table 5.1b Analysis of variance (ANOVA) for the failure rate model……………………….....46

Table 5.2 Statistical summary of the Failure Rate Model……………………………………….47

Table 5.3 Normal failure rate equation for all factors and interactions………………………….49

Table 5.4 Analysis of variance (ANOVA) for the square root transformation ...................…...52

Table 5.5 Statistical summary of the Failure Rate Model ………….…………..…………….53

Table 5.6 Analysis of variance (ANOVA) for the Natural Log transformation ..........................55

Table 5.7 Statistical summary of the Failure Rate Model……………………………………….56

Table 5.8 Statistical summary of the Failure Rate Model……………………………………….57

Table 5.9 Analysis of variance (ANOVA) for the Base 10 Log transformation………………...58

Table 5.10 Statistical summary of the Failure Rate Model……………………………………...60

Table 5.11 Analysis of variance (ANOVA) for the inverse square root transformation……..….61

Table 5.12 Statistical summary of the Failure Rate Model……………………………………...63

Table 5.13 Analysis of variance (ANOVA) for the inverse transformation……………………..64

Table 6.1Summary of statistical characteristics of the model transformation……………..........66

Table 6.2 Failure rate model equation for all factors and interactions…………………………..67

Table 6.3 Some of the recent high profile accidents……………………………………………..68

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# CHAPTER 1

# INTRODUCTION

## 1.1 HISTORY OF NATURAL GAS PIPELINE

Pipelines are among the safest means of transporting energy fuels. Consequently, the United States relies on them to distribute energy. Most of the natural gas and two-thirds of petroleum products are transported by pipelines system. According to the Pipeline and Hazardous Materials Safety Administration (PHMSA), the United States pipelines encompass a total of 1.8 million miles; 20 percent of these are transmission pipelines Although energy demand has risen by 35 percent over the previous decade, more recent estimates suggest that this demand may increase by another 36 percent during the upcoming decade. (EIA forecasts 2010) (Figure 1.2). This new demand for energy is visible in metropolitan areas, as they are continuously expanding and additional miles of transmission pipelines may be necessary to sustain the demand. As natural gas consumption increases, so does the need to have transportation infrastructure in place to supply the increased demand (Figure 1.3).

Pipelines provide a safe and economic means of transporting fluids such as natural gas, crude oil, refined products and natural gas liquids products across great distances and over all manner of terrain. As man-made systems however, they can and do fail from time to time, sometimes with catastrophic effect. It is important to understand that the efficient and useful transportation of natural gas from source point to utilization points require the use of a highly structured transportation system. In most cases, natural gas travels a great distance from source point to utility point. Natural gas is most commonly transported using pipeline infrastructure. This is simply a system of pipes often underground which are being used to move petroleum based products or water from source point to processing or utility point (Muhlbauer, 2004). The advantage of the pipeline system is that it conveys a large amount hydrocarbon and fluid to their destination quickly, with less exposure to hazard and with ease when compared to the other options (trucking and hauling). According to the United States Energy Information Administration (EIA), there are currently at least 8 intrastate and about 28 interstate, operators of the natural gas pipeline within the Southeast Region of the country (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee). Natural gas pipelines in the United States have a total transmission mileage of 305000 mile, (Interstate- 217000 miles and Intrastate- 89000 miles) having numerous compressor stations (Figure 1.1). Most of the operators receive supplies using pipelines from the Gulf of Mexico and the States of Texas and Louisiana. A few of those operators also transport most of their deliveries beyond the region, to various utility areas around the Midwest or Northeast regions. Most of the natural gas produced in this region is transported via pipeline infrastructure. The natural gas transportation structure involves a multipart network of pipelines, intended to quickly and proficiently convey natural gas from source to end use point. According to a report by the Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) report, there have been about 4,646 gas pipeline accidents reported and recorded between 1990 - 2009. From statistical reports, corrosion and excavation damage have been described to be the major causes of most fatal pipeline accidents. Other causes include outside force damage, equipment failure, incorrect operation, materials or weld damage can also bring about pipeline incidents.

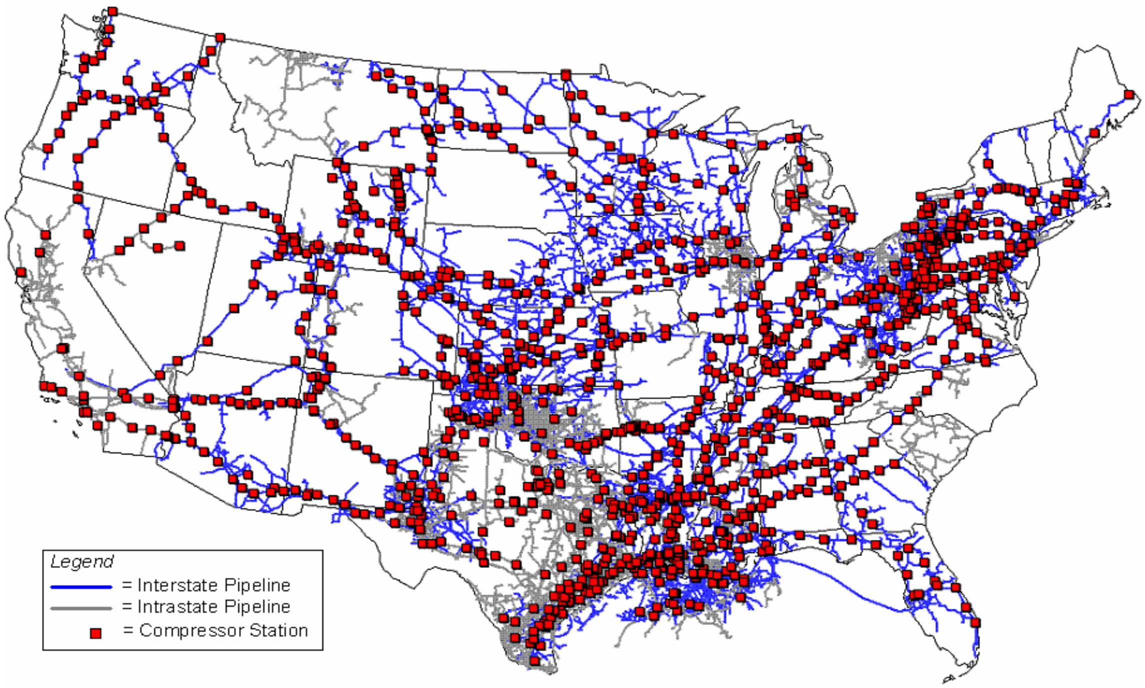


**Figure 1.1 United States Natural Gas Pipeline Compressor Stations**
*EIA, Office of Oil & Gas, Natural Gas Division, NG Transportation Information System*

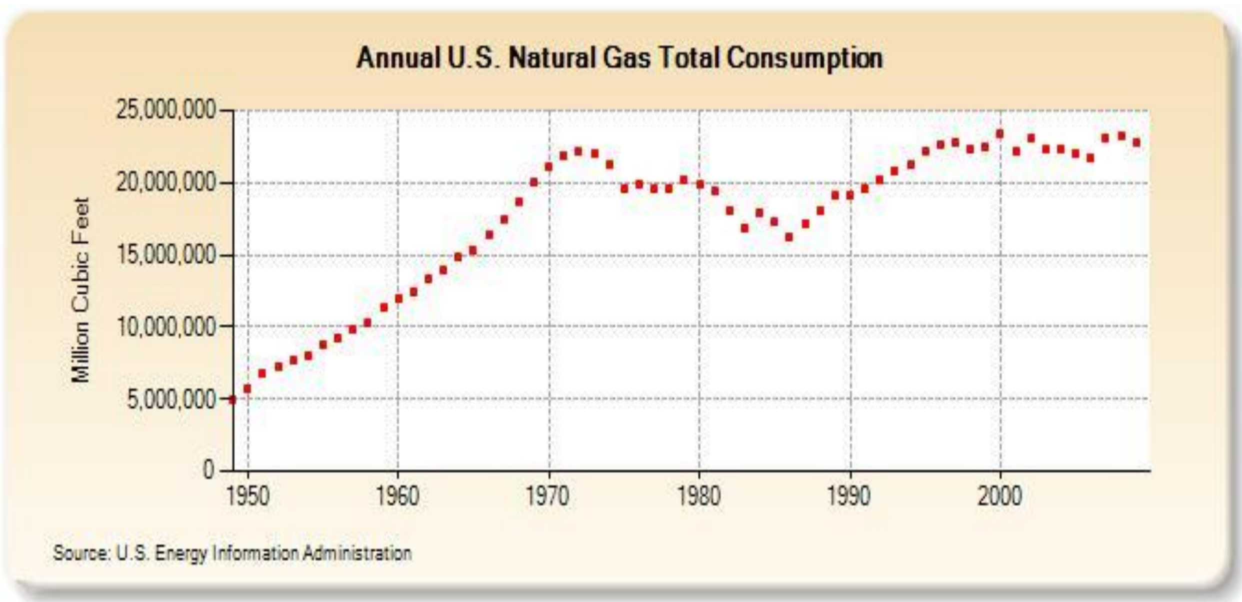


**Figure 1.2 Natural Gas consumption in the United States**
*United States Energy Information Administration*

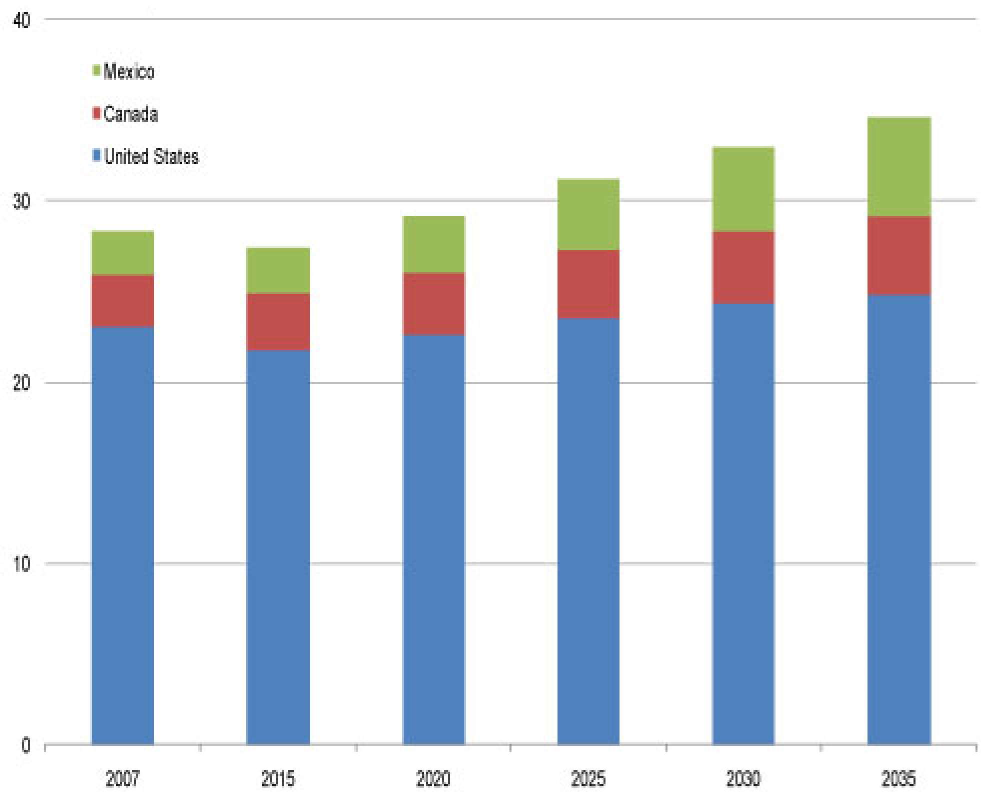


**Figure 1.3 Natural Gas consumption in the United States**
*United States Energy Information Administration*

According to United States Department of Transportation Research and Special Programs Administration, Office of Pipeline Safety (RSPA/OPS), outside force damage can include the effects of earth movement, lightning, heavy rains and flood, temperature, high winds, excavation by the operator, excavation by a third party, fire or explosion external to the pipeline, being struck by vehicles not related to excavation, rupture of previously damaged pipe, and vandalism. Pipelines can also be heavily affected by corrosion (external and internal). This has been noted to be the most common recorded cause of natural gas pipeline incidents in the year between 2002 - 2003 (PHMSA, 2005). Due to these various sources of damage, companies and countries have been implementing extra procedures to monitor safety in pipeline systems. In order to tackle pipeline security and reduce failures, hazard identification and risk reduction methods must be effectively developed and implemented.

## 1.2 OBJECTIVE OF PROPOSED STUDY

Regardless of the design and protection method used in pipeline construction, once installed, natural gas pipelines are at risk of external damage which can be due to soil movement/instability, abuse, third party damage and coating disbandment (Wong et al., 1988). Figure 1.4 illustrates the damage record on the transmission lines in the United States (Crouch et al., 1994).

This research aimed to use statistical tools to describe the interaction of the significant factors required for an effective evaluation and assessment of the risk encountered in natural gas transportation pipelines. This analysis characterized natural gas pipeline failure rates based on the need to minimize pipeline failure rates and costs associated accidents in natural gas transportation using pipelines. A decision model to be used for quantitative risk assessment and for ranking the risk of various sections of natural gas pipelines was developed to minimize pipeline failure rates.

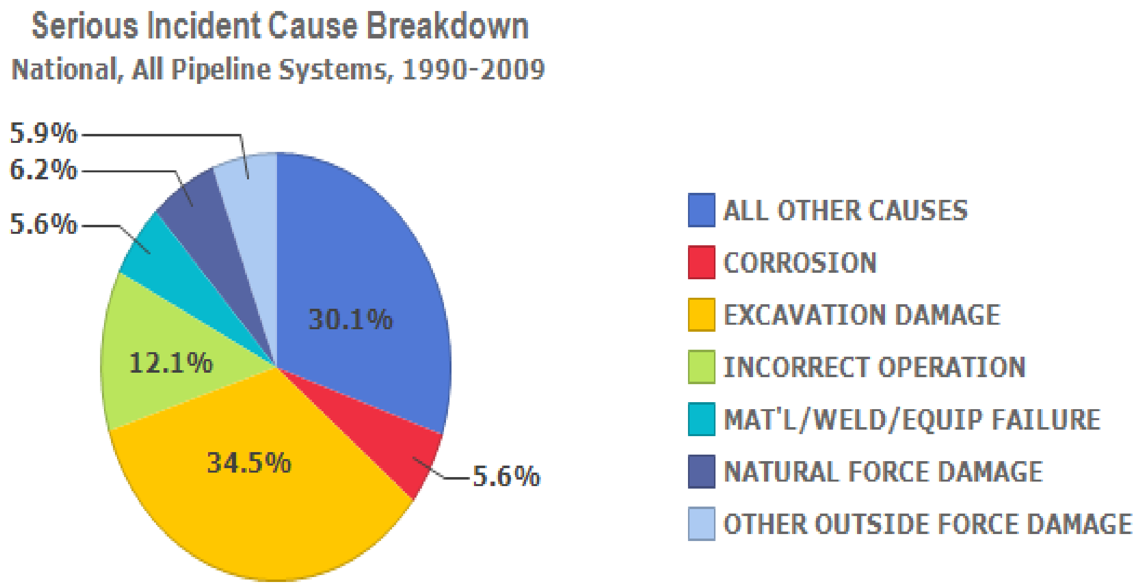


**Figure 1.4 Damage record on the transmission lines in the United States**
*(PHMSA, 2009)*

This thesis also provides a research base for the use of statistical techniques such as analysis of variance (ANOVA) to investigate the interactive effects of various factors causing pipeline failures, evaluating consequences and likelihood of occurrence of the failure. The results of the analysis (interaction) were compared with the hypothetical failure rate curve for systems over their lifetimes (Figure 1.5).

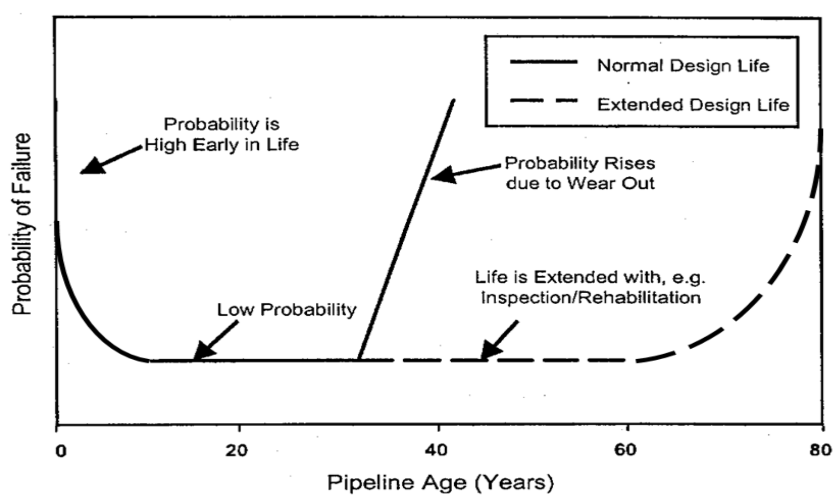


**Figure 1.5 Hypothetical Pipeline Failure Rate Curve (Wilkins, 2002)**

The results could also be used to identify and play down pipeline incident rates for better allocation and optimization of resources. Considering that pipelines are an integral asset to upstream operations, this research aimed at ensuring a safe, reliable and environmentally friendly operation when using the nation's pipeline system for transportation.

Improving the safety of natural gas transportation pipelines reduces the number of failures, and likelihood of major incidents, mitigates the consequences of incidents, and provides the basis for increased public confidence in pipeline safety. This could contribute to the current literature in technical evaluations of pipeline integrity programs and would be based on the need to apply quantitative analysis of past incident records to establish effective assessment models.

## 1.3 PROBLEMS ENCOUNTERED

Increased energy demand coupled with the high pipeline failure rate, causes regulatory agencies to regard pipeline safety as a serious problem that must be addressed. As reported by PHMSA, there have been about 4,646 significant gas pipeline accidents recorded since 1990. More than a third of these caused deaths and significant injuries. The United States Energy Information Administration (EIA) describes the nation's gas network as a highly integrated transmission and distribution grid that can transport natural gas to and from nearly any location in the lower 48 States. This grid has over 210 natural gas pipeline systems, running about 305,000 miles of both intrastate and interstate transmission routes in the country. These grids located at various regions are exposed to failure or damage due to a number of causes. Damage ensuing from pipeline accidents brings about a widespread set of consequences. They are typically not restricted to fatalities or human injuries, but also engross ecological damage caused by fires, and large financial losses due to supply interruptions. As stated by the American Gas Association (AGA), the foremost cause of accidents in both transmission and distribution systems is the damage occurring from excavation near existing pipeline. Excavation damage accounted for almost 60 percent of all reported distribution pipeline incidents between 1995 and 2004, according to statistics kept by the United States Department of Transportation's Office of Pipeline Safety. Corrosion is another major cause of pipeline failure. This sometimes results from excavation damage, which, while not harsh enough to bring about a puncture or the failure of the pipeline, may possibly cause weaknesses in the pipeline as it ages there by making it vulnerable to corrosion later in life. From records (Figure 1.6), over 60 percent of the nation's gas transmission pipelines are 40 years old and above (the pipeline though San Bruno was 54 years old) and with steel pipe life about 50 years, aging infrastructure becomes a problem.

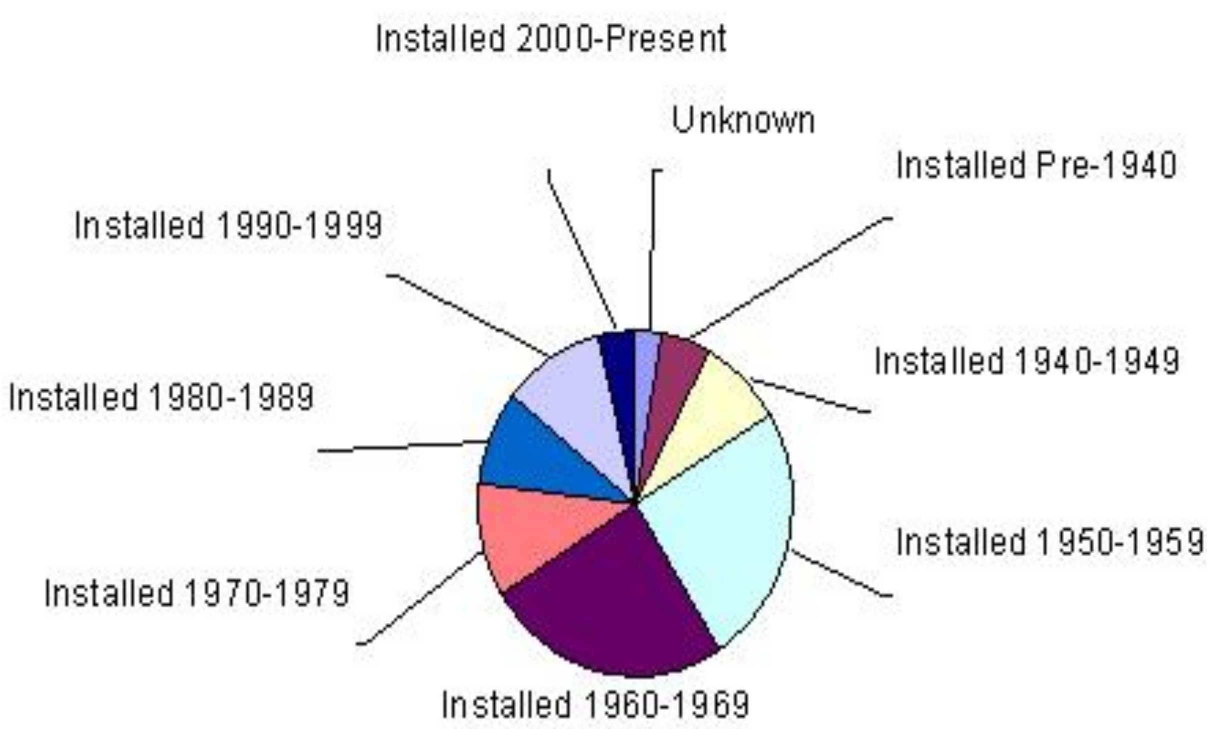


**Figure 1.6 Installation Dates for United States Gas Transmission and Distribution Lines**
*netl.doe.gov*

Also, cast iron pipes still exist and some wooden gas mains remain in use in Pennsylvania. Figures 1.7 show the distribution in miles of the aging pipes (PHMSA, 2009). Most of the old pipes cover more miles as shown in Table 1.1.

**Table 1.1 Age of onshore Natural Gas transmission pipelines and miles covered in the United States.**
*(PHMSA, 2009)*

| Year Installed | Mileage | Percent of total Mileage |
|---|---|---|
| Unknown | 4,853 | 3.64% |
| Pre 1940 | 11,839 | 7.00% |
| Installed 1940-1949 | 22,452 | 13.58% |
| Installed 1950-1959 | 70,568 | 23.84% |
| Installed 1960-1969 | 70,994 | 23.98% |
| Installed 1970-1979 | 30,207 | 17.20% |
| Installed 1980-1989 | 26,357 | 8.90% |
| Installed 1990-1999 | 31,473 | 7.63% |
| Installed 2000-2009 | 27,273 | 9.21% |
| **TOTAL MILES** | **269,017** | |

## 1.4 AGING NATURAL GAS PIPELINE INFRASTRUCTURE

In the United States, the Southwest Region has some of the largest and oldest gas pipeline infrastructure; Oklahoma, Texas, Louisiana, New Mexico, and Arkansas (United States Energy Information Administration, 2010). Based on the United States Department of transportation report (2009), the energy transportation network comprises over 2.5 million miles of pipelines and about 3,000 companies operate these pipelines. The pipeline system includes gas transmission and gathering pipelines (onshore and offshore) – about 321,000miles and gas distribution pipelines (mains and service) – about 2,066,000miles (PHMSA, 2009). According to the Pipeline Safety Trust Report (2009), over 60% of the miles covered by transmission pipelines in the United States have pipelines over 40years of age (Figure 1.7).

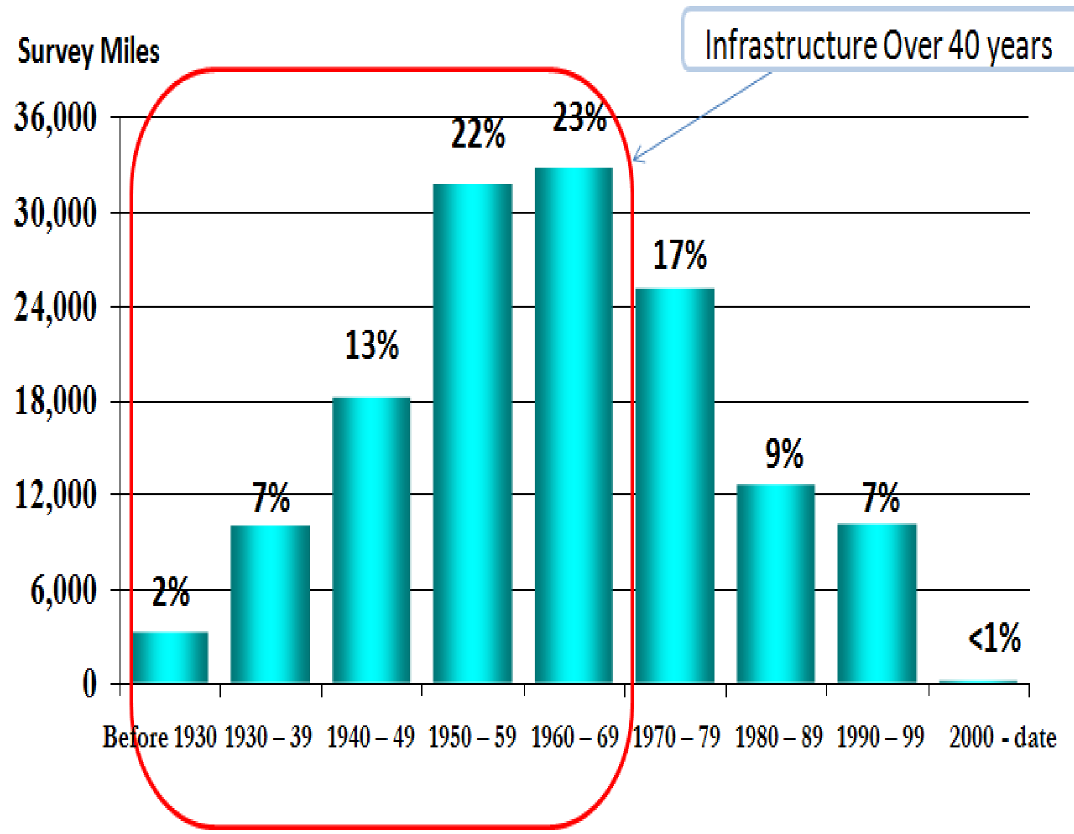


**Figure 1.7 Chart of Age of pipe line and miles covered in the United States.**
*(PHMSA, 2009)*

In the United States, distribution of natural gas to consumers is usually done using these aging and increasingly feeble infrastructure of pipelines made from several materials such as steel, cast iron and in some cases, plastic or wood. Due to this, adequate maintenance and proper replacement of aging pipeline infrastructure is required. In most cases, the integrity of these aging pipeline infrastructures could be compromised. The Brookhaven National Laboratories

(2005) reported that when pipelines leak badly, they discharge toxic methane directly into the atmosphere at an alarming rate, concluding that over a 20year period, the methane gas is about 72 times more damaging to the environment than carbon dioxide ($CO_2$). The state of Pennsylvania currently has about 13,000 miles of degenerating cast iron and steel pipes (Pennsylvania Public Utilities Commission, 2007), accounting for about 95 percent of natural gas leaks in the Commonwealth. O'Brien (2010) reported that most of Pennsylvania's gas pipeline infrastructure consists mainly of cast iron and unguarded steel pipes that are at high risk of corrosion. Some of these pipes have been installed over 100 years ago. Fleck (2008) claimed that in Rhode Island, the National Grid discovered an unacceptable and increasing rate of leaks in various locations where the infrastructure material was cast-iron and unprotected bare steel. This aging pipeline infrastructure mostly leads to recurrent leaks, which often causes explosions that could destroy property, cause injury and most times deaths (CDOG, 2009). The National Transportation and Safety Board (NTSB) has indicated that most of the major pipeline incident investigations carried out in recent years have involved aging pipeline systems installed over 30 years ago (Hart, 2010). A large majority of the aging pipelines were laid years prior to the expansion of suburbs over them and now are at a great risk of leaking or even erupting (Figure 1.6). As age takes its toll on the pipeline infrastructure, community safety threats increase. Pipeline Safety Trust concluded that older pipelines are at greater risk considering that they have not been protected with the current technologies in place such as corrosion protection or tar paper wrapping.

**1.5 CONSEQUENSES OF AGE ON PIPELINES**

In the 1980s, investigations revealed that frequent natural gas pipeline failures occurring involved pipelines made with cast-iron, most of which had been installed and used for about a century (NTSB, 1998). Some of the effects of age on a gas pipeline infrastructure include corrosion and material degradation.

Corrosion is a time dependent factor which challenges most pipeline materials. Corrosion (internal and external) is a big challenge to natural gas pipeline industry and occurs as a result of the reaction of several factors; nature of the material, environment, temperature, humidity, surface conditions and corrosive elements (Revie &Uhlig 2008). According to Worthingham et al. (1993), higher pipe roughness occurs as a result of increasing pipeline age due to the internal accumulation of elements on the pipe surface. An increase in roughness can reduce the flow rate in the pipe as well as a significant pressure drop in the transmission pipelines (Menon, 2005). This in turn affects the overall performance of the transmission systems. Based on a simulation study conducted by Woldeyohannes and Majid (2011), on the performance of 10 and 20 years old gas transmission pipelines evaluated, they observed that there was a decrease in the flow rate of about 2.16% and 4.35% respectively. Corrosion could be considered to be one of the major leading causes of failures in transmission pipeline infrastructure. Significant pipeline incidents in for the 20 year period (1988 – 2008) revealed that corrosion of aging pipes accounted for 18% of the incidents. (Baker & Fessler, 2008).

Most of the pipelines used in the United States are made of high strength steel, with older design having a high probability to be affected by corrosion. The more problematic pipes which still exist are made of cast-iron. Study shows that quite a few places in the state of Pennsylvania still employ the use of wooden gas pipes. Based on this, as the pipeline network expands and the existing pipeline infrastructure ages, potential safety threats increase. Gas transmission pipelines being one of the nation's modes of natural gas transportation has to be safely maintained. Gas pipeline failures have caused an average of three deaths and eight injuries per year, over the past decade. Nevertheless, the practice of pipeline risk assessment has been based primarily on the extensive study of probabilities for diverse levels of human fatalities, which are indeed the most critical aspects. In order to improve gas transmission pipelines safety (risk-based) programs have to be tailored to re-assess pipeline and reduce safety threats. These threats may include leaks, ruptures which could be due to an incorrect operation or corrosion to pipeline segments located in frequently assessed areas such as parks or highly populated regions. According to PHMSA, the natural gas industry standard requires that operators evaluate their gas pipelines for all safety risks at intervals of about 10, 15, or 20 years. This evaluation can be carried out primarily depending on the condition and the pressure at which the pipelines operate. If conditions are unfavorable, then re-assessments and evaluation of the pipeline must be carried out frequently. All materials used in gas pipelines become more brittle with age, and winter's freezing and thawing conditions can cause the ground to shift and pipes be broken, thereby causing leaks and reduced pressure could occur, allowing the pipes to be subjected to external and internal corrosion (Ashby, 2004). According to the Department of transportation (DOT, 2009), majority of the pipeline failures involved systems installed before 1969 (Figure 1.8) Leaks can also occur from material imperfections or construction crews that accidentally bump or cut pipes during excavation. Safety is clearly the main concern for the natural gas pipeline operating industries.

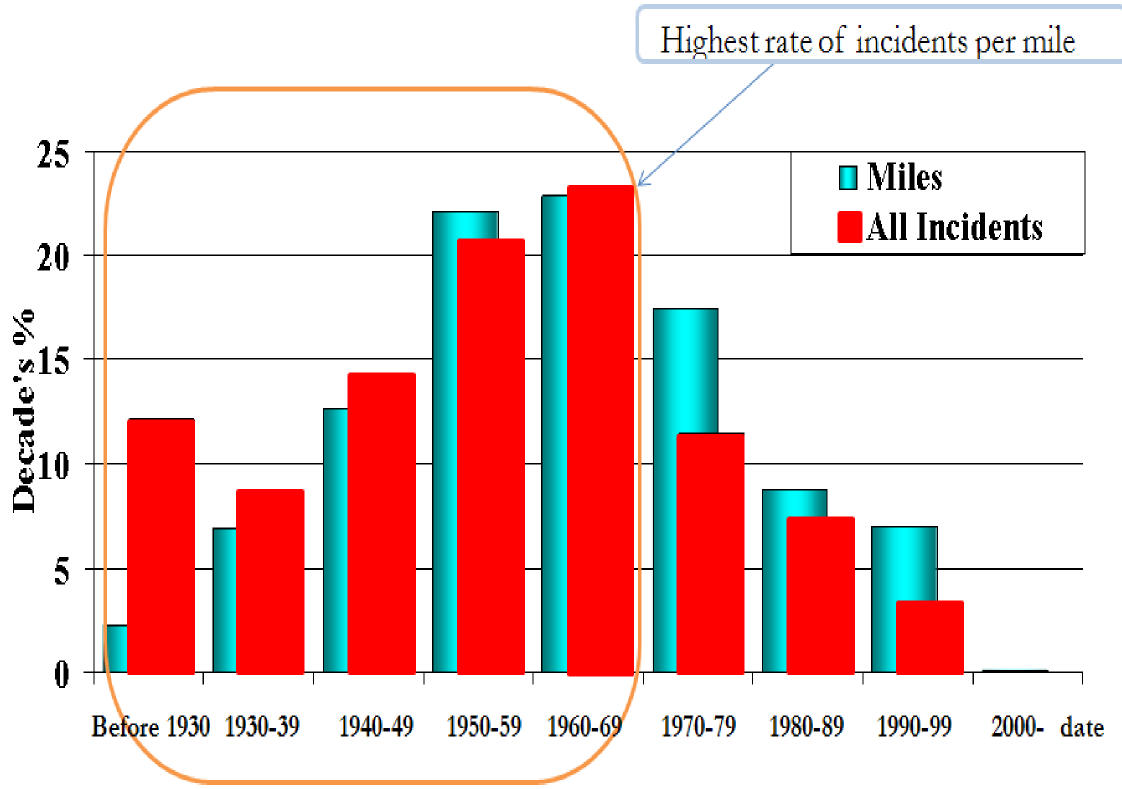


**Figure 1.8 All Incidents and Pipeline Miles by Decade of Construction**
*United States Department of transportation 2009*

### 1.6 THE NEED FOR NATURAL GAS PIPELINE ASSESMENT

As described by the Special Report 281 on Transmission Pipelines and Land Use (2004), the increasing energy demand is accompanied by a similar increase in urbanization. As a result, there are more people working and living closer to pipelines. In most situations, developments near pipelines occur in formerly rural, non-residential areas as at the time the pipelines were built. In addition, this development takes place prior to land use regulations that consider the risks of allowing such development. During recent years, public opposition to the construction of new pipeline rights-of-way has resulted from major pipeline incidents. Figure 1.9 shows a graphical representation of recorded pipeline incidents occurring in the United Stated between 1986- 2009 (PHMSA, 2010). These incidents have drawn attention to the need for more careful and rational assessment of the risks associated with the development of residential areas in close proximity to transmission pipelines. Land use controls that will permit pipelines and people to inhabit the same space without posing unnecessary risks to each other should be considered. Jo and Ahn (2005) developed a simplified method for the quantitative risk assessment for natural gas pipelines using the information of pipeline geometry and population density of a Geographic Information Systems (GIS).  This model proposed that the minimum proximity of the pipeline to occupied buildings should be approximately proportional to the square root of the operating pressure of the pipeline system.

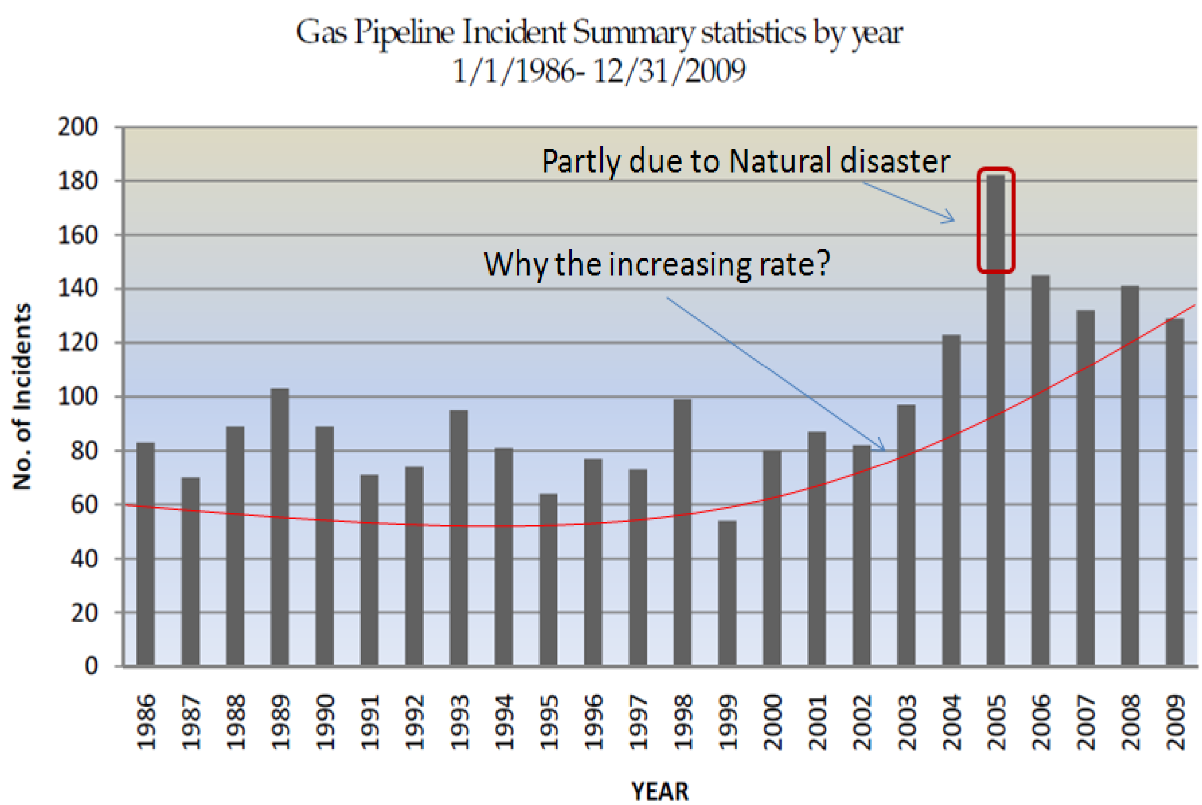


**Figure 1.9 Chart of gas pipeline incidents in the United States**
*(PHMSA, 2010)*

Pipelines have been seen to be one of the economically effective modes for transporting natural gas. Muhlbauer (1999) stated that since the risk of pipeline failure is sensitive to uncertain or unknown initial conditions, risk efforts are often not put in place to predict how many failures will occur or where the next failure will occur. Instead, efforts are designed to systematically and objectively capture everything that is known and use the information to make better decisions. Several researchers have advocated the need for the assessment of risk associated with natural gas pipeline system of transportation. Generally, the higher the natural gas consumption, the more the need for expansion of the pipeline systems and the more the economies become dependent on the stable, continuous and safe operation of these facilities. Transportation by pipeline infrastructure has created an easy movement of natural gas, hence making it an increasingly popular form of energy in the United States.

Overall, the interstate natural gas pipeline grid in the United States consists of about 183 Bcfd of capacity and approximately 217,000 miles of pipeline (EIA, 2009). Historically, accidents involving natural gas pipelines usually occur, even though the frequency of such occurrences is generally low in comparison to road or rail accidents. In addition, pipeline accidents often result in consequences which have great impacts of different magnitudes. This indicates the importance of safety actions to be taken in order to adequately quantify and mitigate the risks. In gas transportation, the uses of high strength steel pipelines are like interstate highways. They are used in moving millions of cubic feet of natural gas from source point to utility areas across the country. Gas utilities mostly receive gas from these interstate pipelines network and then distribute it to various consumers using a smaller network of pipes which can either be made of steel or plastic. Qualitative and quantitative risk assessments of these pipes must be conducted periodically to ensure safety of the infrastructures.

In this work, each of the pipeline networks in each region was categorized into groups according to their, age, maximum allowable operating pressures (MAOP) and material composition. Most significant failures identified in this research include: corrosion, mechanical failure, operational failure, outside force damage, third party damage, and sabotage. For this reason, regardless of the design criteria, pipelines may always have a certain level of risk due to the operating conditions, design, and the environment.

# CHAPTER 2

# 2. BACKGROUND

## 2.1 PIPELINE SYSTEM SAFETY

Pipeline system safety is a deliberate attempt to find patterns of operation that could lead to safer, more precise and predictable results. The need for pipeline system safety is rooted in the economic consideration of production and transportation. Unplanned incidents with injuries and fatalities cost money, especially due to environmental hazards. Studies have shown that it is more cost-effective to correct actions before they lead to fatal incidents/hazards. A hazard is an unsafe condition or activity that if left uncontrolled, can contribute to an unintentional injury or damage (Hagan et al., 2001). Before hazards are being controlled, they must be identified. This identification of hazards can be accomplished through a systematic hazard analysis program. Hazard analysis is performed to identify and evaluate the hazards for the purpose of their elimination or control (Firenze, 1978). Data from the analysis can be regarded as a baseline for future monitoring activities.

## 2.2 HAZARD/THREAT ASSESSMENT

Hazard or threat assessment is intended to identify the principal causes of pipeline failure or failure modes that could occur, or that may have occurred, during the operation of the line. A hazard assessment is comprised of three (3) processes:

- Identification
- Classification
- Susceptibility

The hazard identification process uses existing information such as leak/rupture history, in-line inspections and field investigations to identify hazards experienced in the past that may or may not be occurring in the present or which could occur in the future. The hazard classification process determines the failure mechanisms of the identified hazards by classifying them as to whether they grew over time, or are expected to grow in the future. Pipeline characteristics, operating conditions, and inspection and maintenance findings over time are evaluated.

The hazard Susceptibility process determines the potential for hazards that could affect, or may already be affecting, the integrity of the pipeline. These potential hazards have not been clearly identified as yet, but changes in the current or future pipeline integrity status (e.g. age, coating deterioration), operating conditions that is product, pressure cycling, cleaning practices, and environment/weather conditions (e.g. flooding, external interference) may introduce them as either new, or inactive threats. Susceptibility criteria modeling and selective/investigative digs are used to assist in the identification of the susceptible areas and associated potential hazards.

## 2.3 NATURAL GAS PIPELINE RISK MANAGEMENT

The United States Environmental Protection Agency considers risk to be a chance or possibility of harmful occurrences and effect to human health resulting from exposure to any environmental hazard. This hazard could be physical chemical or biological and has the possibility of inducing an adverse effect/response on the environment with which they interact. Muhlbauer (2004) described risk management as a set of actions adopted to control the risk involved in an activity. This culture or process is aimed at generating great ideas and endorsing good practices for an effective management, which can hence minimize spending and the negative effects of risks. Risk management is an organized arrangement of restricted resources on those actions and circumstances with the utmost possibility for reducing risk. The risk of pipeline failure is extremely sensitive to un-measurable or unknowable initial conditions that risk efforts may not predict. Also they may not precisely predict how many failures will occur or where the next failure will occur (Muhlbauer, 1999). Alternatively, efforts are designed to systematically and objectively capture everything that is known, which is in turn used to make better decisions. In risk a management process, decision makers apply the results from risk assessments and use them to rank the risk reduction events. Figure 2.1 shows the risk management process, modified from the Mines Occupational Safety and Health Advisory Board (MOSHAB, 1999).

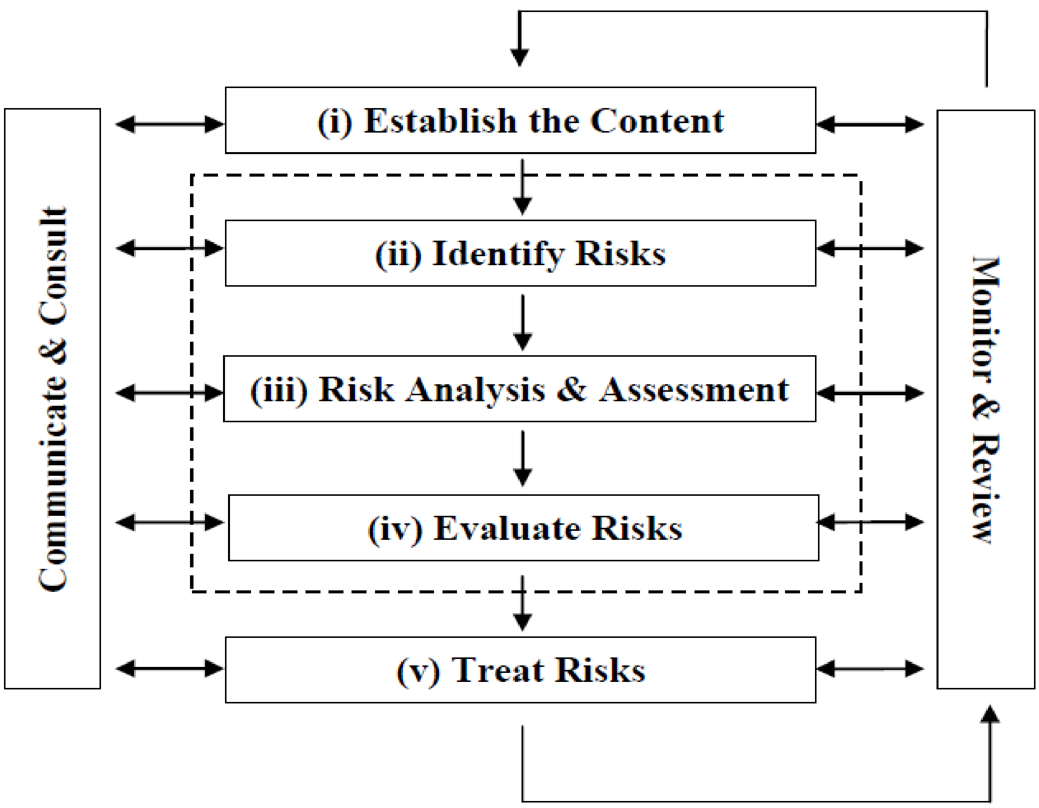


**Figure 2.1: The Risk Management Process, Modified from MOSHAB.**
Source: Department of Industry and Resources, Safety and Health Risk management Guideline, MOSHAB, 1999.

This process involves taking steps to reduce and maintain the risk level to an acceptable standard. The basics of risk management involve four steps;

a. Risk Identification
b. Risk Assessment
c. Risk Reduction
d. Risk Mitigation

### 2.3.1 RISK IDENTIFICATION

Risk Identification is fundamental for effective risk management. This is the first stage for discovering, describing and documenting risks at early stages in a management process. For an effective risk management procedure, accurate and comprehensive risk identification must be conducted. Risk identifications are aimed at capturing as many risks as possible in the system. There are several techniques that can be often applied during risk identification. Useful techniques embrace brainstorming methods, systematic inspections and sometimes also involve process analysis. Despite the consequences of the technique applied, it is important to ensure the identifications process is done accurately.

### 2.3.2 RISK ASSESSMENT

Risk assessment can be quantitative or qualitative. This is a step in the risk management process which involves evaluations of the threats (hazard) identified in a system/process. Risk assessment is the quantification of potential failure and needs the answers to the following three questions:

**1.** What can go wrong within an engineering system?

**2.** How likely is the failure to happen?

**3.** What will be caused by the failure as a consequence? (Wang et al., 2000)

Murphy's Law tells us "If anything can go wrong, it will." Risk assessment provides further insight about how likely a system is to go wrong, and what the consequence may be. Risk assessments create the quantitative inputs for engineering design. Risk managers use this information obtained to help in decisions on how to protect humans and the environment from incidents that may have adverse effects. This requires evaluation of quantities of the risk, the magnitude of the potential loss (L), and the probability (p) that the loss will occur. This is expressed mathematically in the equations 1 below.

$$R_i = L_i p(L_i) \quad \text{......... (2.3.2)}$$

Risk assessments can guide pipeline operators in the decision making process and take precautions so that the risks will be minimized or avoided entirely.

### 2.3.3 RISK REDUCTION

This is a process in the risk management procedure that involves the organization of baseline risk levels and establishment of significant risk thresholds to make available system parameters for the evaluation of multiple risks and thereby used in the reduction. This process eliminates the threat from hazards. It includes synchronized actions to direct and manage a process/system with regards to risk.

### 2.3.4 RISK MITIGATION

Risk mitigation is a systematic approach usually regarded as a final step in the risk management procedure. Mitigation is a process intended to reduce risk through decreasing either probability of failure from identified threats or consequence, or both. Recently, integrity assessments such as in-line inspection or hydro-testing have also been used as mitigation strategies providing knowledge that reduces risk uncertainty and assists in the effective selection of mitigation methods (e.g. operational improvements, training, awareness, repairs, etc.). This is often applied by decision makers to eliminate the risk identified in a system after assessment. This action in a risk management process is taken to permanently eliminate or reduce the risk of failure to the system and the damage to property.

# CHAPTER 3

## 3.1 FACTORS LEADING TO PIPELINE INCIDENTS

The causes of pipeline failures can range from internal issues such as corrosion or material defects to outside forces. Such forces can include damage from natural hazards, which include but are not limited to earthquakes or intentional destruction by humans. Pipeline failure can have a substantial impact. Such events can cause multiple deaths, complete shutdown of facilities for thirty days or more, and can cause more than fifty percent of affected properties to be destroyed or suffer major damage. (Texas Department of Public Safety Report, 2002). Even though transportation of energy fuels via transmission pipelines is the safest mode, any significant failure can result in: serious injury, property damage, environmental harm, or even death. In the last 3 years, pipeline incidents involving natural gas in the United States has caused on average: 2 deaths, 11 injuries, and $97 million in property damage each year (PHMSA, 2009) Incidents involving natural gas transmission pipelines have resulted in an annual average of 6 deaths, 10 injuries, and $20 million in property damage. Although various causes and contributors to pipeline failures exist, the main ones include: material defects, construction errors, internal and external corrosion, malfunctions of control systems or relief equipment, operational errors and outside force damage (e.g., by third parties during excavation).

Pipeline damages related to excavations and construction remain among the leading causes of pipeline failure. In 2003, United States Department of Transportation estimated that such failures contributed to 24 percent of natural gas transmission pipeline and 22 percent of hazardous liquids incidents. The growth in urbanization, population and land development activities near transmission pipelines along with the construction of new facilities will increase the likelihood of pipeline damage due to human activity. Every pipeline has a unique exposure to damage based on its age, geometry, location, and operational parameters.

### 3.1.1 THIRD PARTY DAMAGE

According to Gonzales (2008), a person not involved or associated with the operation or maintenance of a pipeline can be regarded as a “third party”. This can include home owners, farmers, excavators and construction crews, or others who in the line of duty or in their usual daily activities can come in contact with a pipeline. This failure mode is sometimes referred to as outside force or external force. Despite extensive safeguards, pipeline accidents can still occur. As shown by the United States Department of transportation and the NTSB reports show that the leading causes of pipeline damage in distribution pipelines is mostly digging or excavation near existing pipelines ( Table 3.1). In spite of this statistics, the potential for third party damage is often the least considered aspects of pipeline hazard assessment (Muhlbauer, 1999). Hence one of the greatest risks to underground natural gas pipelines is accidental damage during excavation. Considering that even minor damage such as a gouge, dent, scrape, or crease to a pipeline or its coating may cause a leak, rupture or failure.

**Table 3.1 Outside force as the leading cause of Distribution pipeline failure 2002-2003**

| Reported Cause | Number of Incidents | % of Total Incidents | Property Damages | % of total Damages | Fatalities | Injuries |
|---|---|---|---|---|---|---|
| **Construction /Operation** | 20 | 8.1 | $3,086,000 | 6.7 | 0 | 16 |
| **Corrosion** | 3 | 1.2 | $60,000 | 0.1 | 2 | 9 |
| **Outside Force** | 153 | 62.2 | $32,334,352 | 70.1 | 6 | 48 |
| **Other** | 70 | 28.5 | $10,617,683 | 23.0 | 13 | 31 |
| **Total** | 246 | | $46.098.035 | | 21 | 104 |

Note that over 60% of natural gas distribution pipeline incidents were caused by outside force damage in 2002-2003. These incidents can include damage from excavation by the operator or by other parties as well as damage from the natural forces

### 3.1.2 CORROSION DAMAGE

Oftentimes, pipeline corrosion begins with excavation damage, causing weakness in the pipe that makes it susceptible to corrosion. Although most pipelines are coated in corrosion-resistant material, it may chip off over time. All unprotected pipelines face a high risk of corrosion. Without proper maintenance, these pipeline systems will eventually deteriorate. Examples of these types of pipelines are ones that are buried in the ground, exposed to the atmosphere, or submerged in water. The process of corrosion can weaken the structural integrity of a pipeline, causing dangerous conditions for transporting potentially hazardous materials. However, technology exists that are capable of extending the structural life of pipelines if applied correctly and maintained consistently. Corrosion damage in pipelines can be detected by various methods. When it is discovered, the primary concern is whether the pipeline remains structurally sound at the maximum allowable operating pressure (MAOP). If not, the pipe may leak or rupture.

A number of analytical techniques have been developed to determine if a defect will affect the pipeline's capability to operate at the MAOP. The best known method of assessing the remaining strength of corroded pipelines is that of the ANSI/ASME B31 G manual, first published in 1973. It was later perceived to be conservative, so refinements to the underlying concepts were made leading to the development of a modified B31G and later the effective area method. All three approaches stem from the innovative work conducted by Kiefner et al., (1970) to predict the failure stress level for a through wall axial defect in a pipe. This model, commonly referred to as the log secant model, links the hoop stress at failure, to the geometry of the pipe and its toughness as shown in the equation 3.1.2 (a).

$$\frac{K_c^2\pi}{8c\bar{\sigma}} = \ln \sec \frac{\pi}{2}\left[\frac{M_p\ \sigma_p}{\bar{\sigma}}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.1.2\ (a)$$

Where $K_c{}^2 = \dfrac{12\ C_v\ E}{A_c}$ and $C_V$ is the upper shelf Charpy V-notch impact energy, ft-lb

$A_c$ = Area of Charpy V-notch specimen, square inches

E = Elastic Modulus, psi

L = Length of area affected by corrosion and/or stress corrosion cracking.

$\bar{\sigma}$ = Flow Stress, psi (SMYS + 10,000 psi)

$\bar{\sigma}$ p = Failure stress, psi

SMYS = Specified minimum yield strength, psi

D = Nominal outside diameter of the pipe

The Folias factor (M) is used to account for stress magnification as a consequence of bulging due to pipe wall weakness is given as shown by the equation 3.1.2 (b):

$$M = \sqrt{1+0.8\left(L/\sqrt{Dt}\right)^{2}} \quad \ldots\ldots\ldots\ldots 3.1.2\ (b).$$

Where t is the nominal wall thickness of the pipe, in consistent units.

Corrosion most times occurs in various forms. People are familiar with degradations such as rusting of a fence made of materials such as iron or piling of steel. However, corrosion is much more that the invisible rusting pictured on the surfaces of an exposed material. According to National Association of Corrosion Engineers publication (NACE, 2003) pipelines are totally subject to corrosion. Mostly in this case, the corrosion attacks mostly from the inside lining of the pipe walls. This occur when the pipe wall is open to water and the elements/contaminants in the gas which include those like Oxygen ($O_{2}$), Chlorides, Carbon dioxide($CO_{2}$) or hydrogen Sulfide($H_2S$). The degree of corrosion damage that takes place in a pipeline is usually a function of the amount as well as combinations of a variety of corrosive constituents as listed above inside the pipe, and the operating conditions to which the pipe is exposed to (NACE, 2000).

All unprotected pipelines face a high risk of corrosion. Without proper maintenance, these pipeline systems will eventually deteriorate. Examples of these types of pipelines are ones that are buried in the ground, exposed to the atmosphere, or submerged in water. The process of corrosion can weaken the structural integrity of a pipeline, causing dangerous conditions for transporting potentially hazardous materials. However, technology exists that are capable of extending the structural life of pipelines if applied correctly and maintained consistently. Four of the most common methods used to control corrosion on pipelines are: protective coatings and linings, cathodic protection, materials selection, and inhibitors (Peabody, 2001) are:

a). Coatings and linings are the primary tools for preventing corrosion. They are often applied together with cathodic protection systems to provide the most cost-effective protection for pipelines.

b). Cathodic protection (CP) uses direct electrical current to counteract the normal external corrosion of a metal pipeline. CP is used where all or part of a pipeline is buried underground or submerged in water. CP can help prevent corrosion from starting on new pipelines, while stopping existing corrosion from getting worse on existing pipelines.

c). Material selection refers to the selection and use of corrosion-resistant materials such as stainless steels, plastics, and special alloys to extend the lifetime of a pipeline. The pipeline's desired lifespan as well as the environment in which the pipeline will exist must be considered.

d). Corrosion inhibitors are substances which when added to a particular environment, decrease the rate of attack of that environment on a material (e.g. metal or steel reinforced concrete). They can extend the life of pipelines, prevent system shutdowns/failures and avoid product contamination.

Evaluating the environment in which a pipeline is or will be located is very significant to corrosion control, regardless of the method(s) being used. There are simple, yet effective ways of reducing the potential for corrosion. The moisture can be reduced or the drainage can be improved in the environment immediately surrounding a pipeline. Furthermore, the roles that personnel trained in corrosion control serve and the inclusion of corrosion control into pipeline operators' risk assessment are both critical to the success of any corrosion mitigation program. The process of corrosion control is ongoing and dynamic. The keys to effective corrosion control of pipelines are use of appropriate technologies, quality design/installation of equipment, and ongoing maintenance and monitoring by trained professionals. The best insurance plan against preventable problems associated with corrosion is an effective maintenance and monitoring program. Effective corrosion control can extend utility of all pipelines. The increased risk of pipeline failure is far worse than the costs associated with installing, monitoring, and maintaining corrosion control systems. In the long run, the prevention of deteriorating or failing pipelines from will save money, the environment, and public safety. The statistics of corrosion damage for year 2002-2003 is as shown in Table 3.2

**Table 3.2 Corrosion as the leading cause of transmission pipeline failure 2002-2003**

| Reported Cause | Number of Incidents | % of Total Incidents | Property Damages | % of total Damages | Fatalities | Injuries |
|---|---|---|---|---|---|---|
| **Excavation Damage** | 32 | 17.8 | $4,583,379 | 6.9 | 2 | 3 |
| **Natural Force Damage** | 12 | 6.7 | $8,278,011 | 12.5 | 0 | 0 |
| **Outside Force** | 16 | 8.9 | $4,688,717 | 7.1 | 0 | 3 |
| **Corrosion** | 46 | 25.6 | $24,273,051 | 36.6 | 0 | 0 |
| **Equipment** | 12 | 6.7 | $5,337,364 | 8.0 | 0 | 0 |
| **Material** | 36 | 20.0 | $12,130,558 | 18.3 | 0 | 0 |
| **Operation** | 6 | 3.3 | $2,286,455 | 3.4 | 0 | 2 |
| **Other** | 20 | 11.1 | $4,773,647 | 7.2 | 0 | 0 |
| **Total** | 180 | | $66,351,182 | | 2 | 13 |

Note the corrosion (external and internal) is the most common cause of natural gas transmission pipeline incidents in 2002-2003

### 3.1.3 MECHANICAL DAMAGE

Mechanical damage can be defined as a localized damage resulting from contact between the pipe and an object. Mechanical damage may occur during the transportation, manufacture, on-site handling and laying of pipelines. In most cases, such damage is found and fixed prior to service. However some damages particularly due to contact with rocks and buried objects during pipe-laying, may not be detected until the pipeline has seen service. Such damage is included within this definition of mechanical damage. Mechanical damage occurs after the pipeline has commenced service, which could often result from activities in the pipeline right-of-way. Activities associated with mechanical damage occurrences typically include: excavation, drilling, fencing, horizontal drilling and trenching drainage, and sometimes agricultural activity (Hopkins et al., 1983). It can be seen from the above that mechanical damage may occur slowly (e.g., rocks) or quickly (e.g., excavation equipment); it may be accidentally or deliberately caused; and it may originate at the outside or the inside of the pipe.

Also, mechanical damage may result for example from the activities of pipeline operators or their sub-contractors, other utility operators, landowners, civil engineering contractors or the general public; these are often categorized as ‘first party’, ‘second party’ or ‘third party’ activities respectively (Eiber, 2003).

### 3.1.4 OPERATIONAL DAMAGE

Operation such as over pressuring that could have been caused by inappropriate procedures, training or operator error. Incorrect operation failures are typically those where better procedures may have prevented an incident from occurring. These types of failures often occur during maintenance activities. Some examples of this type of failure are unintentional gas ignition during a welding or maintenance activity or other reportable incidents where a fire occurred not intentionally started by the operator, where an employee removes the wrong bolts from an assembly, leaves a valve open or closed at the wrong time, or failures where human error, employee fatigue, and/or lack of experience may have played a role.

### 3.1.5 EQUIPMENT DAMAGE

This section includes malfunctions of control and relief equipment (typically the result of failed and leaking valves), failures of threaded components and broken pipe couplings, and seal failures such as compressor pump packing failures. Incidents resulting from incorrect operations or inadequate procedures are also included in this category.

## 3.2 RISK ASSESSMENT TECHNIQUES CURRENTLY USED IN THE PIPELINE INDUSTRY

During the past two decades, the focus of pipeline safety has shifted from response to prevention of incidents. Some preventive techniques include: more public involvement, more extensive inspections and prospective analysis of the pipeline dangers. From the Special Report 281 on transmission pipelines and land use (2004), Pipeline companies have also begun utilizing a variety of risk assessment techniques, some of which include: scenario-based analysis, fault tree analysis, indexing methods, hazard and operability (HAZOP) analysis. Most analyses are centered around specific factors that affect the probability of pipeline failure (e.g., internal corrosion, external corrosion, pipeline loading) or on the consequences of rupture (such as heat intensity, thermal impact radius, depth of cover). While a few of these analyses attempt to take component interdependencies into account, others actually focus on specific pipeline system components.

Muhlbauer (2004) stated that the pipeline risk management and assessment techniques that exist in the current literature involve various methodologies to obtain the probabilities and consequences of processes and events leading to risk. What they share in common is the emphasis of the calculating of a risk number (i.e., a mathematical product of probability and consequence). Even though this calculation allows for a quantitative assessment using several components of pipeline safety, it is not sufficient for a general understanding of risk (Transmission Pipelines and Land Use, 2004).

First, it will be mandatory for natural gas pipeline operators to perform risk assessments on all of their pipeline segments that are considered high-consequence areas (SR281, 2004).

Inspections may be achieved through utilization of in-line inspection tools, analysis of operating and maintenance records, and direct examination of pipe in selected areas. Risk criteria have been expanded in other countries to include societal risk which occurs as a result of land use near pipelines (Committee for the Prevention of Disasters, 1999).

### 3.3 CURRENT APPROACH TO RISK ASSESSMENTIN THE PIPELINE INDUSTRY

According to Muhlbauer (1999), risk assessment is the process of identifying, describing, and analyzing risk with the following elements:

- Recognition or identification of a hazard or potential adverse event, perhaps with definition of accident scenarios in which the hazards are realized or experienced;
- Analysis of the mechanisms by which an event can occur and the mechanisms by which the event can create loss;
- Analysis of the consequences of an adverse event as a function of various factors of design or circumstance; and
- Estimation of the likelihood of the sequences of events that lead to the consequences.

In the process of evaluating risk factors, field data is crucial because failure analysis depends on it. This type of data can be in the form of construction documents, maintenance records, employee interviews, design documents, expert testimonies and inspection of facilities. Mandatory pipeline data include age, minimum depth cover, coating type, material specifications, road crossing, welding requirements, minimum/maximum pressures and potential earth movement. In this study, 1958 cases over a 23 year time span are described. Failure causes and repair information are grouped according to available information (location of failure, reason of failure, pipeline age etc.)

## 3.4 PIPELINE DATA ANALYSIS

The risk assessment model must take into account all failure data that can be obtained from the pipeline system. Data analysis must be done with great care to ensure an effective risk assessment model. Additionally, the relationship between all parameters must be identified; the physical condition and historical data of the pipeline must be investigated. Gas pipeline failure is a complex process that depends on pipe characteristics, inspection/maintenance policies, physical processes and actions of third parties. Although, a great deal of information is known concerning pipeline history and physical processes, this knowledge is not sufficient enough to predict the occurrence of failures under all possible conditions. The lack of data concerning physical conditions and processes contribute to this. Consequently, failure frequency predictions are usually associated with substantial uncertainties. Managing the predictions require a defensible and traceable assessment of these uncertainties.

# CHAPTER 4

# METHODOLOGY AND RESEARCH DESIGN

## 4.1 DATA SOURCE AND ANALYSIS TECHNIQUE

In this analysis, the data used was based on the study and historical reports of various pipeline incidents in the United States from the Pipeline and Hazardous Materials Safety Administration (PHMSA), the National Transportation and Safety Board (NTSB) and the Pipeline Safety Trust reports. The pipeline incident data was collected for a time period of 23years (1986 – 2009). Each of the years from the data set was sorted using the excel spreadsheet and considered separately. The categories of data obtained from the reports include: year of installation, year of failure, failure cause, maximum allowable operating pressure, fatalities, injuries and property damage in dollars. Incorporating the event frequency, concepts of failure, and the potential consequences of an event determines an effective pipeline risk evaluation. This approach to pipeline risk assessment identified factors of main concern at various levels and focus on failure rate using a detailed model and analysis tools. With the use of the Pareto chart obtained in the analysis, a graphical display of the relative importance of the differences between the various groups of data (factors), the positive and negative effects of each of the factors were recognized.

The data obtained is grouped into time dependent and time independent factors. For this research, the various pipeline failure threats recognized by the American Engineering Code, grouped into eight threat classes; external corrosion, internal corrosion, third party damage, stress corrosion cracking, manufacturing defects, construction defects, equipment failure and incorrect operation were further categorized in two major groups/Factors and this was based on the similarities of the activities. These factors were made to interact with other pipeline failure parameters such as the pipeline age and the maximum allowable operating pressure. The failure rate model developed in this study used the same approach as the model developed by Aller et al., (1987), which attributes proportional weightings to a variety of risk factors. The failure rate Model is comprised of factors accounting for damage, and age of systems. Each factor is assigned a corresponding weighting to account for its relative importance in the model. The weightings are described in Tables 4.1 – 4.6 and are scaled such that the sum of all weightings is 100%. The certainty factor accounts for the level of confidence in the data source. The sum of each risk factor multiplied by its weighting determines the risk zone value:

$$\textbf{RISK} = \sum \textbf{(RISK FACTOR X WEIGHTING)}$$

## 4.2 EXPERIMENTAL DESIGN PROCEDURE

These groups are as listed below:

**FACTOR A**: Age of the Operating Pipeline

This is an important factor considering that most of the pipelines currently in use in the United States are over 40 years. According to material science, pipeline materials which include steel and cast iron degrade with time. Hence a good percentage of pipeline incidents have age as a major contributing factor. Based on the data obtained, the various pipeline ages were grouped and weighted as shown in Table 4.1

**Table 4.1Grouping and Weighting of Factor A**

| CATEGORY | WEIGHT LEVEL |
|---|---|
| Above the age of 60 | 5 |
| Pipelines between 46 – 59 years | 4 |
| Pipelines between 31– 45years | 3 |
| Pipelines between 16 – 30 years | 2 |
| Pipelines below 15 years | 1 |

**FACTOR B**: Maximum Allowable Pressure of the Pipe

As materials age and degrade, their tensile strength reduces over time and also their ability to withstand the MAOP. The pressure at with a pipeline operates at every time is an important factor to consider during this analysis. Based on the data obtained, the various pipeline pressures were grouped and weighted as shown in Table 4.2

**Table 4.2 Grouping and Weighting of Factor B**

| CATEGORY (PSI) | WEIGHT LEVEL |
|---|---|
| Pipeline Pressure >2500 | 10 |
| Pipeline pressure between 1500- 2500 | 8 |
| Pipeline pressure between 999-1499 | 6 |
| Pipeline pressure Between 500-999 | 4 |
| Pipeline Pressure <500 | 2 |

**FACTOR C**: Damage Level

This was grouped according to the costs (in USD) involved and the number of fatalities or injuries involved. Based on the data obtained, the various pipeline damages levels were categorized and weighted as shown in Table 4.3

**Table 4.3 Grouping and weighting of factor C**

| COST | TYPE OF DAMAGE | WEIGHT LEVEL |
|---|---|---|
| >$500,000 | Corrosion | Level 5 |
| < $500000 | Corrosion | Level 4 |
| >$500,000 | Excavation /third party | Level 3 |
| < $500000 | Excavation /third party | Level 2 |
| Any Amount | Other | Level 1 |

**FACTOR D**: Time Independent

This failure mode is sometimes referred to as outside force or external force. This will include damages which do not occur as a function of time or age instead is random in occurrence. Examples include incorrect operation and Excavation damage. Based on the Data obtained, the various pipeline damages causes were categorized and weighted as shown in Table 4.4

**Table 4.4 Grouping and weighting of factor D**

| CATEGORY | WEIGHT LEVEL |
|---|---|
| Excavation | 5 |
| Incorrect Operation | 4 |
| Mechanical Damage | 3 |
| Others | 2 |
| Unknown | 1 |

**FACTOR E**: Time Dependent

This considers factors which are time dependent and occur gradually over the years due to various environmental situation and conditions or material degradation due to age. These factors include corrosion (internal and external), cracking of pipeline. Based on the data obtained, the various pipeline damages causes were categorized and weighted as shown in Table 4.5

**Table 4.5 Grouping and weighting of factor E**

| CATEGORY | WEIGHT LEVEL |
|---|---|
| Above the age of 60 | 50 |
| Pipelines between 46 – 59 years | 40 |
| Pipelines between 31– 45years | 30 |
| Pipelines between 16 – 30 years | 20 |
| Pipelines below 15 years | 10 |

Several steps have been provided in order to better understand this research easily. Considering that pipelines are mostly buried or laid underground and sometimes the incidents are somewhat uncommon, they still cannot be categorized as “fit and forget”. Except frequently evaluated, and cared for, pipelines will in the long run undergo damages as a result of leaks or ruptures.

Blocking was applied to help decrease and get rid of the error which can occur due to the impact of trouble factors such as noise in the model. In this analysis, the troubling factors not accounted for are classified as earth movements, natural disasters, climate and humidity, preceding safety report, and other political problems brought about by government issues. Blocking in an experimental design enhances sensitivity of detecting significant effect to be improved in model where needed (Gardiner & Gettingby, 1998; Montgomery, 2008; Telford, 2007).This research applied a Qualitative evaluation approaches to risk assessment, these approach included relative assessment methods. Qualitative methods (relative assessment) were based on the concept of risk factor grouping and scoring against a number of significant parameters, with a weighting technique applied to each of the parameters to replicate the impact and input to the overall level of risk.

In calculating the risk, likelihood of failure was calculated as discussed earlier. The other element taken into account in this work was the determination of the consequence of failure.

# CHAPTER 5

# ANALYSIS AND RESULTS

## 5.1 ANALYSIS OF VARIANCE

The Design of Experiments (DOE) Design Expert 8.0.4 software package was used for the statistical analysis of the sorted data. Analysis of variance (ANOVA) tests for a 2-level factorial design were carried out based on a confidence level of 95%. The effect of each of the five factors to the total failure rate corresponds to $x_1$, $x_2$, $x_3$, $x_4$ and $x_5$. The variables"$x_1$, $x_2$, $x_3$, $x_4$ and $x_5$" are considered as the independent variables (Figure 5.2). The dependent variable is the total failure rate recorded over the 23 year period is denoted as (X'). The mathematical representation for the interactive relationship between the independent and dependent variables is given in equation 5.1 as:

$$\mathbf{X' = f\,(x_1, x_2, x_3, x_4, x_5, \mathcal{E})} \ldots\ldots\ldots\ldots\ldots\ldots(5.1)$$

Where $\mathcal{E}$ denotes the various errors which may be due to uncontrollable and nuisance factors which include but not limited to government regulations and sabotage. This data was further grouped and sorted with an approach similar to the data collection process adopted by Oyewole et al., (2010). This analysis aimed at describing how each of the various factors varies with the other and how multiple factors play in the pipeline failures. The data used in this thesis was grouped into various factors A,B. C D and E which includes time dependent (corrosion and cracking) and time independent (third party, incorrect operation and design) factors. The ANOVA (Figure 5.1) test was conducted in order to determine the interaction and relationships of each factor to the other in the model

## ANALYSIS

Using the Design Expert Analysis of variance (ANOVA)

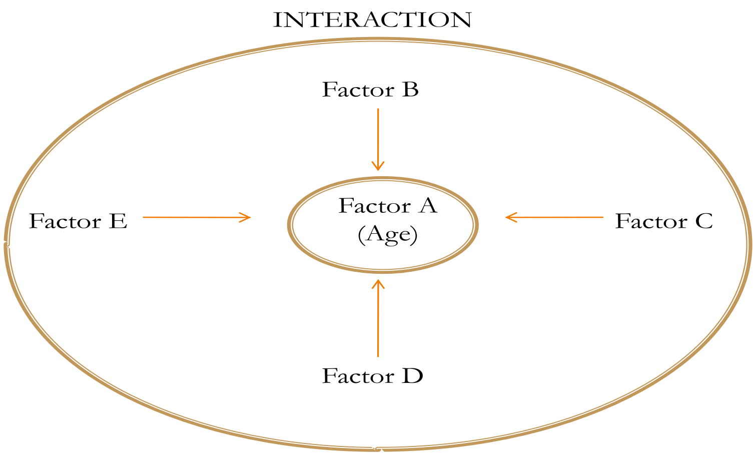


**Figure 5.1 Schematic diagram of the analytical process**

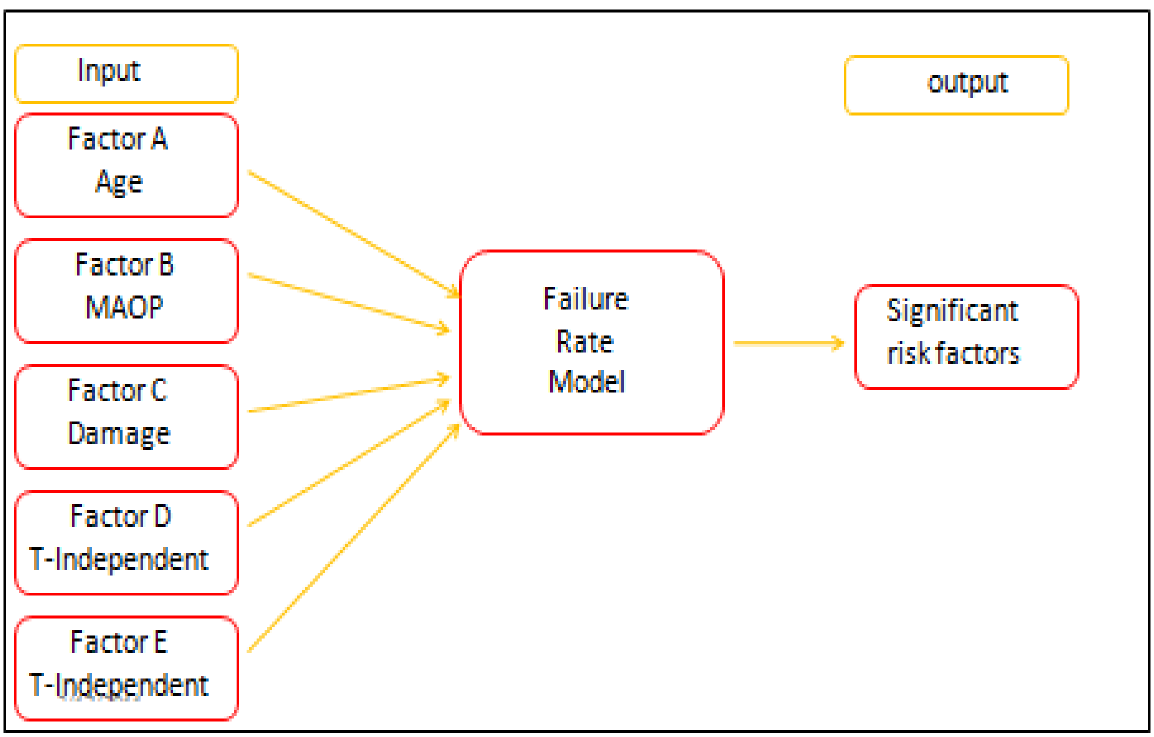


**Figure 5.2 Representation of the Failure rate model**

(Adapted from Oyewole et al., 2010)

With the use of the Pareto chart obtained in this analysis, a graphical display of the relative importance of the differences between the various groups of data (factors), the positive and negative effects of each of the factors were recognized. In Pareto chart shown in the Figure 5.2 below, there are 31 effects observed (16 positive effects and 15 negative effects) from the various factors and their interactions. The interactions which amplify the level of significance of a model can be described as the positive effects. On the other hand, the interactions which reduce the level of significance of a model can be described as the negative effects.

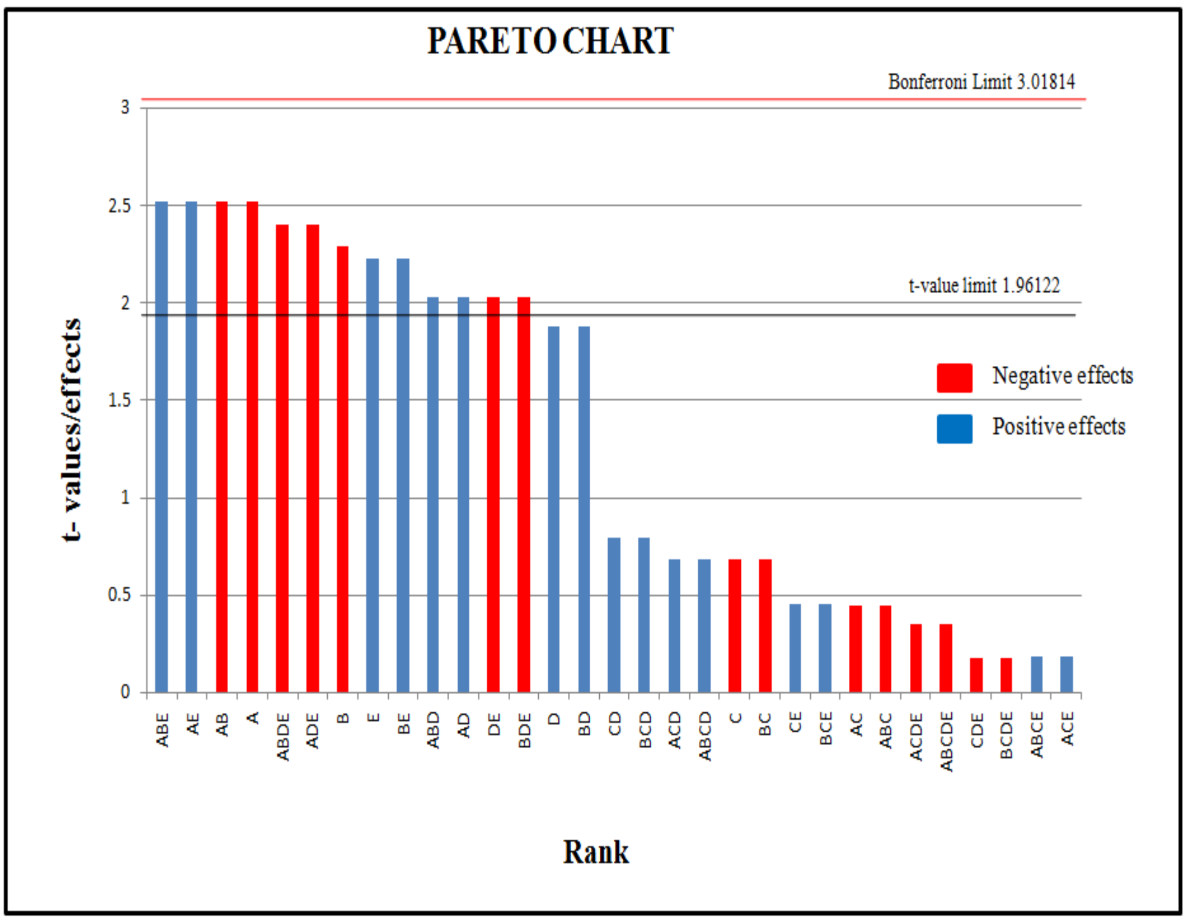


**Figure 5.3 Positive and Negative effects for the various risk factors and their interactions**

Figure 5.2 illustrates all the 31 factor interactions with factors A, B, D and E having obtained t-values of 2.52, 2.29, 1.88 and 2.23 respectively. Factors A, B, D and E have very significant positive effects. This shows the effect of the pipeline age factor, time dependent factors and time independent factors on the pipeline failure rate model. A positive or negative effect does not indicate that a risk factor or the interaction of the risk factors is significant or not significant (Oyewole et al., 2010). The effect of these factors on the failure rate model could assist in the allocation of resources to the various risk factors for a proper assessment. The interaction of the individual risk factors can bring about a more positive effect when combined. It is important to focus on the significant factors with positive effects for an effective pipe line risk management activity. Table 5.1(a) shows the ranks and t-values of the risk factors and factor interactions.

**Table 5.1 (a) Ranks and t-values for risk factors and factor interactions.**

| RANK | EFFECT | T-VALUE |
|---|---|---|
| 1 | ABE | 2.52 |
| 2 | AE | 2.52 |
| 3 | AB | 2.52 |
| 4 | A | 2.52 |
| 5 | ABDE | 2.4 |
| 6 | ADE | 2.4 |
| 7 | B | 2.29 |
| 8 | E | 2.23 |
| 9 | BE | 2.23 |
| 10 | ABD | 2.03 |
| 11 | AD | 2.03 |
| 12 | DE | 2.03 |
| 13 | BDE | 2.03 |
| 14 | D | 1.88 |
| 15 | BD | 1.88 |
| 16 | CD | 0.79 |
| 17 | BCD | 0.79 |
| 18 | ACD | 0.68 |
| 19 | ABCD | 0.68 |
| 20 | C | 0.68 |
| 21 | BC | 0.68 |
| 22 | CE | 0.45 |
| 23 | BCE | 0.45 |
| 24 | AC | 0.45 |
| 25 | ABC | 0.45 |
| 26 | ACDE | 0.35 |
| 27 | ABCDE | 0.35 |
| 28 | CDE | 0.18 |
| 29 | BCDE | 0.18 |
| 30 | ABCE | 0.18 |
| 31 | ACE | 0.18 |

Table 5.1(b) shows the analysis of the various factors to observe their interactions and how significant they are on the failure rate; In this case A, B, D, E, AB, AD, AE, BD, BE, DE, ABD, ABE, ADE, BDE, ABDE are the significant interaction.

**Table 5.1(b) Analysis of variance (ANOVA) for the failure rate model**

| | | | | | |
|---|---|---|---|---|---|
| Source | Sum of Squares | df | Mean Square | F- Value | p-value Prob> F |
| Block | 102.64 | 2 | 51.32 | | |
| Model | 2372.79 | 31 | 76.54 | 155.40 | < 0.0001 |
| A-AGE | 3.29 | 1 | 3.29 | 6.68 | 0.0098 |
| B-MAOP | 2.41 | 1 | 2.41 | 4.90 | 0.0270 |
| C-DAMAGE | 0.153 | 1 | 0.15 | 0.31 | 0.5762 |
| D-T- INDEPENDENT | 1.82 | 1 | 1.82 | 3.69 | 0.0546 |
| E-TIME DEPENDENT | 2.23 | 1 | 2.23 | 4.53 | 0.0334 |
| AB | 3.29 | 1 | 3.29 | 6.68 | 0.0098 |
| AC | 0.08 | 1 | 0.09 | 0.18 | 0.6747 |
| AD | 2.13 | 1 | 2.13 | 4.33 | 0.0376 |
| AE | 3.31 | 1 | 3.31 | 6.72 | 0.0096 |
| BC | 0.15 | 1 | 0.15 | 0.31 | 0.5766 |
| BD | 1.81 | 1 | 1.81 | 3.68 | 0.0550 |
| BE | 2.22 | 1 | 2.23 | 4.51 | 0.0337 |
| CD | 0.22 | 1 | 0.22 | 0.45 | 0.5028 |
| CE | 0.09 | 1 | 0.09 | 0.18 | 0.6687 |
| DE | 2.09 | 1 | 2.10 | 4.26 | 0.0392 |
| ABC | 0.08 | 1 | 0.09 | 0.176 | 0.6748 |
| ABD | 2.13 | 1 | 2.13 | 4.32 | 0.0376 |
| ABE | 3.31 | 1 | 3.31 | 6.72 | 0.0096 |
| ACD | 0.16 | 1 | 0.17 | 0.34 | 0.5585 |
| ACE | 2.47E-03 | 1 | 2.47 E-03 | 5.02 E-03 | 0.9435 |
| ADE | 3.01 | 1 | 3.01 | 6.11 | 0.0135 |
| BCD | 0.22 | 1 | 0.22 | 0.45 | 0.5030 |
| BCE | 0.09 | 1 | 0.09 | 0.18 | 0.6691 |
| BDE | 2.09 | 1 | 2.09 | 4.25 | 0.0393 |
| CDE | 3.11 E-03 | 1 | 3.11 E-03 | 6.33 E-03 | 0.9366 |
| ABCD | 0.17 | 1 | 0.17 | 0.34 | 0.5587 |
| ABCE | 2.48 E-03 | 1 | 2.48 E-03 | 5.04 E-03 | 0.9434 |
| ABDE | 3.01 | 1 | 3.01 | 6.12 | 0.0135 |
| ACDE | 0.05 | 1 | 0.05 | 0.11 | 0.7395 |
| BCDE | 2.99 E-03 | 1 | 2.99 E-036 | 6.07 E-03 | 0.9379 |
| ABCDE | 0.05 | 1 | 0.05 | 0.11 | 0.7411 |
| Residual | 928.92 | 1886 | 0.49 | | |
| Lack of Fit | 869.68 | 1170 | 0.74 | 8.98 | < 0.0001 |
| Pure Error | 59.24 | 716 | 0.08 | | |
| Cor Total | 3404.36 | 1919 | | | |

The Table 5.2 interprets the statistical behavior of the failure rate model using the mean, prediction error sum of squares (PRESS), standard deviation, adequate precision, the $R^2$ values and coefficient of variance (CV);

**Table 5.2 Statistical summary of the Failure Rate Model**

| | | | | |
|---|---|---|---|---|
| Std. Dev. | 0.70 | | R-Squared | 0.72 |
| Mean | 2.34 | | Adj R-Squared | 0.71 |
| C.V. % | 29.92 | | Pred R-Squared | 0.71 |
| PRESS | 965.58 | | Adeq Precision | 45.29 |

The Normality of the mode was plotted (Figure 5.4) based on the normal plot and using the results of the "fat pencil" criteria, it appears that the thickness data is normally distributed. Thus, applying other statistical tests that involve the hypothesis of normality is appropriate. Statistical tests based on the t-values and the F-values are fairly strong to minor departures from normality, so a subjective visual examination of the probability plot is usually sufficient to use these tests with confidence (Rossi, 1956).

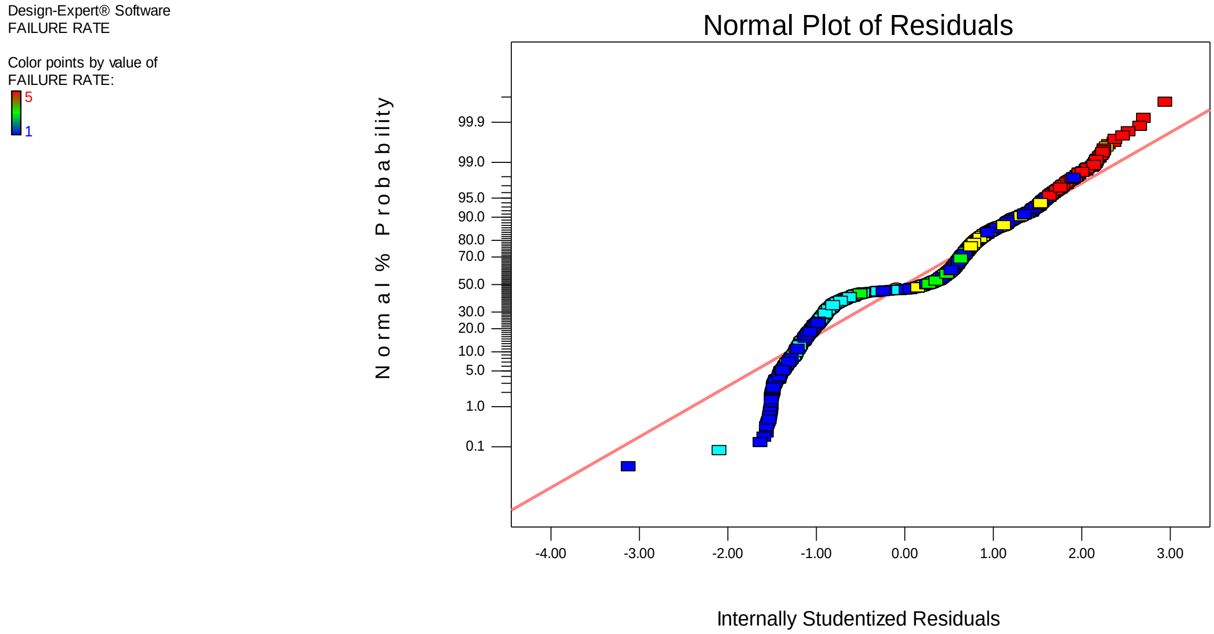


**Figure 5.4 Normal plots of residuals for the failure rate model**

**Table 5.3 Normal Failure rate equation for all factors and interactions**

| Failure Rate X= | |
|---|---|
| -931.22 | |
| -1238.65 | * A |
| -934.47 | * B |
| -577.97 | * C |
| 1507.28 | * D |
| 932.28 | * E |
| -1240.85 | * A * B |
| -466.64 | * A * C |
| 2018.55 | * A * D |
| 1276.28 | * A * E |
| -579.12 | * B * C |
| 1508.51 | * B * D |
| 934.08 | * B * E |
| 1025.31 | * C * D |
| 454.23 | * C * E |
| -1660.43 | * D * E |
| -467.55 | * A * B * C |
| 2022.12 | * A * B * D |
| 1278.64 | * A * B * E |
| 1026.18 | * A * C * D |
| 80.46 | * A * C * E |
| -2438.23 | * A * D * E |
| 1027.8 | * B * C * D |
| 455.08 | * B * C * E |
| -1663.76 | * B * D * E |
| -124.68 | * C * D * E |
| 1027.58 | * A * B * C * D |
| 80.77 | * A * B * C * E |
| -2442.5 | * A * B * D * E |
| -593.81 | * A * C * D * E |
| -122.53 | * B * C * D * E |
| -591.17 | * A * B * C * D * E |

## 5.2 DATA TRANSFORMATION ANALYSIS AND NORMALITY

In most quantitative analysis, data transformations are commonly used tools that can serve many functions. One approach to the problem of non-homogeneous variances is to apply transformations to the data. In this analysis, focus is on the use of various data transformations most commonly applied in statistical modeling: square root, natural log, the inverse square root and base 10 log transformations for improving the normality of variables. These transformations are sometimes called variance-stabilizing because their purpose is to make variances the same. They also tend to normalize distributions. Although, many statistical procedures assume that the variables are normally distributed. As discussed by Osborne (2002), in statistical analysis, an important defiance of the hypothesis of normality can gravely increase the chances of error in the model. On the other hand, one of the main reasons why this analysis utilized data transformations is to improve the normality of variables and to compare with the normal model residual plots. Major aims of applying transformation of data in statistics are to bring data closer to normal distribution, to reduce relationship between mean and variance, to reduce the influence of outliers, to improve linearity in regression, to reduce interaction effects, to reduce skewness and kurtosis.

### 5.2.1 SQUARE ROOT TRANSFORMATION

This transformation of data is appropriate for the data sets where the variance is proportional to the mean. Here, the original observations are brought to square root scale by taking the square root of each observation.This can be expressed mathematically as;

$$\mathbf{X'} = \sqrt{X} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5.2.1)$$

Applying the square rot transformation to this model, factors A, B, D and E are significant. Also interactions; AB, AD, AE, BD, BE, DE, ABD, ABE, ADE, BDE, ABDE are significant. In this case, the factor C had a p-value of 0.4028 and still remained insignificant having a p-value above 0.05 (Table 5.4). The Table 5.5 interprets the statistical behavior of the failure rate model after the square root transformation using the mean, prediction error sum of squares (PRESS), standard deviation, adequate precision, the $R^2$ values and coefficient of variance (CV). The "Pred R-Squared" of 0.76 is in reasonable agreement with the "Adj R-Squared" of 0.76. "Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. The ratio of 9.06 indicates an adequate signal.

**Table 5.4 Analysis of variance (ANOVA) for the square root transformation**

| Source | Sum of Squares | df | Mean Square | F-Value | p-value Prob> F |
|---|---|---|---|---|---|
| Block | 8.1 | 2 | 4.05 | | |
| Model | 268.43 | 31 | 8.65 | 201.87 | < 0.0001 |
| A-AGE | 0.39 | 1 | 0.39 | 9.28 | 0.0024 |
| B-MAOP | 0.29 | 1 | 0.29 | 6.9 | 0.0087 |
| C-DAMAGE | 0.03 | 1 | 0.03 | 0.7 | 0.4028 |
| D-TIME INDEPENDENT | 0.19 | 1 | 0.19 | 4.56 | 0.0335 |
| E-TIME DEPENDENT | 0.26 | 1 | 0.26 | 5.95 | 0.0148 |
| AB | 0.39 | 1 | 0.39 | 9.28 | 0.0023 |
| AC | 0.02 | 1 | 0.02 | 0.47 | 0.4951 |
| AD | 0.23 | 1 | 0.23 | 5.43 | 0.0199 |
| AE | 0.38 | 1 | 0.38 | 8.89 | 0.0029 |
| BC | 0.03 | 1 | 0.03 | 0.69 | 0.4032 |
| BD | 0.19 | 1 | 0.19 | 4.51 | 0.0339 |
| BE | 0.25 | 1 | 0.25 | 5.93 | 0.015 |
| CD | 0.03 | 1 | 0.03 | 0.72 | 0.3969 |
| CE | 0.02 | 1 | 0.02 | 0.49 | 0.4808 |
| DE | 0.21 | 1 | 0.21 | 4.86 | 0.0277 |
| ABC | 0.02 | 1 | 0.02 | 0.47 | 0.4951 |
| ABD | 0.23 | 1 | 0.23 | 5.43 | 0.0199 |
| ABE | 0.38 | 1 | 0.38 | 8.89 | 0.0029 |
| ACD | 0.026 | 1 | 0.03 | 0.6 | 0.438 |
| ACE | 4.49 E-03 | 1 | 4.49 E-03 | 0.1 | 0.7461 |
| ADE | 0.31 | 1 | 0.31 | 7.31 | 0.0069 |
| BCD | 0.03 | 1 | 0.03 | 0.72 | 0.3972 |
| BCE | 0.02 | 1 | 0.02 | 0.49 | 0.4811 |
| BDE | 0.21 | 1 | 0.21 | 4.85 | 0.0278 |
| CDE | 4.02 E-03 | 1 | 4.02 E-03 | 0.094 | 0.7593 |
| ABCD | 0.03 | 1 | 0.03 | 0.6 | 0.4383 |
| ABCE | 4.50 E-03 | 1 | 4.50 E-03 | 0.11 | 0.7459 |
| ABDE | 0.31 | 1 | 0.31 | 7.31 | 0.0069 |
| ACDE | 1.30 E-03 | 1 | 0.01 | 0.31 | 0.5797 |
| BCDE | 3.98 E-03 | 1 | 3.98 E-03 | 0.09 | 0.7606 |
| ABCDE | 0.01 | 1 | 0.01 | 0.3 | 0.5811 |
| Residual | 80.89 | 1886 | 0.04 | | |
| Lack of Fit | 76.18 | 1170 | 0.07 | 9.9 | < 0.0001 |
| Pure Error | 4.7 | 716 | 6.57 E-03 | | |
| Cor Total | 357.43 | 1919 | | | |

**Table 5.5 Statistical summary of the Failure Rate Model**

| | | | |
|---|---|---|---|
| Std. Dev. | 0.21 | R-Squared | 0.77 |
| Mean | 1.47 | Adj R-Squared | 0.76 |
| C.V. % | 14.09 | Pred R-Squared | 0.76 |
| PRESS | 84.12 | Adeq Precision | 9.06 |

Analysis of the normal plot (Figure 5.5) determined the normality off the square root transformation. The normal plot of residuals shown in Figure 5.5 shows several similarities to that of the Figure 5.4 which indicates some adequacies in the normality of the failure rate model obtained using the square root transformation.

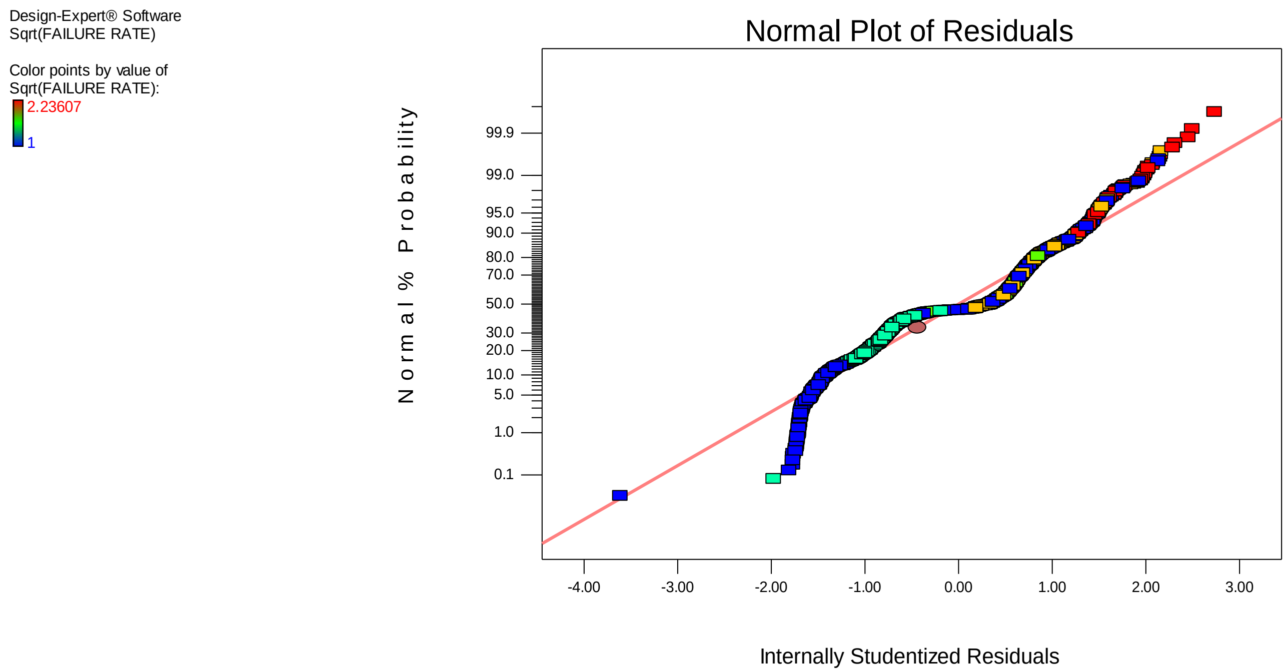


**Figure 5.5 Normal plots of residuals for the square root transformation**

### 5.2.2 NATURAL LOG TRANSFORMATION

Logarithmic transformation of data is suitable for the data where the variance is proportional to square of the mean or the coefficient of variation (S.D./mean) is constant or where effects are multiplicative.This can be expressed mathematically as;

$$\mathbf{X'} = \ln (X) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5.2.2)$$

Applying the Natural Log transformation to this model, factors A, B, D and E are significant. Also interactions; AB, AD, AE, BD, BE, DE, ABD, ABE, ADE, BDE, ABDE are significant. In this case, the factor C had a smaller p-value of 0.2456 when compared with the value on Tables 5.1 and 5.4 and still remained insignificant having a p-value above 0.05 (Table 5.6). The Table 5.7 interprets the statistical behavior of the failure rate model after the Natural Log transformation using the mean, prediction error sum of squares (PRESS), standard deviation, adequate precision, the $R^2$ values and coefficient of variance (CV). The "Pred R-Squared" of 0.79 is in reasonable agreement with the "Adj R-Squared" of 0.80. "Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. The ratio of 53.36 indicates an adequate signal.

**Table 5.6 Analysis of variance (ANOVA) for the Natural Log transformation**

| Source | Sum of Squares | df | Mean Square | F-Value | p-value Prob> F |
|---|---|---|---|---|---|
| Block | 10.82 | 2 | 5.41 | | |
| Model | 529.84 | 31 | 17.09 | 254.33 | < 0.0001 |
| A-AGE | 0.83 | 1 | 0.83 | 12.37 | 0.0004 |
| B-MAOP | 0.62 | 1 | 0.63 | 9.35 | 0.0023 |
| C-DAMAGE | 0.09 | 1 | 0.09 | 1.35 | 0.2456 |
| D-TIME INDEPENDENT | 0.35 | 1 | 0.35 | 5.28 | 0.0217 |
| E-TIME DEPENDENT | 0.51 | 1 | 0.51 | 7.55 | 0.0061 |
| AB | 0.83 | 1 | 0.83 | 12.38 | 0.0004 |
| AC | 0.07 | 1 | 0.07 | 0.97 | 0.3239 |
| AD | 0.44 | 1 | 0.44 | 6.48 | 0.011 |
| AE | 0.76 | 1 | 0.76 | 11.31 | 0.0008 |
| BC | 0.09 | 1 | 0.09 | 1.38 | 0.2459 |
| BD | 0.35 | 1 | 0.35 | 5.26 | 0.022 |
| BE | 0.51 | 1 | 0.51 | 7.52 | 0.0061 |
| CD | 0.07 | 1 | 0.07 | 1.04 | 0.3069 |
| CE | 0.07 | 1 | 0.07 | 1.07 | 0.3006 |
| DE | 0.35 | 1 | 0.35 | 5.25 | 0.022 |
| ABC | 0.07 | 1 | 0.07 | 0.97 | 0.3238 |
| ABD | 0.44 | 1 | 0.44 | 6.48 | 0.011 |
| ABE | 0.76 | 1 | 0.76 | 11.31 | 0.0008 |
| ACD | 0.07 | 1 | 0.07 | 0.97 | 0.3242 |
| ACE | 0.03 | 1 | 0.03 | 0.39 | 0.53 |
| ADE | 0.56 | 1 | 0.56 | 8.29 | 0.004 |
| BCD | 0.07 | 1 | 0.07 | 1.04 | 0.3072 |
| BCE | 0.07 | 1 | 0.07 | 1.07 | 0.3009 |
| BDE | 0.35 | 1 | 0.35 | 5.24 | 0.0221 |
| CDE | 0.02 | 1 | 0.02 | 0.31 | 0.5784 |
| ABCD | 0.07 | 1 | 0.07 | 0.97 | 0.3244 |
| ABCE | 0.03 | 1 | 0.03 | 0.39 | 0.5295 |
| ABDE | 0.56 | 1 | 0.56 | 8.29 | 0.004 |
| ACDE | 0.04 | 1 | 0.04 | 0.65 | 0.419 |
| BCDE | 0.02 | 1 | 0.02 | 0.3 | 0.5797 |
| ABCDE | 0.04 | 1 | 0.04 | 0.65 | 0.4201 |
| Residual | 126.74 | 1886 | 0.07 | | |
| Lack of Fit | 120.24 | 1170 | 0.1 | 11.31 | < 0.0001 |
| Pure Error | 6.51 | 716 | 0.01 | | |
| Cor Total | 667.41 | 1919 | | | |

**Table 5.7 Statistical summary of the Failure Rate Model**

| | | | |
|---|---|---|---|
| Std. Dev. | 0.26 | R-Squared | 0.81 |
| Mean | 0.68 | Adj R-Squared | 0.80 |
| C.V. % | 37.93 | Pred R-Squared | 0.79 |
| PRESS | 131.75 | Adeq Precision | 53.36 |

Analysis of the normal plot (Figure 5.6) determined the normality of the natural log transformation. The normal plot of residuals shown in Figure 5.4 shows some similarities to that in the Figure 5.6 which indicates slight inadequacies in the normality of the failure rate model obtained using the natural log transformation.

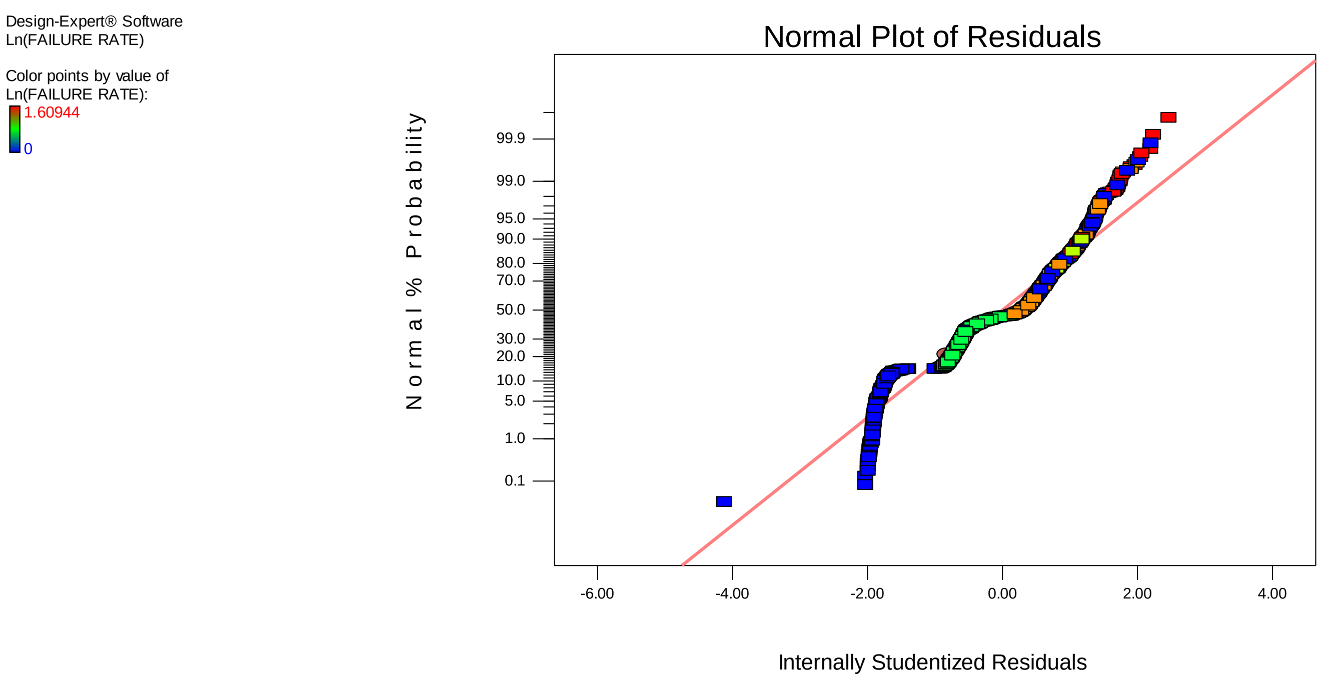


**Figure 5.6 Normal plot of residuals for the natural log transformation**

### 5.2.3 BASE 10 LOG TRANSFORMATIONS

These transformations can often fix problems with non-linearity, unequal variances, and non-normality of errors. This can be expressed mathematically as;

$$X' = \text{Log}_{10}(X) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5.2.3)}$$

Applying the Base 10 Log transformation to this model, factors A, B, D and E are significant. Also interactions; AB, AD, AE, BD, BE, DE, ABD, ABE, ADE, BDE, ABDE are significant. In this case, the factors C had a smaller p-value of 0.2456 same as the model with the natural log transformation. The factor still remained insignificant having a p-value above 0.05 (Table 5.9). The Table 5.8 below interprets the statistical behavior of the failure rate model after the Base 10 Log transformation using the mean, prediction error sum of squares (PRESS), standard deviation, adequate precision, the $R^2$ values and coefficient of variance (CV). The "Pred R-Squared" of 0.79 is in reasonable agreement with the "Adj R-Squared" of 0.80. "Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. The ratio of 53.36 indicates an adequate signal.

**Table 5.8 Statistical summary of the Failure Rate Model**

| | | | |
|---|---|---|---|
| Std. Dev. | 0.11 | R-Squared | 0.81 |
| Mean | 0.29 | Adj R-Squared | 0.80 |
| C.V. % | 37.94 | Pred R-Squared | 0.79 |
| PRESS | 24.85 | Adeq Precision | 53.36 |

**Table 5.9 Analysis of variance (ANOVA) for the Base 10 Log transformation**

| Source | Sum of Squares | df | Mean Square | F- Value | p-value Prob> F |
|---|---|---|---|---|---|
| Block | 2.04 | 2 | 1.02 | | |
| Model | 99.93 | 31 | 3.22 | 254.33 | < 0.0001 |
| A-AGE | 0.15 | 1 | 0.16 | 12.37 | 0.0004 |
| B-MAOP | 0.11 | 1 | 0.12 | 9.35 | 0.0023 |
| C-DAMAGE | 0.01 | 1 | 0.02 | 1.35 | 0.2456 |
| D-TIME INDEPENDENT | 0.06 | 1 | 0.07 | 5.28 | 0.0217 |
| E-TIME DEPENDENT | 0.09 | 1 | 0.09 | 7.55 | 0.0061 |
| AB | 0.16 | 1 | 0.16 | 12.38 | 0.0004 |
| AC | 0.01 | 1 | 0.01 | 0.97 | 0.3239 |
| AD | 0.08 | 1 | 0.08 | 6.48 | 0.011 |
| AE | 0.14 | 1 | 0.14 | 11.31 | 0.0008 |
| BC | 0.02 | 1 | 0.02 | 1.35 | 0.2459 |
| BD | 0.07 | 1 | 0.07 | 5.26 | 0.022 |
| BE | 0.09 | 1 | 0.09 | 7.52 | 0.0061 |
| CD | 0.01 | 1 | 0.01 | 1.04 | 0.3069 |
| CE | 0.01 | 1 | 0.01 | 1.07 | 0.3006 |
| DE | 0.07 | 1 | 0.07 | 5.25 | 0.022 |
| ABC | 0.01 | 1 | 0.01 | 0.97 | 0.3238 |
| ABD | 0.08 | 1 | 0.08 | 6.48 | 0.011 |
| ABE | 0.14 | 1 | 0.14 | 11.31 | 0.0008 |
| ACD | 0.01 | 1 | 0.01 | 0.97 | 0.3242 |
| ACE | 5.00 E-03 | 1 | 5.00 E-03 | 0.39 | 0.53 |
| ADE | 0.11 | 1 | 0.11 | 8.29 | 0.004 |
| BCD | 0.01 | 1 | 0.01 | 1.04 | 0.3072 |
| BCE | 0.01 | 1 | 0.014 | 1.07 | 0.3009 |
| BDE | 0.07 | 1 | 0.07 | 5.24 | 0.0221 |
| CDE | 3.92 E-03 | 1 | 3.92 E-03 | 0.31 | 0.5784 |
| ABCD | 0.01 | 1 | 0.01 | 0.97 | 0.3244 |
| ABCE | 5.01 E-03 | 1 | 5.01 E-03 | 0.39 | 0.5295 |
| ABDE | 0.11 | 1 | 0.11 | 8.29 | 0.004 |
| ACDE | 8.28 E-03 | 1 | 8.28 E-03 | 0.65 | 0.419 |
| BCDE | 3.89 E-03 | 1 | 3.89 E-03 | 0.3 | 0.5797 |
| ABCDE | 8.24 E-03 | 1 | 8.24 E-03 | 0.65 | 0.4201 |
| Residual | 23.91 | 1886 | 0.01 | | |
| Lack of Fit | 22.68 | 1170 | 0.02 | 11.31 | < 0.0001 |
| Pure Error | 1.23 | 716 | 1.71 E-03 | | |
| Cor Total | 125.88 | 1919 | | | |

Analysis of the normal plot (Figure 5.7) determined the normality of the base 10 log transformations. The normal plot of residuals shown in Figure 5.6 shows some similarities to that in the Figure 5.7 which indicates slight inadequacies in the normality of the failure rate model obtained using the base 10 log transformations.

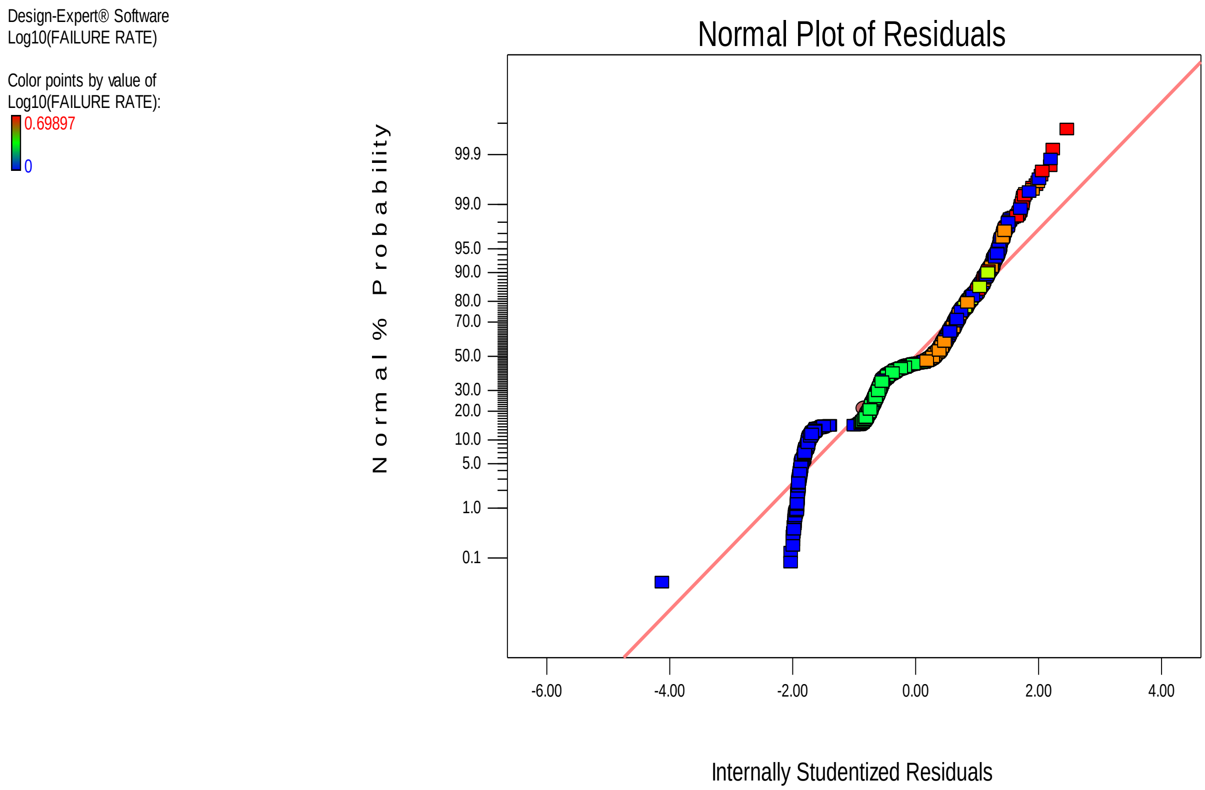


**Figure 5.7 Normal plots of residuals for the Base 10 Log transformation**

### 5.2.4 INVERSE SQUARE ROOT TRANSFORMATION

The analysis of variance for the inverse square root transformation was carried out to verify the statistical behavior of the failure rate model. The inverse square root transformation analysis indicates a high level of model significance. This can be expressed mathematically as;

$$X' = 1/\sqrt{X} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5.2.4)$$

Applying the inverse square root transformation to this model, factors A, B, D and E are significant. Also interactions; AB, AD, AE, BD, BE, DE, ABD, ABE, ADE, BDE, ABDE are significant terms. In this case, the factor C has a p-value of 0.1385 and still remained insignificant with a p-value above 0.05 (Table 5.11). The Table 5.10 interprets the statistical behavior of the failure rate model after the inverse square root transformation using the mean, prediction error sum of squares (PRESS), standard deviation, adequate precision, the $R^2$ values and coefficient of variance (CV). The "Pred R-Squared" of 0.8330 is in reasonable agreement with the "Adj R-Squared" of 0.8362. "Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. The ratio of 56.405 indicates an adequate signal.

**Table 5.10 Statistical summary of the Failure Rate Model**

| | | | |
|---|---|---|---|
| Std. Dev. | 0.09 | R-Squared | 0.83 |
| Mean | 0.74 | Adj R-Squared | 0.83 |
| C.V. % | 11.84 | Pred R-Squared | 0.82 |
| PRESS | 15.09 | Adeq Precision | 56.12 |

**Table 5.11 Analysis of variance (ANOVA) for the inverse square root transformation**

| Source | Sum of Squares | df | Mean Square | F-Value | p-value Prob> F |
|---|---|---|---|---|---|
| Block | 0.96 | 2 | 0.48 | | |
| Model | 71.15 | 31 | 2.29 | 297.66 | < 0.0001 |
| A-AGE | 0.12 | 1 | 0.12 | 15.17 | 0.0001 |
| B-MAOP | 0.09 | 1 | 0.09 | 11.66 | 0.0007 |
| C-DAMAGE | 0.02 | 1 | 0.02 | 2.19 | 0.1385 |
| D-TIME INDEPENDENT | 0.04 | 1 | 0.04 | 5.66 | 0.0175 |
| E-TIME DEPENDENT | 0.07 | 1 | 0.07 | 8.86 | 0.003 |
| AB | 0.12 | 1 | 0.12 | 15.17 | 0.0001 |
| AC | 0.01 | 1 | 0.01 | 1.65 | 0.1985 |
| AD | 0.05 | 1 | 0.05 | 7.08 | 0.0078 |
| AE | 0.1 | 1 | 0.1 | 13.29 | 0.0003 |
| BC | 0.02 | 1 | 0.02 | 2.19 | 0.1388 |
| BD | 0.04 | 1 | 0.04 | 5.63 | 0.0177 |
| BE | 0.07 | 1 | 0.07 | 8.83 | 0.003 |
| CD | 0.01 | 1 | 0.01 | 1.35 | 0.2462 |
| CE | 0.01 | 1 | 0.01 | 1.87 | 0.1714 |
| DE | 0.04 | 1 | 0.04 | 5.21 | 0.0225 |
| ABC | 0.01 | 1 | 0.01 | 1.66 | 0.1984 |
| ABD | 0.05 | 1 | 0.05 | 7.08 | 0.0078 |
| ABE | 0.1 | 1 | 0.1 | 13.29 | 0.0003 |
| ACD | 0.01 | 1 | 0.01 | 1.39 | 0.2385 |
| ACE | 0.01 | 1 | 6.86 E-03 | 0.89 | 0.3457 |
| ADE | 0.07 | 1 | 0.07 | 8.63 | 0.0033 |
| BCD | 0.01 | 1 | 0.01 | 1.34 | 0.2465 |
| BCE | 0.01 | 1 | 0.01 | 1.87 | 0.1715 |
| BDE | 0.04 | 1 | 0.04 | 5.19 | 0.0227 |
| CDE | 4.85 E-03 | 1 | 4.85 E-03 | 0.62 | 0.4277 |
| ABCD | 0.011 | 1 | 0.01 | 1.38 | 0.2387 |
| ABCE | 6.87 E-03 | 1 | 6.87 E-03 | 0.89 | 0.3452 |
| ABDE | 6.65 E-03 | 1 | 6.87 E-03 | 8.63 | 0.0034 |
| ACDE | 8.60 E-03 | 1 | 8.60 E-03 | 1.12 | 0.2909 |
| BCDE | 4.82 E-03 | 1 | 4.82 E-03 | 0.63 | 0.4288 |
| ABCDE | 8.57 E-03 | 1 | 8.57 E-03 | 1.11 | 0.2917 |
| Residual | 14.54 | 1886 | 7.71 E-03 | | |
| Lack of Fit | 13.94 | 1170 | 0.01 | 14.21 | < 0.0001 |
| Pure Error | 0.6 | 716 | 8.38 E-04 | | |
| Cor Total | 86.66 | 1919 | | | |

Analysis of the normal plot (Figure 5.8) determined the normality of the inverse square root transformation. The normal plot of residuals shown in Figure 5.4 shows some similarities to that of the Figure 5.8 which indicates inadequacies in the normality of the failure rate model obtained using the inverse square root transformation.

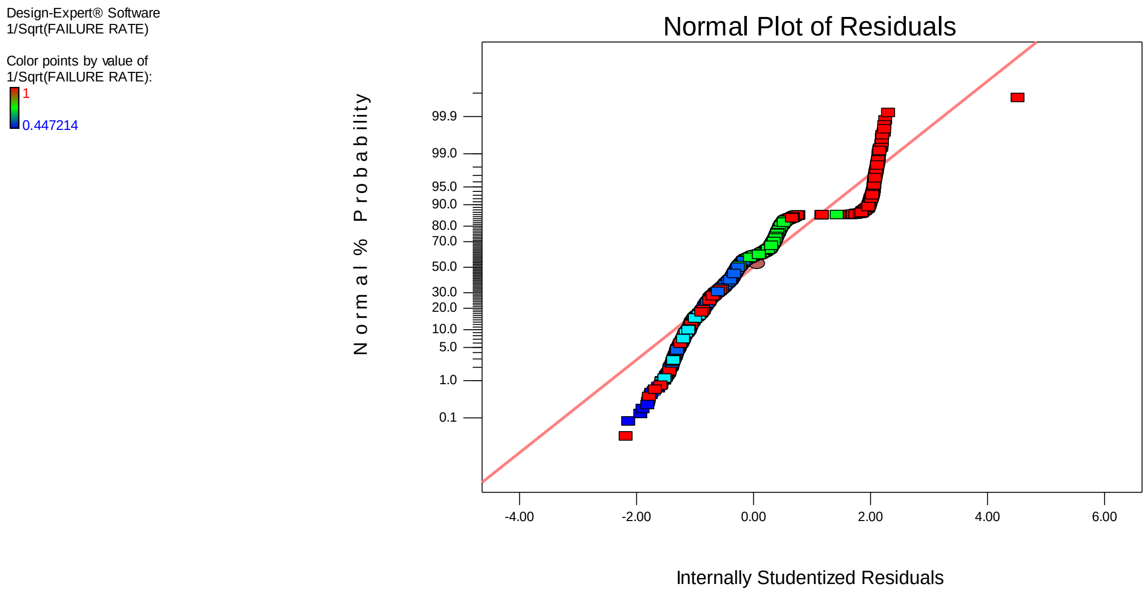


**Figure 5.8 Normal plot of residuals for the inverse square root transformation**

### 5.2.5 INVERSE TRANSFORMATION

The analysis of variance for the inverse transformation was carried out to verify the statistical behavior of the failure rate model. The inverse transformation analysis indicates a high level of failure rate model significance. This can be expressed mathematically as;

$$X' = 1/X \qquad (5)$$

Applying the inverse transformation to this model, factors A, B, D and E are significant. Also interactions; AB, AD, AE, BD, BE, DE, ABD, ABE, ADE, BDE, ABDE are significant terms. In this case, the factors C has a p-value of 0.0831 and still remained insignificant having a p-value above 0.05 (Table 5.13). The Table 5.12 below interprets the statistical behavior of the failure rate model after the inverse transformation using the mean, prediction error sum of squares (PRESS), standard deviation, adequate precision, the $R^2$ values and coefficient of variance (CV). The "Pred R-Squared" of 0.83 is in reasonable agreement with the "Adj R-Squared" of 0.83. "Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable. The ratio of 56.40 indicates an adequate signal.

**Table 5.12 Statistical summary of the Failure Rate Model**

| | | | |
|---|---|---|---|
| Std. Dev. | 0.13 | R-Squared | 0.83 |
| Mean | 0.59 | Adj R-Squared | 0.83 |
| C.V. % | 21.82 | Pred R-Squared | 0.83 |
| PRESS | 32.95 | Adeq Precision | 56.40 |

**Table 5.13 Analysis of variance (ANOVA) for the inverse transformation**

| Source | Sum of Squares | df | Mean Square | F-Value | p-value Prob> F |
|---|---|---|---|---|---|
| Block | 1.47 | 2 | 0.73 | | |
| Model | 165.54 | 31 | 5.33 | 316.7 | < 0.0001 |
| A-AGE | 0.28 | 1 | 0.28 | 16.74 | < 0.0001 |
| B-MAOP | 0.22 | 1 | 0.22 | 13.07 | 0.0003 |
| C-DAMAGE | 0.05 | 1 | 0.05 | 3.01 | 0.0831 |
| D-TIME INDEPENDENT | 0.09 | 1 | 0.09 | 5.49 | 0.0191 |
| E-TIME DEPENDENT | 0.16 | 1 | 0.16 | 9.43 | 0.0022 |
| AB | 0.28 | 1 | 0.28 | 16.74 | < 0.0001 |
| AC | 0.04 | 1 | 0.04 | 2.31 | 0.1279 |
| AD | 0.12 | 1 | 0.12 | 7 | 0.0082 |
| AE | 0.24 | 1 | 0.24 | 14.13 | 0.0002 |
| BC | 0.05 | 1 | 0.05 | 3 | 0.0832 |
| BD | 0.09 | 1 | 0.09 | 5.47 | 0.0194 |
| BE | 0.16 | 1 | 0.13 | 9.4 | 0.0022 |
| CD | 0.03 | 1 | 0.03 | 1.52 | 0.2175 |
| CE | 0.05 | 1 | 0.05 | 2.68 | 0.1013 |
| DE | 0.08 | 1 | 0.08 | 4.69 | 0.0305 |
| ABC | 0.04 | 1 | 0.04 | 2.32 | 0.1278 |
| ABD | 0.12 | 1 | 0.12 | 7 | 0.0082 |
| ABE | 0.24 | 1 | 0.24 | 14.13 | 0.0002 |
| ACD | 0.03 | 1 | 0.03 | 1.73 | 0.1885 |
| ACE | 0.02 | 1 | 0.02 | 1.46 | 0.2263 |
| ADE | 0.13 | 1 | 0.13 | 8.13 | 0.0044 |
| BCD | 0.02 | 1 | 0.02 | 1.52 | 0.2179 |
| BCE | 0.04 | 1 | 0.04 | 2.68 | 0.1015 |
| BDE | 0.07 | 1 | 0.07 | 4.67 | 0.0307 |
| CDE | 0.01 | 1 | 0.01 | 0.95 | 0.3285 |
| ABCD | 0.02 | 1 | 0.02 | 1.72 | 0.1887 |
| ABCE | 0.02 | 1 | 0.02 | 1.46 | 0.2258 |
| ABDE | 0.13 | 1 | 0.13 | 8.12 | 0.0044 |
| ACDE | 0.02 | 1 | 0.02 | 1.56 | 0.2111 |
| BCDE | 0.01 | 1 | 0.01 | 0.95 | 0.3295 |
| ABCDE | 0.02 | 1 | 0.02 | 1.56 | 0.2117 |
| Residual | 31.79 | 1886 | 0.01 | | |
| Lack of Fit | 30.86 | 1170 | 0.02 | 20.29 | < 0.0001 |
| Pure Error | 0.93 | 716 | 1.29E-03 | | |
| Cor Total | 198.8 | 1919 | | | |

Analysis of the normal plot (Figure 5.9) determined the normality of the inverse transformation. The normal plot of residuals shown in Figure 5.4 shows some similarities to that in the Figure 5.9 which indicates inadequacies in the normality of the failure rate model obtained using the inverse transformation.

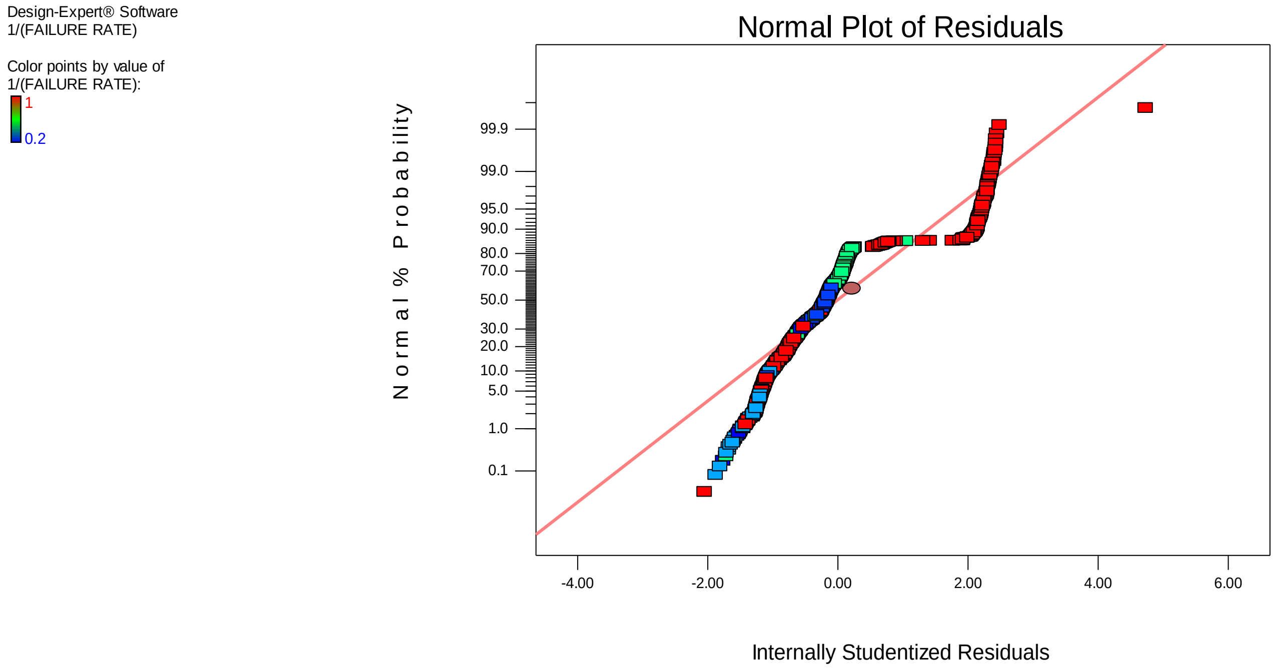


**Figure 5.9 Normal plots of residuals for the inverse transformation**

# CHAPTER 6

# DISCUSSION

## 6.1 THE FAILURE RATE MODEL

The failure rate model represents an overarching process that requires risk assessment and risk management at all stages of the process. Transformation analysis on the model showed a significant improvement in the model interaction and parameters (Table 6.1). The inverse transformation analysis of variance results for the failure rate model in Table 5.12 showed the obtained p-values for the factors A: Age (0.0001), B: MAOP (0.0003), C: Damage (0.0831), D: Time Independent (0.0191) and E: Time Dependent (0.0022). Terms A, B, D and E are considered significant since their obtained p-values are less than 0.05.Comparing this with the other transformation analysis indicates that the inverse transformation analysis gives the most valid model. From this I inferred that Factors A: Age, B: MAOP, D: Time Independent and E: Time Dependent are major contributing factors in the pipeline failure rates. Factor C: Damage is not a significant model term considering that its obtained p-value is greater than 0.05. Significant interactions in the model included: AB, AD, AE, BD, BE, DE, ABD, ABE, ADE, BDE, ABDE. The failure rate equation obtained considering all factors and interactions, despite the consequences of the level of significance is shown in Table 6.2.

**Table 6.1 Summary of statistical characteristics of the model transformation**

| Transformation | Normal Model (X) | Square Root of (X) | Natural Log of (X) | Base 10 Log of (X) | Inverse Square Root of (X) | Inverse of (X) |
|---|---|---|---|---|---|---|
| F- Value | 155.40 | 201.87 | 254.33 | 254.33 | 297.66 | 316.70 |
| $R^2$ Value | 0.72 | 0.77 | 0.81 | 0.81 | 0.83 | 0.83 |
| Normality | Yes | No | No | No | No | Yes |

**Table 6.2 Failure rate equation for all factors and interactions**

| Failure rate model = 1/(X') | |
|---|---|
| 282.65 | |
| 362.81 | * A |
| 282.35 | * B |
| 331.74 | * C |
| -340.05 | * D |
| -248.90 | * E |
| 363.43 | * A * B |
| 313.24 | * A * C |
| -475.12 | * A * D |
| -342.44 | * A * E |
| 332.59 | * B * C |
| -340.10 | * B * D |
| -249.30 | * B * E |
| -349.24 | * C * D |
| -321.89 | * C * E |
| 322.40 | * D * E |
| 314.12 | * A * B * C |
| -475.80 | * A * B * D |
| -342.95 | * A * B * E |
| -426.84 | * A * C * D |
| -254.16 | * A * C * E |
| 520.33 | * A * D * E |
| -349.90 | * B * C * D |
| -322.80 | * B * C * E |
| 322.77 | * B * D * E |
| 283.39 | * C * D * E |
| -427.48 | * A * B * C * D |
| -255.03 | * A * B * C * E |
| 520.91 | * A * B * D * E |
| 413.31 | * A * C * D * E |
| 283.62 | * B * C * D * E |
| 413.61 | * A * B * C * D * E |

**6.2 FACTOR INTERACTION USING PLOTS/GRAPHS**

Further analysis was carried out to determine the margin effect and to obtain the graphical relationships in the level of interaction effects of the model terms. The various factors (both significant and non-significant) were considered. Figures 6.1 - 6.10 describe the various interaction and behaviors. Also the effect of the various factors A, B, C, D, and E with one another and in combinations on the failure rate model is shown.

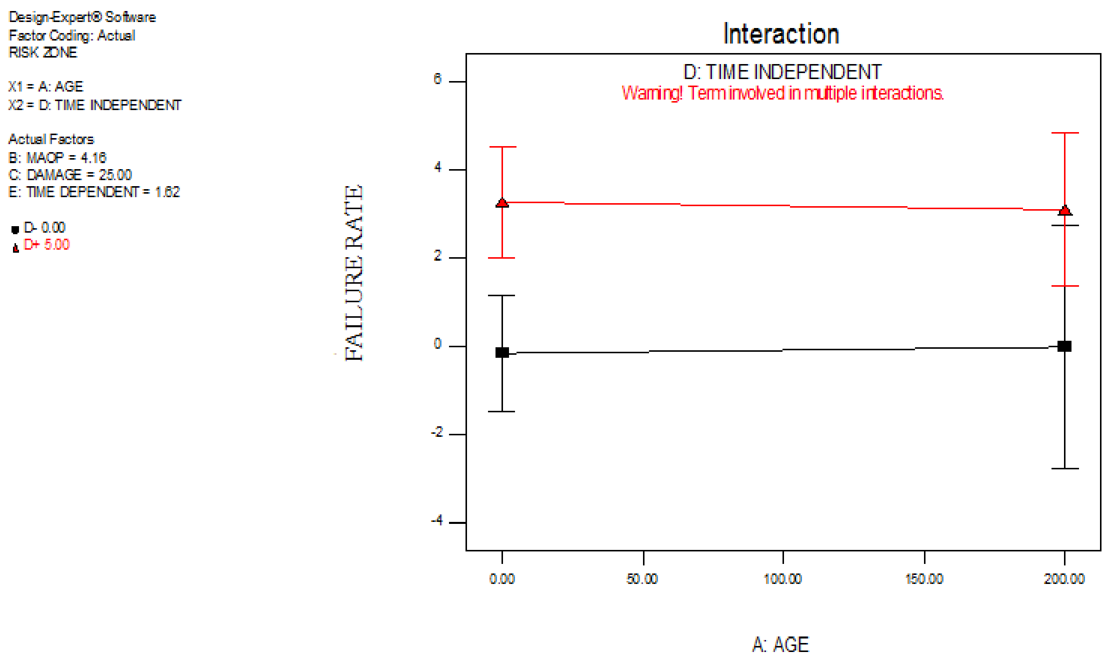


**Figure 6.1 Interactions between A and D**

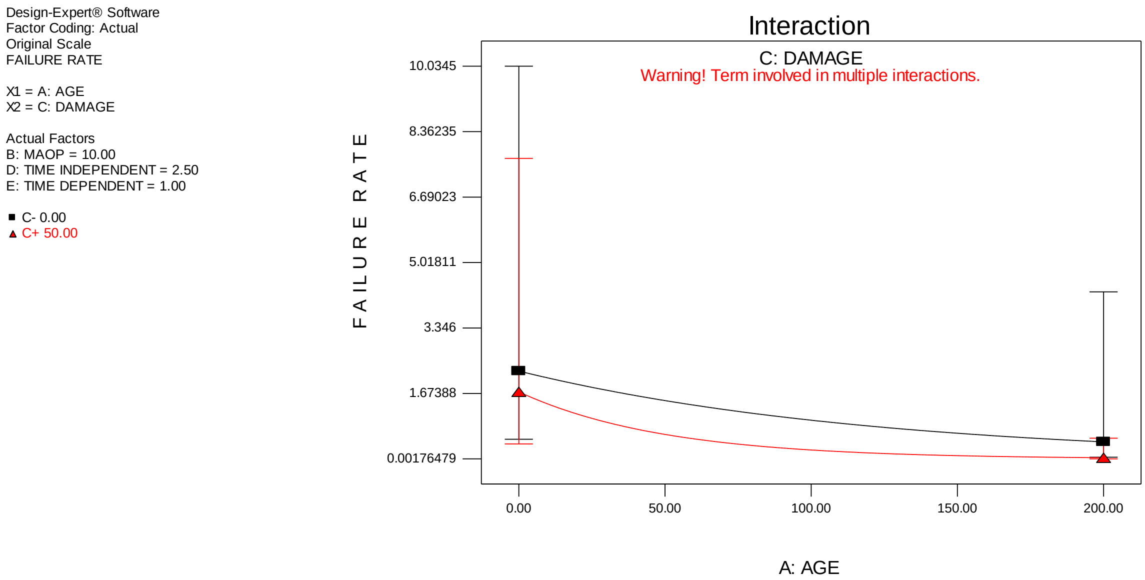


**Figure 6.2 Interactions between A and C**

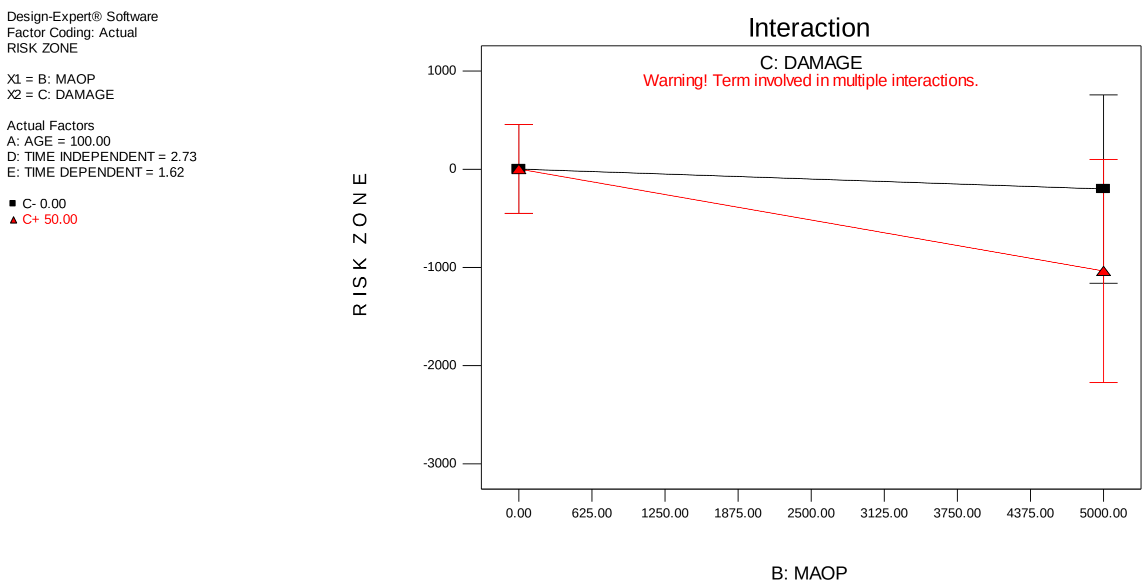


**Figure 6.3 Interactions between B and C**

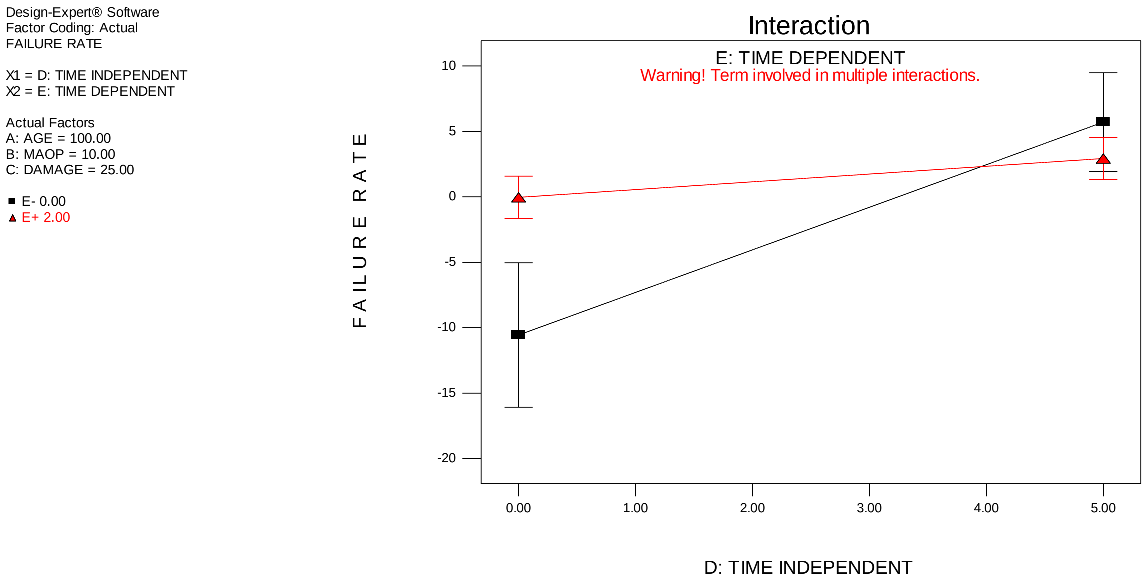


**Figure 6.4 Interactions between D and E**

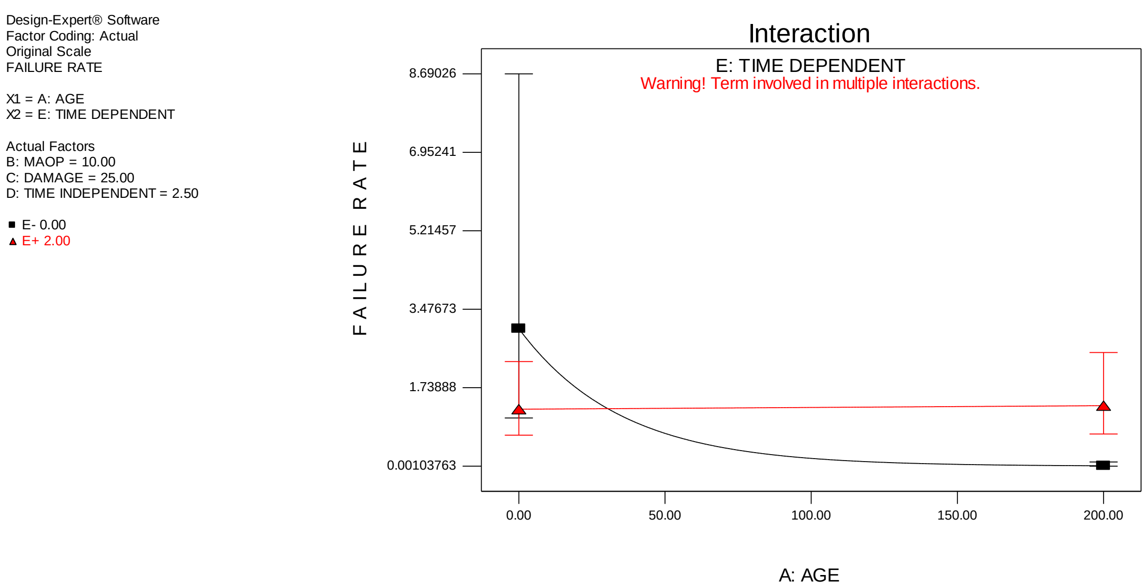


**Figure 6.5 Interactions between A and E**

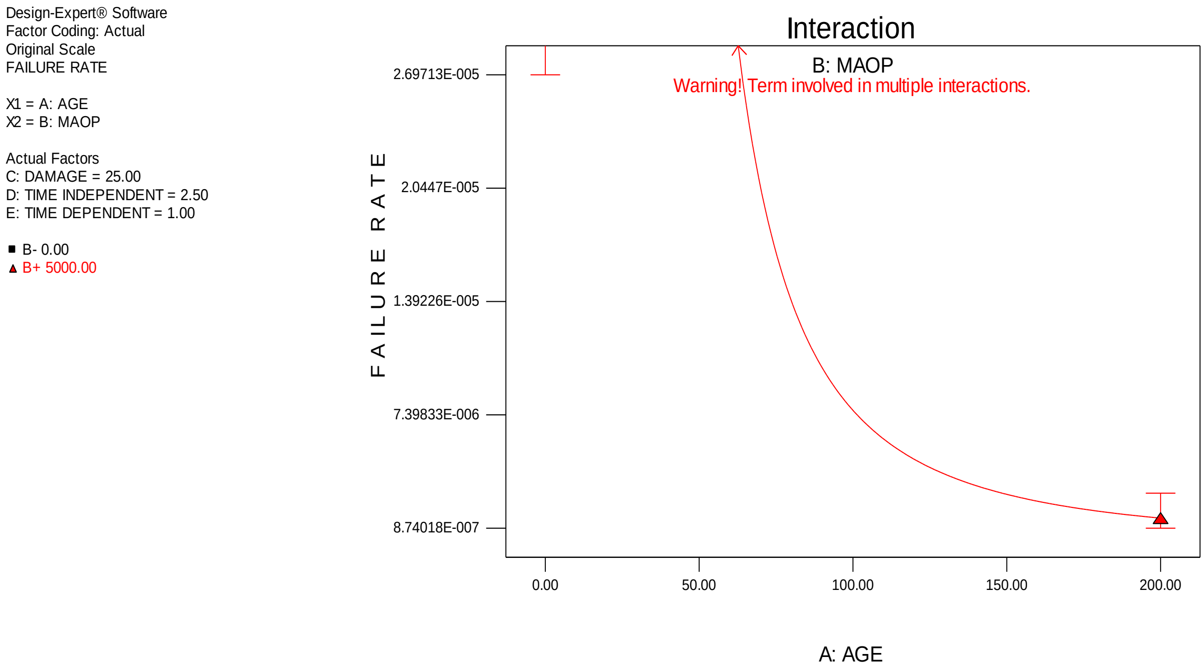


**Figure 6.6 Behavior of MAOP over time (AGE)**

In Figure 6.1 it is evident that from the statistical model that there is no interaction between the time independent factors and age (remain constant with time as the age of the pipeline increases) showing that time has no effect on the time independent (random) factors. Figure 6.4 shows an interaction of the time dependent factors with the time independent factors indicating that sometimes the time independent factors over time bring about the time dependent factors. This means a mathematical relationship can be established as shown in equation 6.1

$$\mathbf{E} = \boldsymbol{f}\,(\mathbf{D})\ldots\ldots\ldots\ldots\ldots(6.1)$$

Figure 6.5 shows an interaction of the time dependent factors with pipeline age at about 45 years old. This shows that the time dependent factors will always occur as the pipeline ages and can only be reduced or mitigated with proper and well coordinated assessment programs. Figure 6.6

shows the behavior of the factor B: MAOP over time as the pipeline reaches the age of 60 and declines up until over 100 years.

## 6.3 MODEL VALIDATION

The failure rate model was developed to create a better understanding of the impact of system age and failure type on pipeline system failure rate. Available data on system malfunction or failure (from inspection reports, local knowledge, and replacement permits), along with pipeline integrity and pipeline inspection data were be used to validate the model. As pipes age, they become susceptible to corrosion. Currently, more than 60 percent of the country's pipelines are 40 years old and older. Most of the pipelines are composed of steel and cast iron, which is especially prone to corrosion as it ages. Some recent high profile accidents used for the model validation areas shown in Table 6.3.

**Table 6.3 Some of the recent high profile accidents**

| LOCATION | DATE | YEAR OF INSTALLATION |
|---|---|---|
| Hanoverton, Ohio | 2011 | 1950s |
| Philadelphia, Pennsylvania | 2011 | 1940 |
| Allentown, Pennsylvania | 2011 | 1928 |
| San Bruno, California | 2010 | 1956 |
| Oak lawn, Wichita | 2004 | 1952 |
| Carlsbad, New Mexico | 2000 | 1950 |

### 6.3.1 DATA COLLECTION METHODOLOGY

The data was collected from various sources to validate the failure rate model. Accident reports from the National Transportation Safety Board (NTSB) and United States Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) were used to obtain data sets on the various recent high profile pipeline incidents. Categories of the data obtained include: failure type, most likely failure cause, age of the pipeline at time of incident. Figure 6.7 illustrates the relationship and trend of the various causes of major incidents and the pipeline ages in the United States. From the result we can observe that the smoothened curve for the corrosion incidents with respect to system age is similar to the 3$^{rd}$ stage of the system failure rate cure (Figure 1.5). It can also be seen that at about age 16 years, the curve for time independent factors (excavation damage) is similar to the 2$^{nd}$ stage of the system failure rate cure (Figure 1.5).

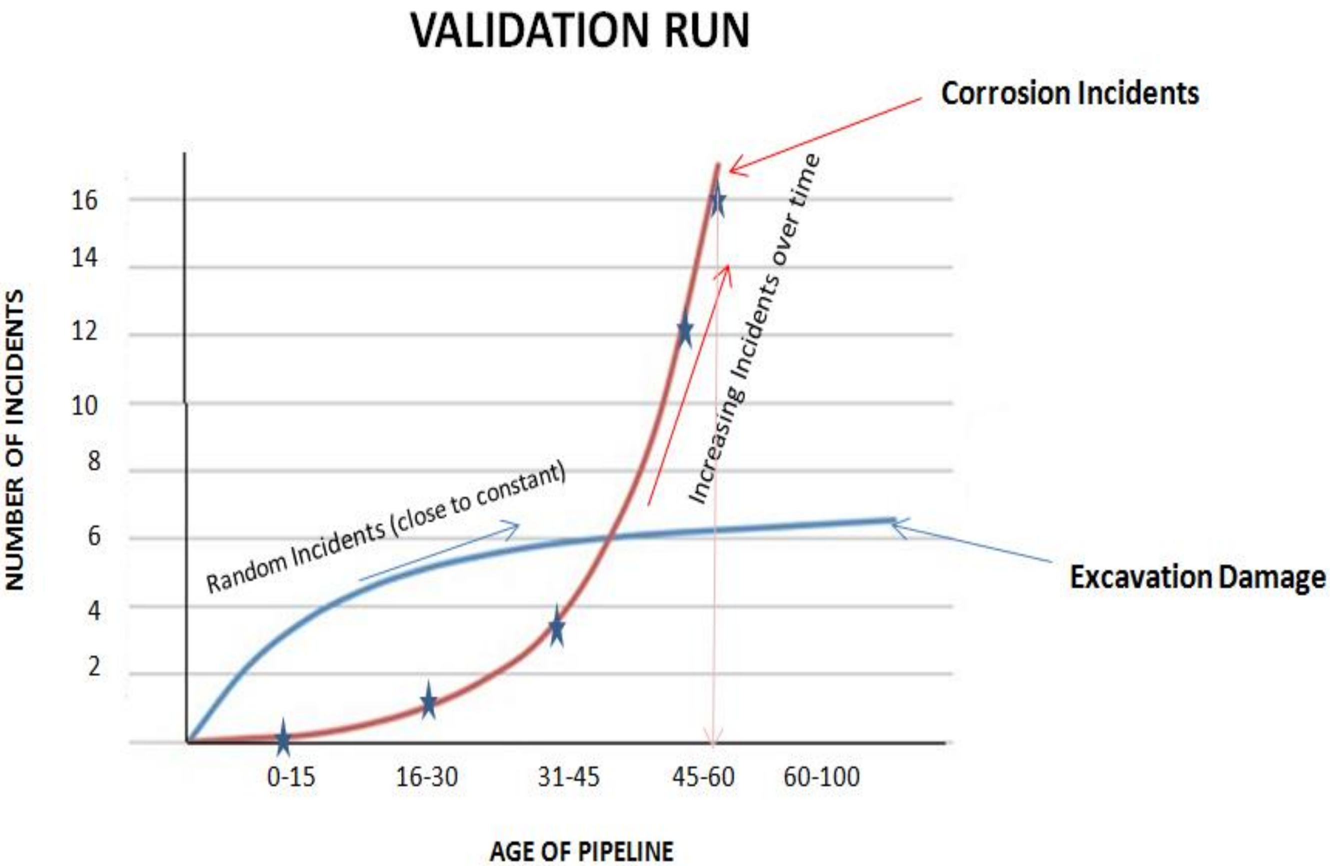


**Figure 6.7 Plot of Major incidents Causes vs. Age of pipeline in the United States.**

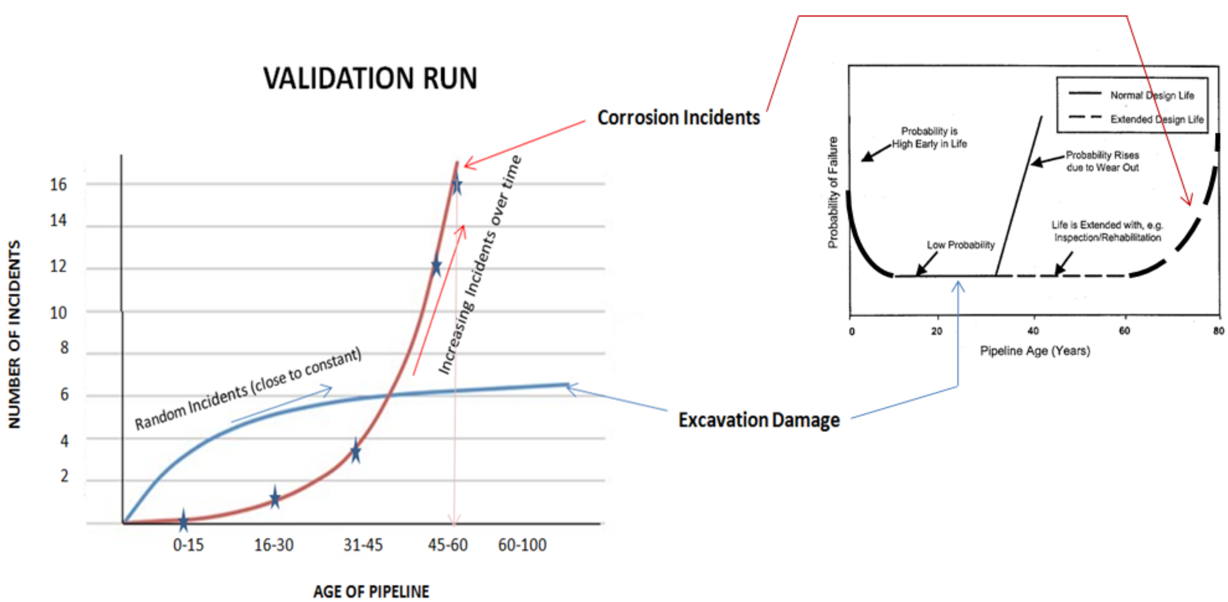


**Figure 6.8 Comparison of Validation run with Hypothetical failure rate curve**

# CHAPTER 7

# CONCLUSIONS

A number of key issues have been established as a result of this research and it is strongly believed that the risk from the various factors affecting pipeline failure rate can be managed successfully at least in part, by implementing the proper risk assessment programs. The approach has been to establish the need for a practical risk assessment program by industries, rather than a strict theoretical determination of the need for such programs. The analysis methodology was focused to take account of the key risk factors since pipeline age was generally a major issue. Considering the failure rate model representations and the transformation analysis on the model, the analysis of variance results for the failure rate model in Table 5.1 showed the obtained p-values for the factors A: Age (0.0001), B: MAOP (0.0003), C: Damage (0.0831), D: Time Independent (0.0191) and E: Time Dependent (0.0022). From this result, terms A, B, D and E were seen to be significant since their obtained p-values are less than 0.05, hence concluding that factors A: Age, B: MAOP, D: Time Independent and E: Time Dependent are major contributing factors in the pipeline failure rates. Factor C: Damage is not a significant model term considering that its p-value is greater than 0.05.

Significant interactions in the model include are AB, AD, AE, BD, BE, DE, ABD, ABE, ADE, BDE, ABDE. Some of this can be observed from the statistical Figures 6.1- 6.6. Figure 6.1 shows that there is no interaction between the time independent factors and age showing that time has no effect on the time independent (random) factors. Figure 6.4 shows an interaction of the time dependent factors with the time independent factors indicating that sometimes the time independent factors over time result in the time dependent factors concluding that $E = f(D)$. Figure 6.5 shows an interaction of the time dependent factors with the pipeline age at about 45 years of age. This indicates that the time dependent factors will surface as the pipeline ages and can be reduced or mitigated with proper and well-coordinated assessment programs. Figure 6.6 shows the behavior of the factor B: MAOP over time as the pipeline reaches the age of 60 and declines up until 100 years. With $R^2$ value – 0.83, prediction error sum of squares (PRESS) – 32.95 and coefficient of variance (CV) – 21.92.

Finally, this model can be an extremely powerful tool that will help operators to evaluate the risk of failure of each pipeline segment in a natural gas transmission system, determine the highest threat of failure on each segment. This model will also enable operators respond to the strict regulations so as meet their technical and safety responsibilities.

## 7.1 RECOMMENDATIONS

This model is recommended for the identification of high risk areas and factors in order to prioritize re-inspection programs. The model will also be useful to planners in developing environmentally sustainable growth of the pipeline infrastructure in the United States. The purpose of this failure rate model is to assist an operator in determining the relative level of risk involved in operating the various segments of its transmission pipeline system and to help the operator to make sound pipeline integrity decisions regarding operation, maintenance and risk mitigation. This model can be a powerful tool that will help operators to evaluate the risk of failure of each pipeline segment in a natural gas transmission system, determine the highest threat of failure on each segment, develop the most appropriate mitigative strategy for each segment by conducting cost/benefit analyses, and identify the order that baseline assessment should follow as well as when reassessment should occur. It will enable operators to respond to the impending regulation in an organized and cost-effective manner.

The goal of this work is to evaluate the current and historical pipeline integrity data and failure consequences in order to quantify threats to integrity, prioritize and plan subsequent integrity assessments together with other mitigation actions; be they corrective, preventative or reactive. Also reduce the risk of gas leaks using pipeline for transportation. Finally, driven by public laws on safety in all operating areas and the need for proper practice of engineering processes, there is the great need for risk assessment of pipelines to be appropriately and frequently carried out. This can be accomplished through use of qualitative assessments, which involves a high level of engineering decision, and by the use of quantitative assessments, based more on analysis, understanding and interpretation of the structural reasons for failure. Hence considering that the delivery of a qualitative pipeline risk assessment can best be accomplished by combining risk calculation facilities into risk model and matrixes, this thesis aims to provide a research base for the application of statistical techniques using plots to investigate the natural gas pipeline failure rates.

## 7.2LIMITATIONS OF STUDY

Complete information is needed for comprehensive risk assessment and management of natural gas pipelines system. Much of the engineering knowledge for each credible failure mode is ignored in order to promote a ‘simple’ approach. The functional dependencies between the relevant parameters at failure are replaced with relative weightings. While a statistical approach can be applicable in cases where significant failure data is available to develop the weightings based on trends, few pipeline systems have experienced a sufficient number of failures to warrant a purely statistical approach. The relative weightings tend therefore not to be well validated against operational experience and can be very subjective. However, obtaining information for analysis using qualitative risk assessment is not readily possible due to availability of information from the operators and regulating agencies to the public. Thus, in this research, using probabilistic (quantitative risk analysis QRA) assessment, a model is developed, which is an appropriate technique for the comprehensive risk assessment and management of pipeline systems.

## 7.3SUGGESTIONS FOR FUTURE WORK

Due to the unavailability of actual pipeline data and limitations on available data, this study made several assumptions to conduct the quantitative risk analysis. To further improve the analysis a more detailed study of the natural gas pipeline would be valuable. The exact material of construction and the various areas of location will improve the analysis. Another improvement is performing detailed fire and explosion studies for gas leaks and explosions to give a more full-bodied assessment of the risk involved with natural gas transportation. Work can also be done to find ways to mitigate the risk.

A number of open problems must be solved to allow the development of a truly general purpose model. These problems suggest a variety of research directions that need to be pursued to make such a model feasible. One such direction would be to investigate the possibility of using software packages such as MATLAB or SAS to develop a comprehensive probabilistic model that can establish and predict (forecast) failure rates. This model using the current trend of incidents should have the ability to schedule maintenance periods for operators based on the location and various factors affecting a particular system at a particular time.

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Appendix A

DATA SORTING FORM

| COMPANY NAME | STATE | YEAR INSTALLED | YEAR DAMAGED | AGE OF PIPELINE | MAOP | GENERAL CAUSE GROUPED | PROPERTY DAMAGE IN 2008 DOLLARS |
|---|---|---|---|---|---|---|---|
| TXU FUEL CO | TX | 1962 | 2002 | 40 | 880 | CORROSION | $173,081 |
| NORTHERN NATURAL GAS CO (ENRON) | | 1982 | 2002 | 20 | 1440 | CORROSION | $1,520,307 |
| NORTH CAROLINA NATURAL GAS CORP | NC | 1959 | 2002 | 43 | 642 | THIRD PARTY DAMAGE | $165,190 |
| COLORADO INTERSTATE GAS CO | WY | 1978 | 2002 | 24 | 850 | PIPELINE DESIGN | $111,099 |
| ENOGEX INC (EX. MUSTANG FUEL CORP) | OK | 1970 | 2002 | 32 | 780 | THIRD PARTY DAMAGE | $143,211 |
| VOYAGEUR PIPELINE LLP | TX | 1956 | 2002 | 46 | 815 | CORROSION | $52,626 |
| NORTHERN NATURAL GAS CO (ENRON) | NE | 1940 | 2002 | 62 | 700 | THIRD PARTY DAMAGE | $85,371 |
| EL PASO FIELD SERVICES | | 1983 | 2002 | 19 | 1440 | OTHERS | $200,379 |
| WILLIAMS GAS PIPELINE - TRANSCO | MD | 1955 | 2002 | 47 | 780 | PIPELINE DESIGN | $409,313 |
| TENNESSEE GAS PIPELINE CO | KY | 1950 | 2002 | 52 | 750 | PIPELINE DESIGN | $2,351,798 |
| WILLIAMS FIELD SERVICES | LA | 1959 | 2002 | 43 | 1440 | CORROSION | $222,199 |
| GREAT LAKES GAS TRANSMISSION CO | MI | 1968 | 2002 | 34 | 974 | CORROSION | $3,630,762 |
| MISSISSIPPI RIVER TRANSMISSION CORP | AR | 1929 | 2002 | 73 | 450 | OTHERS | $185,945 |
| TENNESSEE GAS PIPELINE CO | OH | 1966 | 2002 | 36 | 790 | CORROSION | $81,863 |
| COLORADO INTERSTATE GAS CO | WY | 1982 | 2002 | 20 | 1000 | PIPELINE DESIGN | $169,573 |
| ANR PIPELINE CO | IN | 1955 | 2002 | 47 | 1037 | OTHERS | $999,706 |
| TENNESSEE GAS PIPELINE CO | LA | 1978 | 2002 | 24 | 1440 | CORROSION | $105,252 |
| UNION OIL CO OF CALIFORNIA | AK | 1965 | 2002 | 37 | 975 | THIRD PARTY DAMAGE | $35,084 |
| FLORIDA GAS TRANSMISSION CO (ENRON) | FL | 1999 | 2002 | 3 | 1235 | PIPELINE DESIGN | $236,232 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SOUTHERN NATURAL GAS CO | MS | 1939 | 2002 | 63 | 500 | CORROSION | $43,681 |
| MONTANA POWER CO | MT | 1978 | 2002 | 24 | 960 | OTHERS | $58,473 |
| TENNESSEE GAS PIPELINE CO | OH | 1956 | 2002 | 46 | 790 | PIPELINE DESIGN | $81,863 |
| DOMINION TRANSMISSION INC | WV | 2000 | 2002 | 2 | 500 | OTHERS | $58,473 |
| CENTRAL HUDSON GAS & ELECTRIC CORP | NY | 1969 | 2002 | 33 | 750 | THIRD PARTY DAMAGE | $189,454 |
| ANR PIPELINE CO | LA | 2002 | 2002 | 1 | 850 | INCORRECT OPERATION | $2,338,934 |
| PACIFIC GAS & ELECTRIC CO | CA | 1953 | 2002 | 49 | 650 | THIRD PARTY DAMAGE | $70,168 |
| TENNESSEE GAS PIPELINE CO | MA | 1990 | 2002 | 12 | 902 | CORROSION | $67,244 |
| SEA ROBIN PIPELINE CO | | 1976 | 2002 | 26 | 1440 | CORROSION | $280,672 |
| SOUTHERN STAR CENTRAL GAS PIPELINE | KS | 1948 | 2002 | 54 | 900 | THIRD PARTY DAMAGE | $74,711 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1968 | 2002 | 34 | 1008 | CORROSION | $192,962 |
| WILLIAMS GAS PIPELINE - TRANSCO | AL | 2001 | 2002 | 1 | 2180 | PIPELINE DESIGN | $585,318 |
| COLORADO INTERSTATE GAS CO | CO | 1963 | 2002 | 39 | 614 | THIRD PARTY DAMAGE | $60,812 |
| NORTHWEST PIPELINE CORP (WGP) | UT | 1955 | 2002 | 47 | 809 | CORROSION | $0 |
| GREKA ENERGY | CA | 1966 | 2002 | 36 | 200 | THIRD PARTY DAMAGE | $0 |
| K N INTERSTATE GAS TRANSMISSION CO | NE | 1954 | 2002 | 48 | 810 | CORROSION | $99,034 |
| TENNESSEE GAS PIPELINE CO | LA | 1997 | 2002 | 5 | 1200 | THIRD PARTY DAMAGE | $99,405 |
| TENNESSEE GAS PIPELINE CO | LA | 1973 | 2002 | 29 | 1440 | CORROSION | $278,333 |
| ANR PIPELINE CO | LA | 1967 | 2002 | 35 | 1300 | CORROSION | $99,405 |
| WILLIAMS GAS PIPELINE - TRANSCO | AL | 1951 | 2002 | 51 | 800 | THIRD PARTY DAMAGE | $59,058 |
| TENNESSEE GAS PIPELINE CO | LA | 1958 | 2002 | 44 | 1310 | CORROSION | $178,928 |
| EL PASO NATURAL GAS CO | AZ | 1936 | 2002 | 66 | 475 | THIRD PARTY DAMAGE | $18,711 |
| COLUMBIA GAS TRANSMISSION CORP | WV | 1969 | 2002 | 33 | 936 | OTHERS | $2,535,451 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SOUTHERN NATURAL GAS CO | LA | 1980 | 2002 | 22 | 1728 | PIPELINE DESIGN | $111,099 |
| MARATHON ASHLAND PIPE LINE LLC | LA | 1997 | 2002 | 5 | 1300 | CORROSION | $140,441 |
| TRUNKLINE GAS CO | | 1972 | 2002 | 30 | 1202 | CORROSION | $160,334 |
| TEXAS EASTERN TRANSMISSION CORP (DUKE) | | 1988 | 2002 | 14 | 1000 | CORROSION | $278,298 |
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | IL | 1951 | 2002 | 51 | 596 | CORROSION | $140,336 |
| TXU LONE STAR PIPELINE | TX | 1972 | 2002 | 30 | 960 | PIPELINE DESIGN | $114,608 |
| GULF SOUTH PIPELINE COMPANY, LP | LA | 1928 | 2002 | 74 | 470 | CORROSION | $115,942 |
| LOUISIANA INTRASTATE GAS CO, L.L.C. | | 1978 | 2002 | 24 | 1250 | CORROSION | $233,893 |
| ANR PIPELINE CO | IN | 1956 | 2002 | 46 | 858 | PIPELINE DESIGN | $153,200 |
| FLORIDA GAS TRANSMISSION CO (ENRON) | AL | 2002 | 2002 | 1 | 975 | PIPELINE DESIGN | $187,366 |
| SOUTHERN NATURAL GAS CO | AL | 1948 | 2002 | 54 | 500 | PIPELINE DESIGN | $32,160 |
| CENTERPOINT ENERGY GAS TRANSMISSION | LA | 1927 | 2002 | 75 | 500 | CORROSION | $66,660 |
| NORTHERN NATURAL GAS CO | KS | 1979 | 2002 | 23 | 1600 | CORROSION | $360,196 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1972 | 2002 | 30 | 1250 | OTHERS | $1,754,201 |
| TENNESSEE GAS PIPELINE CO | LA | 1968 | 2002 | 34 | 1235 | OTHERS | $4,502,448 |
| NORTHERN NATURAL GAS CO | IA | 1954 | 2002 | 48 | 800 | THIRD PARTY DAMAGE | $156,592 |
| BRIDGELINE GAS DISTRIBUTION LLC | LA | 1962 | 2002 | 40 | 1000 | PIPELINE DESIGN | $132,680 |
| VENOCO, INC | CA | 1968 | 2002 | 34 | 740 | THIRD PARTY DAMAGE | $28,067 |
| GREAT PLAINS NATURAL GAS CO | MN | 1971 | 2002 | 31 | 730 | THIRD PARTY DAMAGE | $81,863 |
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | AR | 1962 | 2002 | 40 | 858 | CORROSION | $134,489 |
| PRAXAIR, INC | TX | 1962 | 2002 | 40 | 2160 | PIPELINE DESIGN | $49,118 |
| TEJAS GAS PIPELINE LP | TX | 1964 | 2002 | 38 | 844 | CORROSION | $661,603 |
| GULF SOUTH PIPELINE CO | MS | 1930 | 2002 | 72 | 430 | OTHERS | $152,615 |
| SOUTHERN NATURAL GAS CO | LA | 1985 | 2002 | 17 | 1729 | THIRD PARTY | $710,248 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | DAMAGE | |
| GULF SOUTH PIPELINE CO | MS | 1952 | 2002 | 50 | 936 | PIPELINE DESIGN | $133,319 |
| STINGRAY PIPELINE CO | | 1977 | 2002 | 25 | 1200 | PIPELINE DESIGN | $47,805 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1929 | 2002 | 73 | 415 | PIPELINE DESIGN | $58,475 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1947 | 2003 | 56 | 196 | CORROSION | $357,863 |
| TENNESSEE GAS PIPELINE CO | LA | 1969 | 2003 | 34 | 1000 | CORROSION | $127,726 |
| GULF SOUTH PIPELINE CO | LA | 1985 | 2003 | 18 | 936 | CORROSION | $92,055 |
| COPANO GATHERING SYSTEM, INC | TX | 1946 | 2003 | 57 | 1000 | THIRD PARTY DAMAGE | $51,781 |
| HOUSTON PIPELINE CO | TX | 1961 | 2003 | 42 | 1080 | THIRD PARTY DAMAGE | $200,104 |
| ACADIAN GAS PIPELINE SYSTEM | LA | 1945 | 2003 | 58 | 1000 | THIRD PARTY DAMAGE | $475,233 |
| SOUTHERN NATURAL GAS CO | MS | 1946 | 2003 | 57 | 500 | PIPELINE DESIGN | $64,438 |
| WILLIAMS GAS PIPELINE - TRANSCO | GA | 2000 | 2003 | 3 | 800 | CORROSION | $1,517,638 |
| ANR PIPELINE CO | IL | 1949 | 2003 | 54 | 975 | PIPELINE DESIGN | $1,106,959 |
| TXU LONE STAR PIPELINE | TX | 1946 | 2003 | 57 | 500 | THIRD PARTY DAMAGE | $43,003 |
| NORTHERN NATURAL GAS CO | MN | 1961 | 2003 | 42 | 832 | CORROSION | $1,629,625 |
| ANR PIPELINE CO | LA | 1978 | 2003 | 25 | 1300 | CORROSION | $239,918 |
| CENTERPOINT ENERGY GAS TRANSMISSION | OK | 1961 | 2003 | 42 | 800 | CORROSION | $85,151 |
| TEXAS EASTERN TRANSMISSION CORP (DUKE) | MO | 1943 | 2003 | 60 | 800 | CORROSION | $3,754,685 |
| EL PASO NATURAL GAS CO | NM | 1986 | 2003 | 17 | 944 | PIPELINE DESIGN | $148,899 |
| EL PASO NATURAL GAS CO | NM | 1950 | 2003 | 53 | 809 | PIPELINE DESIGN | $141,799 |
| WILLIAMS FIELD SERVICES | LA | 1964 | 2003 | 39 | 1169 | CORROSION | $344,055 |
| FLORIDA GAS TRANSMISSION CO (ENRON) | TX | 1958 | 2003 | 45 | 975 | PIPELINE DESIGN | $115,034 |
| DOMINION TRANSMISSION INC | WV | 1946 | 2003 | 57 | 680 | CORROSION | $72,263 |

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|---|---|---|---|---|---|---|---|
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | OK | 1990 | 2003 | 13 | 1050 | INCORRECT OPERATION | $81,869 |
| ATLANTA GAS LIGHT CO | GA | 1969 | 2003 | 34 | 720 | THIRD PARTY DAMAGE | $63,927 |
| COLORADO INTERSTATE GAS CO | CO | 1978 | 2003 | 25 | 850 | PIPELINE DESIGN | $978,082 |
| ANR PIPELINE CO | IN | 1999 | 2003 | 4 | 858 | PIPELINE DESIGN | $200,219 |
| EQUITRANS INC | WV | 1957 | 2003 | 46 | 1000 | OTHERS | $172,603 |
| NORTHERN NATURAL GAS CO | KS | 1963 | 2003 | 40 | 1000 | CORROSION | $1,791,616 |
| PACIFIC GAS & ELECTRIC CO | CA | 1962 | 2003 | 41 | 650 | THIRD PARTY DAMAGE | $88,603 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1970 | 2003 | 33 | 60 | CORROSION | $2,876,712 |
| TENNESSEE GAS PIPELINE CO | LA | 1973 | 2003 | 30 | 1440 | CORROSION | $215,536 |
| TEJAS GAS PIPELINE LP | TX | 1964 | 2003 | 39 | 844 | THIRD PARTY DAMAGE | $161,683 |
| GULF SOUTH PIPELINE COMPANY, LP | MS | 1930 | 2003 | 73 | 430 | OTHERS | $261,730 |
| OSPREY PETROLEUM CO INC | TX | 1963 | 2003 | 40 | 892 | CORROSION | $74,795 |
| EL PASO FIELD SERVICES | TX | 1971 | 2003 | 32 | 1025 | CORROSION | $126,575 |
| NORTHWEST PIPELINE CORP (WGP) | WA | 1956 | 2003 | 47 | 674 | CORROSION | $116,795 |
| DUKE ENERGY FIELD SERVICES INC | TX | 1959 | 2003 | 44 | 1050 | CORROSION | $146,137 |
| ANR PIPELINE CO | IN | 2003 | 2003 | 1 | 850 | OTHERS | $73,701 |
| GULF SOUTH PIPELINE COMPANY, LP | LA | 1953 | 2003 | 50 | 938 | THIRD PARTY DAMAGE | $308,876 |
| GULF SOUTH PIPELINE COMPANY, LP | LA | 1952 | 2003 | 51 | 925 | CORROSION | $90,352 |
| BEAR CREEK STORAGE CO | LA | 1981 | 2003 | 22 | 3100 | PIPELINE DESIGN | $354,871 |
| CENTERPOINT ENERGY PIPELINE SERVICES | AR | 1964 | 2003 | 39 | 1000 | | $372,527 |
| HOUSTON PIPELINE CO | TX | 1975 | 2003 | 28 | 811 | CORROSION | $6,601,595 |
| DEVON GAS SERVICES LP | TX | 2002 | 2003 | 1 | 850 | CORROSION | $1,586,173 |
| NORTHERN NATURAL GAS CO | TX | 1967 | 2003 | 36 | 1000 | CORROSION | $8,344,767 |
| EL PASO NATURAL GAS CO | AZ | 1980 | 2003 | 23 | 845 | THIRD PARTY DAMAGE | $62,367 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TENNESSEE GAS PIPELINE CO | | 1972 | 2003 | 31 | 1440 | OTHERS | $581,096 |
| ATLANTA GAS LIGHT CO | GA | 1958 | 2003 | 45 | 300 | THIRD PARTY DAMAGE | $792,904 |
| TEXAS EASTERN TRANSMISSION CORP (DUKE) | NJ | 1960 | 2003 | 43 | 795 | THIRD PARTY DAMAGE | $63,173 |
| COLORADO INTERSTATE GAS CO | CO | 1964 | 2003 | 39 | 943 | PIPELINE DESIGN | $253,151 |
| SOUTHERN STAR CENTRAL GAS PIPELINE, INC | KS | 1981 | 2003 | 22 | 960 | INCORRECT OPERATION | $163,296 |
| TXU LONE STAR PIPELINE | TX | 1977 | 2003 | 26 | 3000 | INCORRECT OPERATION | $230,137 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1978 | 2003 | 25 | 1440 | CORROSION | $316,438 |
| ANR PIPELINE CO | | 1980 | 2003 | 23 | 2000 | CORROSION | $74,795 |
| TEXAS EASTERN TRANSMISSION CORP (DUKE) | LA | 1983 | 2003 | 20 | 1440 | THIRD PARTY DAMAGE | $426,904 |
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | OK | 1957 | 2003 | 46 | 720 | CORROSION | $435,888 |
| MISSISSIPPI RIVER TRANSMISSION CORP | IL | 1951 | 2003 | 52 | 200 | THIRD PARTY DAMAGE | $115,540 |
| PACIFIC GAS & ELECTRIC CO | CA | 1931 | 2003 | 72 | 400 | THIRD PARTY DAMAGE | $563,836 |
| LOUISIANA INTRASTATE GAS CO, L.L.C. | LA | 1966 | 2003 | 37 | 1032 | THIRD PARTY DAMAGE | $34,521 |
| NORTH CAROLINA NATURAL GAS CORP | NC | 1999 | 2003 | 4 | 1133 | THIRD PARTY DAMAGE | $428,729 |
| COLUMBIA GAS TRANSMISSION CORP | PA | 1967 | 2003 | 36 | 936 | INCORRECT OPERATION | $0 |
| SABINE GAS TRANSMISSION CO | LA | 1991 | 2003 | 12 | 997 | OTHERS | $3,912,329 |
| GREAT LAKES GAS TRANSMISSION CO | MI | 1981 | 2003 | 22 | 974 | CORROSION | $295,726 |
| WESTAR TRANSMISSION CO | TX | 1955 | 2003 | 48 | 2200 | CORROSION | $0 |
| DOMINION TRANSMISSION INC | PA | 1943 | 2003 | 60 | 800 | CORROSION | $632,877 |
| TEXAS EASTERN TRANSMISSION CORP (DUKE) | IN | 1959 | 2003 | 44 | 763 | THIRD PARTY DAMAGE | $60,467 |
| FLORIDA GAS TRANSMISSION COMPANY | FL | 1956 | 2003 | 47 | 850 | PIPELINE DESIGN | $121,282 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NORTHWEST PIPELINE CORP (WGP) | ID | 1981 | 2003 | 22 | 850 | INCORRECT OPERATION | $99,482 |
| CENTERPOINT ENERGY GAS TRANSMISSION | OK | 1957 | 2003 | 46 | 1000 | PIPELINE DESIGN | $3,798,986 |
| TEXAS EASTERN TRANSMISSION CORP (DUKE) | KY | 1955 | 2003 | 48 | 850 | PIPELINE DESIGN | $98,959 |
| NORTHWEST PIPELINE CORP (WGP) | WY | 1953 | 2003 | 50 | 714 | CORROSION | $805 |
| LAVACA PIPELINE CO | TX | 1945 | 2003 | 58 | 420 | THIRD PARTY DAMAGE | $84,381 |
| TGS RIO, L.L.C. | TX | 1955 | 2003 | 48 | 1000 | CORROSION | $730,685 |
| TRUNKLINE GAS CO | TX | 1982 | 2003 | 21 | 1200 | CORROSION | $0 |
| SOUTHERN NATURAL GAS CO | AL | 1978 | 2003 | 25 | 1440 | THIRD PARTY DAMAGE | $1,438,356 |
| GULF SOUTH PIPELINE COMPANY, LP | LA | 1930 | 2003 | 73 | 930 | CORROSION | $805 |
| ENBRIDGE PIPELINES (KPC) | KS | 1986 | 2003 | 17 | 856 | THIRD PARTY DAMAGE | $30,796 |
| EL PASO FIELD SERVICES | AL | 1955 | 2003 | 48 | 400 | THIRD PARTY DAMAGE | $431,507 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1964 | 2003 | 39 | 700 | PIPELINE DESIGN | $57,534 |
| OSPREY PETROLEUM CO INC | TX | 1953 | 2003 | 50 | 877 | CORROSION | $264,658 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1970 | 2003 | 33 | 275 | THIRD PARTY DAMAGE | $92,055 |
| SOUTH CAROLINA PIPELINE CORP | SC | 1974 | 2003 | 29 | 983 | CORROSION | $52,979 |
| J - W GATHERING CO | LA | 1971 | 2003 | 32 | 1250 | CORROSION | $92,055 |
| ANR PIPELINE CO | LA | 1952 | 2004 | 52 | 813 | CORROSION | $227 |
| NEUMIN PRODUCTION CO. | | 1964 | 2004 | 40 | 1440 | THIRD PARTY DAMAGE | $5,377,872 |
| CHEVRON PIPELINE CO | | 1979 | 2004 | 25 | 562 | THIRD PARTY DAMAGE | $10,222 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1996 | 2004 | 8 | 1080 | THIRD PARTY DAMAGE | $5,679 |
| HESCO UTILITY CO LLC | TX | 1969 | 2004 | 35 | 1000 | INCORRECT OPERATION | $96,540 |
| TENNESSEE GAS PIPELINE CO | LA | 1992 | 2004 | 12 | 976 | OTHERS | $125,361 |
| GULF SOUTH PIPELINE COMPANY, LP | AL | 1979 | 2004 | 25 | 1440 | CORROSION | $407,246 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TENNESSEE GAS PIPELINE CO | LA | 2000 | 2004 | 4 | 750 | INCORRECT OPERATION | $190,443 |
| COLUMBIA GAS TRANSMISSION CORP | WV | 1962 | 2004 | 42 | 960 | THIRD PARTY DAMAGE | $93,731 |
| NORTHERN NATURAL GAS CO | IA | 1951 | 2004 | 53 | 935 | THIRD PARTY DAMAGE | $18,522 |
| K N INTERSTATE GAS TRANSMISSION CO | NE | 1999 | 2004 | 5 | 1066 | THIRD PARTY DAMAGE | $229,529 |
| ATLANTA GAS LIGHT CO | GA | 1983 | 2004 | 21 | 650 | OTHERS | $78,255 |
| LENOX MUNICIPAL GAS SYSTEM | IA | 1976 | 2004 | 28 | 497 | INCORRECT OPERATION | $22,715 |
| WILLIAMS FIELD SERVICES | NM | 1980 | 2004 | 24 | 1440 | CORROSION | $283,943 |
| SEA ROBIN PIPELINE CO | | 1986 | 2004 | 18 | 575 | CORROSION | $0 |
| NEW JERSEY NATURAL GAS CO | NJ | 1962 | 2004 | 42 | 300 | THIRD PARTY DAMAGE | $227,154 |
| PEOPLES GAS LIGHT & COKE CO | IL | 1995 | 2004 | 9 | 40 | INCORRECT OPERATION | $56,789 |
| K N ENERGY INC(KANSAS NEBRASKA GAS CO) (KMI) | CO | 1975 | 2004 | 29 | 45 | INCORRECT OPERATION | $60,196 |
| DOMINION TRANSMISSION INC | PA | 1958 | 2004 | 46 | 712 | CORROSION | $454,308 |
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | KS | 1992 | 2004 | 12 | 850 | INCORRECT OPERATION | $340,731 |
| DOMINION TRANSMISSION INC | OH | 1954 | 2004 | 50 | 800 | THIRD PARTY DAMAGE | $266,906 |
| NORTHERN NATURAL GAS CO | IA | 1986 | 2004 | 18 | 800 | CORROSION | $176 |
| NEUMIN PRODUCTION CO. | TX | 1944 | 2004 | 60 | 400 | CORROSION | $102,582 |
| GULF SOUTH PIPELINE COMPANY, LP | MS | 2002 | 2004 | 2 | 1000 | THIRD PARTY DAMAGE | $346,410 |
| NORTH CAROLINA NATURAL GAS CORP | NC | 1980 | 2004 | 24 | 500 | CORROSION | $90,270 |
| | | 1957 | 2004 | 47 | 220 | THIRD PARTY DAMAGE | $85,183 |
| NORTHERN NATURAL GAS CO | IA | 1956 | 2004 | 48 | 750 | PIPELINE DESIGN | $108,125 |
| NORTHERN STATES POWER COMPANY | MN | 1959 | 2004 | 45 | 638 | PIPELINE DESIGN | $95,518 |
| TENNESSEE GAS PIPELINE CO | KY | 1963 | 2004 | 41 | 300 | THIRD PARTY DAMAGE | $9,495 |

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|---|---|---|---|---|---|---|---|
| WILLIAMS GAS PIPELINE - TRANSCO | NJ | 1966 | 2004 | 38 | 1367 | PIPELINE DESIGN | $90,862 |
| CENTERPOINT ENERGY GAS TRANSMISSION | LA | 1985 | 2004 | 19 | 1440 | THIRD PARTY DAMAGE | $232,833 |
| BLACK MARLIN PIPELINE CO | | 1965 | 2004 | 39 | 600 | CORROSION | $0 |
| TENNESSEE GAS PIPELINE CO | LA | 1954 | 2004 | 50 | 956 | PIPELINE DESIGN | $59,060 |
| | | 1960 | 2004 | 44 | 1090 | CORROSION | $200,351 |
| BLUE DOLPHIN PIPELINE COMPANY | | 1950 | 2004 | 54 | 600 | OTHERS | $433,796 |
| K N INTERSTATE GAS TRANSMISSION CO | KS | 1969 | 2004 | 35 | 1300 | CORROSION | $177,407 |
| SOUTHERN NATURAL GAS CO | GA | 1929 | 2004 | 75 | 450 | CORROSION | $65,274 |
| MIDAMERICAN ENERGY COMPANY | IA | 1965 | 2004 | 39 | 1169 | CORROSION | $681,462 |
| DYNEGY MIDSTREAM SERVICES, L.P. | | 1990 | 2004 | 14 | 1440 | CORROSION | $102,219 |
| MISSISSIPPI RIVER TRANSMISSION CORP | AR | 2000 | 2004 | 4 | 780 | CORROSION | $39,866 |
| WILLIAMS GAS PIPELINE - TRANSCO | LA | 1978 | 2004 | 26 | 960 | | $91,489 |
| WILLIAMS GAS PIPELINE - TRANSCO | | 1986 | 2004 | 18 | 1250 | CORROSION | $738,251 |
| ENOGEX INC (EX. MUSTANG FUEL CORP) | OK | 1990 | 2004 | 14 | 1250 | CORROSION | $90,862 |
| SOUTHERN STAR CENTRAL GAS PIPELINE, INC | KS | 1969 | 2004 | 35 | 1300 | CORROSION | $67,010 |
| NORTHERN NATURAL GAS CO | TX | 1975 | 2004 | 29 | 1280 | CORROSION | $139,018 |
| WILLIAMS GAS PIPELINE - TRANSCO | | 2001 | 2004 | 3 | 800 | INCORRECT OPERATION | $119,004 |
| DYNEGY MIDSTREAM SERVICES, L.P. | | 1992 | 2004 | 12 | 1000 | OTHERS | $73,484 |
| SABCO OPERATING COMPANY | | 1992 | 2004 | 12 | 860 | THIRD PARTY DAMAGE | $227,154 |
| WILLIAMS GAS PIPELINE - TRANSCO | NJ | 1986 | 2004 | 18 | 1250 | CORROSION | $688,050 |
| | | 1968 | 2004 | 36 | 960 | THIRD PARTY DAMAGE | $103,355 |
| TEXAS EASTERN TRANSMISSION CORP (DUKE) | PA | 1970 | 2004 | 34 | 1066 | THIRD PARTY DAMAGE | $28,829 |
| NORTHERN NATURAL GAS CO | KS | 1930 | 2004 | 74 | 430 | THIRD PARTY DAMAGE | $128,922 |

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|---|---|---|---|---|---|---|---|
| AIR PRODUCTS & CHEMICALS INC | TX | 1974 | 2004 | 30 | 1050 | CORROSION | $141,971 |
| NORTHERN NATURAL GAS CO | TX | 1966 | 2004 | 38 | 60 | CORROSION | $84,047 |
| ENOGEX INC (EX. MUSTANG FUEL CORP) | OK | 1959 | 2004 | 45 | 672 | CORROSION | $493,385 |
| FLORIDA GAS TRANSMISSION CO (ENRON) | FL | 2003 | 2004 | 1 | 1380 | CORROSION | $596,279 |
| GULF SOUTH PIPELINE COMPANY, LP | MS | 1992 | 2004 | 12 | 30 | THIRD PARTY DAMAGE | $0 |
| TENNESSEE GAS PIPELINE CO | | 1969 | 2004 | 35 | 1300 | CORROSION | $60,196 |
| | | 1990 | 2004 | 14 | 1250 | CORROSION | $57,697 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1978 | 2004 | 26 | 1038 | CORROSION | $38,258 |
| EL PASO FIELD SERVICES | TX | 1950 | 2004 | 54 | 860 | PIPELINE DESIGN | $283,943 |
| DUKE ENERGY FIELD SERVICES INC | TX | 1986 | 2004 | 18 | 1250 | CORROSION | $399,564 |
| PANHANDLE EASTERN PIPELINE CO | OK | 1954 | 2004 | 50 | 625 | OTHERS | $85,183 |
| GREAT LAKES CHEMICAL CORP | AR | 1963 | 2004 | 41 | 455 | THIRD PARTY DAMAGE | $47,008 |
| EL PASO FIELD SERVICES | | 1974 | 2004 | 30 | 1440 | OTHERS | $2,555,483 |
| SABCO OPERATING COMPANY | | 1970 | 2004 | 34 | 1200 | OTHERS | $5,792,428 |
| DYNEGY MIDSTREAM SERVICES, L.P. | | 1990 | 2004 | 14 | 1200 | OTHERS | $2,555,483 |
| WILLIAMS GAS PIPELINE - TRANSCO | | 1964 | 2004 | 40 | 1200 | INCORRECT OPERATION | $79,398 |
| ENBRIDGE PIPELINES (EAST TEXAS) L.P. | TX | 1995 | 2004 | 9 | 1440 | OTHERS | $4,543,081 |
| NORTHERN NATURAL GAS CO | TX | 1982 | 2004 | 22 | 1440 | OTHERS | $7,439,295 |
| NORTHERN NATURAL GAS CO | TX | 1971 | 2004 | 33 | 1200 | OTHERS | $567,885 |
| PACIFIC GAS & ELECTRIC CO | CA | 1995 | 2004 | 9 | 1440 | OTHERS | ####### |
| RATON GAS TRANSMISSION CO | CO | 1977 | 2004 | 27 | 700 | PIPELINE DESIGN | $81,775 |
| TENNESSEE GAS PIPELINE CO | LA | 1956 | 2004 | 48 | 200 | OTHERS | $193,081 |
| SOUTHERN NATURAL GAS CO | LA | 1966 | 2004 | 38 | 800 | THIRD PARTY DAMAGE | $272,017 |

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|---|---|---|---|---|---|---|---|
| TENNESSEE GAS PIPELINE CO | LA | 1960 | 2004 | 44 | 1030 | CORROSION | $96,540 |
| COLUMBIA GAS TRANSMISSION CORP | OH | 1973 | 2004 | 31 | 1200 | THIRD PARTY DAMAGE | $90,862 |
| EL PASO FIELD SERVICES | | 1973 | 2004 | 31 | 858 | THIRD PARTY DAMAGE | $104,491 |
| TENNESSEE GAS PIPELINE CO | LA | 1995 | 2004 | 9 | 824 | THIRD PARTY DAMAGE | $285,078 |
| SOUTHERN NATURAL GAS CO | LA | 1989 | 2004 | 15 | 1000 | OTHERS | $69,973 |
| ENTERPRISE PRODUCTS OPERATING L.P. | | 1993 | 2004 | 11 | 915 | THIRD PARTY DAMAGE | $37,480 |
| EL PASO FIELD SERVICES | | 1961 | 2004 | 43 | 857 | THIRD PARTY DAMAGE | $108,926 |
| TENNESSEE GAS PIPELINE CO | MA | 1995 | 2004 | 9 | 823 | THIRD PARTY DAMAGE | $113,577 |
| COLUMBIA GAS TRANSMISSION CORP | PA | 1975 | 2004 | 29 | 1250 | CORROSION | $312,337 |
| NORTHERN NATURAL GAS CO | MN | 1951 | 2004 | 53 | 875 | THIRD PARTY DAMAGE | $227,154 |
| EL PASO FIELD SERVICES | TX | 1975 | 2004 | 29 | 1250 | CORROSION | $287,350 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 1986 | 2004 | 18 | 800 | THIRD PARTY DAMAGE | $104,604 |
| ATMOS PIPELINE - TEXAS | TX | 1975 | 2004 | 29 | 1280 | CORROSION | $273,721 |
| ANR PIPELINE CO | LA | 1976 | 2004 | 28 | 898 | OTHERS | $85,183 |
| NATIONAL FUEL GAS SUPPLY CORP | PA | 1920 | 2004 | 84 | 470 | CORROSION | $224,977 |
| GULF SOUTH PIPELINE COMPANY, LP | LA | 1964 | 2004 | 40 | 999 | CORROSION | $170,366 |
| J - W PIPELINE CO | TX | 1961 | 2004 | 43 | 720 | THIRD PARTY DAMAGE | $80,980 |
| CITY OF BRYAN DBA BRYAN TEXAS UTILITIES | TX | 1955 | 2004 | 49 | 809 | CORROSION | $61,332 |
| AMEREN IP | IL | 1966 | 2004 | 38 | 720 | CORROSION | $152,493 |
| DTE ENERGY - MICHIGAN CONSOLIDATED GAS | MI | 1951 | 2004 | 53 | 200 | PIPELINE DESIGN | $189,544 |
| COLUMBIA GULF TRANSMISSION | | 1920 | 2004 | 84 | 390 | THIRD PARTY DAMAGE | $90,862 |

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|---|---|---|---|---|---|---|---|
| TRUNKLINE GAS COMPANY | TX | 2004 | 2004 | 1 | 1287 | INCORRECT OPERATION | $283,943 |
| COLUMBIA GULF TRANSMISSION | | 1940 | 2004 | 64 | 860 | PIPELINE DESIGN | $283,943 |
| K N INTERSTATE GAS TRANSMISSION CO | NE | 1929 | 2004 | 75 | 265 | CORROSION | $17,598 |
| WILLIAMS GAS PIPELINE - TRANSCO | NJ | 1956 | 2004 | 48 | 225 | PIPELINE DESIGN | $68,674 |
| SABCO OPERATING COMPANY | | 1963 | 2004 | 41 | 1440 | OTHERS | $1,117,598 |
| NORTHWEST PIPELINE CORP (WGP) | OR | 1946 | 2004 | 58 | 607 | THIRD PARTY DAMAGE | $80,072 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1973 | 2005 | 32 | 500 | PIPELINE DESIGN | $90,862 |
| TENNESSEE GAS PIPELINE CO | LA | 1954 | 2005 | 51 | 680 | CORROSION | $67,541 |
| ROCKY MOUNTAIN NATURAL GAS CO INC | CO | 1966 | 2005 | 39 | 1214 | OTHERS | $74,821 |
| NORTHWEST PIPELINE CORP (WGP) | CO | 1958 | 2005 | 47 | 200 | CORROSION | $51,152 |
| GULF SOUTH PIPELINE COMPANY, LP | TX | 1967 | 2005 | 38 | 1000 | CORROSION | $117,958 |
| MISSISSIPPI RIVER TRANSMISSION CORP. | IL | 1960 | 2005 | 45 | 970 | CORROSION | $56,088 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 1968 | 2005 | 37 | 899 | CORROSION | $123,353 |
| TRANSCOLORADO PIPELINE COMPANY | CO | 1975 | 2005 | 30 | 270 | CORROSION | $161,432 |
| AIR PRODUCTS LP | TX | 1955 | 2005 | 50 | 300 | THIRD PARTY DAMAGE | $86,045 |
| WEST TEXAS GAS INC | TX | 1959 | 2005 | 46 | 550 | THIRD PARTY DAMAGE | $56,257 |
| COLUMBIA GAS TRANSMISSION | OH | 1965 | 2005 | 40 | 1169 | CORROSION | $800,932 |
| KINDER MORGAN TEJAS PIPELINE L.P. | TX | 1954 | 2005 | 51 | 800 | PIPELINE DESIGN | $136,069 |
| TEXAS GAS TRANSMISSION LLC | LA | 1974 | 2005 | 31 | 1200 | PIPELINE DESIGN | $729,140 |
| GULF SOUTH PIPELINE COMPANY, LP | MS | 1931 | 2005 | 74 | 317 | OTHERS | $448,701 |
| ATMOS PIPELINE - TEXAS | TX | 1946 | 2005 | 59 | 1000 | THIRD PARTY DAMAGE | $141,341 |
| DOMINION TANSMISSION, INC. | WV | 1958 | 2005 | 47 | 200 | CORROSION | $506,095 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1971 | 2005 | 34 | 773 | OTHERS | $2,243,507 |

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|---|---|---|---|---|---|---|---|
| GULF SOUTH PIPELINE COMPANY, LP | MS | 2004 | 2005 | 1 | 1138 | PIPELINE DESIGN | $1,065,666 |
| SOUTHERN STAR CENTRAL GAS PIPELINE INC | KS | 2002 | 2005 | 3 | 1000 | CORROSION | $0 |
| CENTERPOINT ENERGY GAS TRANSMISSION | OK | 1974 | 2005 | 31 | 1440 | CORROSION | $2,916,559 |
| DTE ENERGY - MICHIGAN CONSOLIDATED GAS CO | MI | 1970 | 2005 | 35 | 1000 | PIPELINE DESIGN | $112,175 |
| SOUTHERN STAR CENTRAL GAS PIPELINE INC | KS | 1967 | 2005 | 38 | 1300 | PIPELINE DESIGN | $84,132 |
| SOUTHERN STAR CENTRAL GAS PIPELINE INC | KS | 1966 | 2005 | 39 | 1001 | INCORRECT OPERATION | $0 |
| SOUTHWEST GAS CORPORATION | NV | 1982 | 2005 | 23 | 1440 | THIRD PARTY DAMAGE | $1,794,806 |
| ATMOS PIPELINE - TEXAS | TX | 1951 | 2005 | 54 | 900 | OTHERS | $89,740 |
| TEXAS GAS SERVICE COMPANY | TX | 1974 | 2005 | 31 | 1250 | CORROSION | $196,756 |
| MISSISSIPPI RIVER TRANSMISSION CORP. | MO | 2001 | 2005 | 4 | 1440 | CORROSION | $1,794,806 |
| WILLIAMS GAS PIPELINES - TRANSCO | LA | 1968 | 2005 | 37 | 850 | PIPELINE DESIGN | $168,263 |
| NORTHERN NATURAL GAS | TX | 1989 | 2005 | 16 | 850 | THIRD PARTY DAMAGE | $112,175 |
| TENNESSEE GAS PIPELINE | LA | 2004 | 2005 | 1 | 1070 | THIRD PARTY DAMAGE | $40,961 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 1969 | 2005 | 36 | 1312 | CORROSION | $77,547 |
| ATMOS PIPELINE - TEXAS | TX | 1929 | 2005 | 76 | 450 | CORROSION | $249,043 |
| SOUTHERN STAR CENTRAL GAS PIPELINE INC. | KS | 1975 | 2005 | 30 | 1250 | CORROSION | $353,352 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 1944 | 2005 | 61 | 750 | PIPELINE DESIGN | $78,523 |
| TENNESSEE GAS PIPELINE | | 1978 | 2005 | 27 | 100 | CORROSION | $5,048 |
| NEUMIN PRODUCTION CO | TX | 1975 | 2005 | 30 | 973 | CORROSION | $804,905 |
| TENNESSEE GAS PIPELINE | | 1947 | 2005 | 58 | 78 | CORROSION | $165,274 |
| TENNESSEE GAS PIPELINE | | 1951 | 2005 | 54 | 790 | CORROSION | $1,570,455 |
| ANR PIPELINE | | 2003 | 2005 | 2 | 1000 | CORROSION | $56,089 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| KINDER MORGAN TEJAS PIPELINE | TX | 1967 | 2005 | 38 | 858 | CORROSION | ####### |
| TENNESSEE GAS PIPELINE | | 1971 | 2005 | 34 | 1008 | OTHERS | ####### |
| TRUNKLINE GAS COMPANY | LA | 1994 | 2005 | 11 | 1308 | THIRD PARTY DAMAGE | $72,914 |
| COLUMBIA GULF TRANSMISSION CORPORATION | | 1980 | 2005 | 25 | 1000 | CORROSION | $336,952 |
| TENNESSEE GAS PIPELINE | LA | 1947 | 2005 | 58 | 837 | CORROSION | $118,906 |
| DOMINION TRANSMISSION, INC. | OH | 1968 | 2005 | 37 | 275 | CORROSION | $145,828 |
| NATURAL GAS PIPELINE COMPANY OF AMERICA | TX | 1944 | 2005 | 61 | 780 | THIRD PARTY DAMAGE | $78,523 |
| COLUMBIA GAS TRANSMISSION | WV | 1929 | 2005 | 76 | 450 | INCORRECT OPERATION | $215,560 |
| NORTHERN NATURAL GAS COMPANY | MN | 1980 | 2005 | 25 | 1440 | PIPELINE DESIGN | $201,916 |
| PUBLIC SERVICE OF NORTH CAROLINA INCORPORATED (DBA PSNC ENERGY) | NC | 1982 | 2005 | 23 | 175 | THIRD PARTY DAMAGE | $21,575 |
| TRUNKLINE GAS COMPANY | | 1961 | 2005 | 44 | 960 | PIPELINE DESIGN | $104,927 |
| MISSISSIPPI RIVER TRANSMISSION CORP. | AR | 1989 | 2005 | 16 | 1264 | CORROSION | $102,746 |
| COLUMBIA GULF TRANSMISSION | LA | 2004 | 2005 | 1 | 250 | INCORRECT OPERATION | $813,271 |
| TENNESSEE GAS PIPELINE | MS | 1964 | 2005 | 41 | 800 | CORROSION | $114,419 |
| WILLIAMS GAS PIPELINE - TRANSCO | LA | 1976 | 2005 | 29 | 1050 | OTHERS | $606,869 |
| CROSSTEX MISSISSIPPI PIPELINE LP | MS | 1975 | 2005 | 30 | 1280 | CORROSION | $218,239 |
| DEFS AUSTIN GATHERING, LP DUKE ENERGY FIELD SERVICES | TX | 1990 | 2005 | 15 | 1440 | CORROSION | $168,263 |
| ENOGEX INC. | OK | 1957 | 2005 | 48 | 1100 | CORROSION | $112,175 |
| COLUMBIA NATURAL RESOURCES, LLC | KY | 1971 | 2005 | 34 | 687 | THIRD PARTY DAMAGE | $61,696 |
| CONSUMERS ENERGY | MI | 1998 | 2005 | 7 | 1700 | CORROSION | $101,451 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1947 | 2005 | 58 | 600 | CORROSION | $130,348 |
| ANR PIPELINE COMPANY | OK | 1968 | 2005 | 37 | 1206 | OTHERS | $1,121,754 |
| NATURAL GAS PIPELINE COMPANY OF AMERICA | TX | 1973 | 2005 | 32 | 1000 | CORROSION | $284,925 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TEXAS EASTERN TRANSMISSION LP | PA | 1963 | 2005 | 42 | 1440 | OTHERS | $2,838,036 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 1970 | 2005 | 35 | 1200 | OTHERS | $61,696 |
| COLUMBIA GULF TRANSMISSION | LA | 1995 | 2005 | 10 | 1500 | OTHERS | ####### |
| TEXAS EASTERN TRANSMISSION LP | PA | 1968 | 2005 | 37 | 1235 | THIRD PARTY DAMAGE | $2,467,858 |
| COLORADO INTERSTATE GAS | CO | 1948 | 2005 | 57 | 388 | CORROSION | $158,167 |
| COLUMBIA GULF TRANSMISSION | | 1964 | 2005 | 41 | 1440 | OTHERS | $2,519,359 |
| GULF SOUTH PIPELINE COMPANY, LP | TX | 1974 | 2005 | 31 | 1200 | OTHERS | $392,614 |
| KINDER MORGAN INTERSTATE GAS TRANSMISSON | NE | 1962 | 2005 | 43 | 375 | CORROSION | $67,305 |
| EL PASO NATURAL GAS | NM | 1984 | 2005 | 21 | 780 | PIPELINE DESIGN | $60,037 |
| PLAINS EXPLORATION & PRODUCTION COMPANY | CA | 1958 | 2005 | 47 | 1100 | OTHERS | $63,660 |
| PACIFIC GAS & ELECTRIC COMPANY | CA | 1977 | 2005 | 28 | 1440 | OTHERS | $3,742,994 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 1977 | 2005 | 28 | 1440 | OTHERS | $4,487,014 |
| SOUTHERN STAR CENTRAL GAS PIPELINE | KS | 1968 | 2005 | 37 | 1200 | OTHERS | $280,438 |
| ENTERPRISE PRODUCTS OPERATING LP | | 1969 | 2005 | 36 | 1300 | OTHERS | $384,761 |
| CENTERPOINT ENERGY GAS TRANSMISSION | LA | 1996 | 2005 | 9 | 1440 | OTHERS | $169,385 |
| NORTHERN NATURAL GAS COMPANY | IA | 1970 | 2005 | 35 | 1250 | OTHERS | $280,438 |
| TEXAS GAS TRANSMISSION, LLC | IN | 1951 | 2005 | 54 | 805 | OTHERS | $105,956 |
| DUKE ENERGY FIELD SERVICES, LP - EASTRANS LIMITED PARTNERSHIP | TX | 1990 | 2005 | 15 | 1056 | OTHERS | $89,740 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 1968 | 2005 | 37 | 1250 | OTHERS | $8,244,889 |
| WILLIAMS GAS PIPELINE-TRANSCO | PA | 1952 | 2005 | 53 | 1400 | THIRD PARTY DAMAGE | $2,907,372 |
| INDIANA GAS CO INC | IN | 1974 | 2005 | 31 | 1250 | OTHERS | ####### |
| DOMINION TRANSMISSION INC. | WV | 1990 | 2005 | 15 | 850 | OTHERS | $125,636 |
| WILLIAMS GAS PIPELINE-TRANSCO | TX | 1971 | 2005 | 34 | 1247 | OTHERS | $168,263 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SABCO OPERATING COMPANY | | 1975 | 2005 | 30 | 1440 | OTHERS | ####### |
| WILLIAMS GAS PIPELINES - TRANSCO | | 1976 | 2005 | 29 | 956 | PIPELINE DESIGN | $85,253 |
| NORTHERN NATURAL GAS COMPANY | MN | 1982 | 2005 | 23 | 1250 | OTHERS | $1,772,371 |
| SOUTHERN NATURAL GAS | LA | 1973 | 2005 | 32 | 850 | PIPELINE DESIGN | $263,051 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 2005 | 2005 | 1 | 988 | INCORRECT OPERATION | $62,877 |
| COLUMBIA GAS TRANSMISSION | WV | 1970 | 2005 | 35 | 999 | OTHERS | $245,664 |
| COLUMBIA GAS TRANSMISSION CORPORATION | PA | 1962 | 2005 | 43 | 780 | THIRD PARTY DAMAGE | $181,081 |
| TENNESSEE GAS PIPELINE | | 1957 | 2005 | 48 | 300 | THIRD PARTY DAMAGE | $140,219 |
| TRUNKLINE GAS COMPANY | | 1990 | 2005 | 15 | 1440 | OTHERS | $757,184 |
| TENNESSEE GAS PIPELINE | | 1974 | 2005 | 31 | 1440 | OTHERS | $757,184 |
| TENNESSEE GAS PIPELINE | LA | 1958 | 2005 | 47 | 1168 | THIRD PARTY DAMAGE | $2,370,265 |
| CENTERPOINT ENERGY GAS TRANSMISSION | OK | 2003 | 2005 | 2 | 2220 | OTHERS | ####### |
| GULF SOUTH PIPELINE COMPANY, LP | LA | 1968 | 2005 | 37 | 1300 | OTHERS | $1,738,718 |
| TENNESSEE GAS PIPELINE | | 1964 | 2005 | 41 | 1440 | OTHERS | $286,047 |
| GULF SOUTH PIPELINE, LP | LA | 1947 | 2005 | 58 | 837 | CORROSION | $160,411 |
| WILLIAMS GAS PIPELINES - TRANSCO | | 1953 | 2005 | 52 | 980 | CORROSION | $38,925 |
| SOUTHERN NATURAL GAS | | 1968 | 2005 | 37 | 1200 | THIRD PARTY DAMAGE | $2,019,156 |
| TENNESSEE GAS PIPELINE | | 2002 | 2005 | 3 | 894 | INCORRECT OPERATION | $297,515 |
| SOUTHERN NATURAL GAS | LA | 1980 | 2005 | 25 | 1440 | CORROSION | $381,396 |
| SOUTHERN NATURAL GAS | | 1981 | 2005 | 24 | 1440 | CORROSION | $2,024,765 |
| TENNESSEE GAS PIPELINE | LA | 1989 | 2005 | 16 | 1250 | OTHERS | $2,038,473 |
| TENNESSEE GAS PIPELINE | LA | 1998 | 2005 | 7 | 1440 | OTHERS | $673,052 |
| GULF SOUTH PIPELINE COMPANY, LP | LA | 1956 | 2005 | 49 | 850 | CORROSION | $95,349 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TENNESSEE GAS PIPELINE | | 1985 | 2005 | 20 | 200 | THIRD PARTY DAMAGE | $31,241 |
| TENNESSEE GAS PIPELINE | | 1966 | 2005 | 39 | 960 | THIRD PARTY DAMAGE | $335,404 |
| SOUTHERN NATURAL GAS | | 1954 | 2005 | 51 | 1050 | CORROSION | $464,755 |
| TENNESSEE GAS PIPELINE | | 2000 | 2005 | 5 | 858 | THIRD PARTY DAMAGE | $92,468 |
| SOUTHERN NATURAL GAS | | 1982 | 2005 | 23 | 1200 | OTHERS | $841,315 |
| SOUTHERN NATURAL GAS | | 2001 | 2005 | 4 | 1174 | THIRD PARTY DAMAGE | $0 |
| ENTERPRISE PRODUCTS OPERATING L.P. | | 1970 | 2005 | 35 | 1200 | CORROSION | $1,763,812 |
| GULF SOUTH PIPELINE COMPANY, LP | LA | 1930 | 2005 | 75 | 350 | THIRD PARTY DAMAGE | $67,702 |
| K O TRANSMISSION COMPANY | KY | 1954 | 2005 | 51 | 892 | THIRD PARTY DAMAGE | $830,098 |
| CHEVRON PIPE LINE COMPANY | | 1977 | 2005 | 28 | 1440 | THIRD PARTY DAMAGE | $138,985 |
| TENNESSEE GAS PIPELINE COPMANY | | 1957 | 2005 | 48 | 850 | PIPELINE DESIGN | $1,351,713 |
| CONSUMERS ENERGY | MI | 1979 | 2005 | 26 | 1440 | INCORRECT OPERATION | $772,439 |
| KINDER MORGAN TEXAS PIPELINE CO. | TX | 1983 | 2005 | 22 | 752 | INCORRECT OPERATION | $247,908 |
| COLUMBIA GULF TRANSMISSION | LA | 1951 | 2005 | 54 | 800 | PIPELINE DESIGN | $897,403 |
| SOUTHERN NATURAL GAS | LA | 1961 | 2005 | 44 | 150 | CORROSION | $0 |
| SEA ROBIN PIPELINE COMPANY | | 1957 | 2005 | 48 | 750 | PIPELINE DESIGN | $1,018,588 |
| SEA ROBIN PIPELINE COMPANY | | 1963 | 2006 | 43 | 800 | THIRD PARTY DAMAGE | $61,563 |
| TRUNKLINE GAS COMPANY | | 1989 | 2006 | 17 | 1440 | OTHERS | $318,431 |
| TARGA MIDSTREAM SERVICES LP. | | 1973 | 2006 | 33 | 780 | INCORRECT OPERATION | $491,066 |
| ENBRIDGE OFFSHORE (GAS GATHERING) L.L.C. | | 1938 | 2006 | 68 | 650 | THIRD PARTY DAMAGE | $30,931 |
| SEA ROBIN PIPELINE COMPANY | | 1995 | 2006 | 11 | 1200 | CORROSION | $2,816,994 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| GULF SOUTH PIPELINE COMPANY, LP | LA | 1947 | 2006 | 59 | 920 | CORROSION | $610,327 |
| TRUNKLINE GAS COMPANY | LA | 1965 | 2006 | 41 | 275 | CORROSION | $66,991 |
| ENBRIDGE OFFSHORE (GAS TRANSMISSION) L.L.C. | LA | 1958 | 2006 | 48 | 1011 | CORROSION | $63,676 |
| ANR PIPELINE | | 1965 | 2006 | 41 | 1169 | CORROSION | $265,359 |
| ANR PIPELINE | | 1965 | 2006 | 41 | 1337 | CORROSION | $61,908 |
| TENNESSEE GAS PIPELINE | | 1984 | 2006 | 22 | 550 | THIRD PARTY DAMAGE | $10,276 |
| GULF SOUTH PIPELINE COMPANY, LP | | 2001 | 2006 | 5 | 375 | THIRD PARTY DAMAGE | $95,211 |
| TENNESSEE GAS PIPELINE | | 1966 | 2006 | 40 | 400 | CORROSION | $50,949 |
| NATURAL GAS PIPELINE CO. OF AMERICA | TX | 1971 | 2006 | 35 | 1250 | PIPELINE DESIGN | $478,708 |
| NATURAL GAS PIPELINE CO. OF AMERICA | LA | 1980 | 2006 | 26 | 1000 | PIPELINE DESIGN | $106,250 |
| TENNESSEE GAS PIPELINE | | 1975 | 2006 | 31 | 1280 | CORROSION | $80,686 |
| TENNESSEE GAS PIPELINE | LA | 1968 | 2006 | 38 | 575 | THIRD PARTY DAMAGE | $63,686 |
| WILLIAMS GAS WILLIAMS - TRANSCO | | 1965 | 2006 | 41 | 858 | PIPELINE DESIGN | $384,582 |
| TEXAS EASTERN TRANSMISSION, LP | | 1955 | 2006 | 51 | 499 | CORROSION | $477,647 |
| TENNESSEE GAS PIPELINE | | 1974 | 2006 | 32 | 1200 | CORROSION | $1,592,157 |
| KINDER MORGAN INTERSTATE GAS TRANSMISSION | KS | 1966 | 2006 | 40 | 950 | THIRD PARTY DAMAGE | $119,942 |
| ENTERPRISE PRODUCTS OPERATING LLC. | | 1986 | 2006 | 20 | 1250 | CORROSION | $2,653,595 |
| PACIFIC GAS & ELECTRIC COMPANY | CA | 1986 | 2006 | 20 | 1250 | CORROSION | $2,653,595 |
| TENNESSEE GAS PIPELINE | | 2004 | 2006 | 2 | 2160 | CORROSION | $159,216 |
| COLORADO INTERSTATE GAS | WY | 1979 | 2006 | 27 | 1128 | THIRD PARTY DAMAGE | $49,569 |
| NORTHERN NATURAL GAS COMPANY | MN | 1966 | 2006 | 40 | 1440 | CORROSION | $1,910,588 |
| SHELL PIPELINE COMPANY LP | | 1990 | 2006 | 16 | 1000 | INCORRECT OPERATION | $25,475 |
| TENNESSEE GAS PIPELINE | | 1952 | 2006 | 54 | 1440 | CORROSION | $265,359 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| WILLIAMS GAS PIPELINE - TRANSCO | VA | 1900 | 2006 | 106 | 285 | OTHERS | $77,060 |
| MICHIGAN CONSOLIDATED GAS COMPANY | MI | 1984 | 2006 | 22 | 300 | PIPELINE DESIGN | $61,988 |
| TENNESSEE GAS PIPELINE | | 1989 | 2006 | 17 | 1264 | CORROSION | $182,601 |
| TENNESSEE GAS PIPELINE | | 1975 | 2006 | 31 | 1280 | CORROSION | $653,413 |
| WILLIAMS GAS PIPELINE - TRANSCO | | 1990 | 2006 | 16 | 1050 | CORROSION | $64,822 |
| EQUITRANS, LP | WV | 1965 | 2006 | 41 | 800 | CORROSION | $260,052 |
| ENTERPRISE PRODUCTS OPERATING L.P. | | 1926 | 2006 | 80 | 204 | OTHERS | $1,051,354 |
| ANR PIPELINE COMPANY | | 1952 | 2006 | 54 | 170 | PIPELINE DESIGN | $67,189 |
| CHEVRON PIPE LINE COMANY | | 2002 | 2006 | 4 | 1050 | CORROSION | $427,441 |
| EL PASO NATURAL GAS | TX | 1981 | 2006 | 25 | 1246 | OTHERS | $265,359 |
| LAVACA PIPELINE | | 1979 | 2006 | 27 | 1440 | OTHERS | $63,686 |
| GULF SOUTH PIPELINE COMPANY, LP | | 1964 | 2006 | 42 | 1500 | CORROSION | ####### |
| KINDER MORGAN TEJAS PIPELINE | TX | 1981 | 2006 | 25 | 1264 | PIPELINE DESIGN | $222,902 |
| COLUMBIA GULF TRANSMISSION | LA | 1966 | 2006 | 40 | 756 | CORROSION | $339,660 |
| ENTERPRISE PIPELINE OPERATING, LP | | 1985 | 2006 | 21 | 973 | CORROSION | $184,156 |
| ENTERPRISE PIPELINE OPERATING LLC. | | 1928 | 2006 | 78 | 430 | CORROSION | $59,425 |
| SEA ROBIN PIPELINE COMPANY | | 1951 | 2006 | 55 | 1110 | THIRD PARTY DAMAGE | $27,473 |
| TENNESSEE GAS PIPELINE | | 1952 | 2006 | 54 | 790 | PIPELINE DESIGN | $212,288 |
| NORTHWEST PIPELINE CORPORATION | ID | 1956 | 2006 | 50 | 811 | PIPELINE DESIGN | $159,216 |
| CRANBERRY PIPELINE CORPORATION | WV | 1960 | 2006 | 46 | 3000 | CORROSION | $53,231 |
| ENTERPRISE PIPELINE OPERATING, LP | | 1991 | 2006 | 15 | 1020 | CORROSION | $74,301 |
| NORTHERN NATURAL GAS COMPANY | IA | 1971 | 2006 | 35 | 1000 | INCORRECT OPERATION | $106,957 |
| COLUMBIA GULF TRANSMISSION | KY | 1984 | 2006 | 22 | 920 | THIRD PARTY DAMAGE | $0 |
| EXPRO ENGINEERING, INC. | TX | 1956 | 2006 | 50 | 787 | | $15,285 |
| NICOR GAS | IL | 1974 | 2006 | 32 | 1440 | OTHERS | $127,373 |

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|---|---|---|---|---|---|---|---|
| TENNESSEE GAS PIPELINE | | 1984 | 2006 | 22 | 1200 | PIPELINE DESIGN | $1,400,578 |
| SOUTHWESTERN GAS PIPELINE INC | TX | 1972 | 2006 | 34 | 796 | THIRD PARTY DAMAGE | $53,072 |
| SEA ROBIN PIPELINE CO | TX | 1955 | 2006 | 51 | 975 | CORROSION | $54,133 |
| PACIFIC GAS & ELECTRIC CO | CA | 1985 | 2006 | 21 | 550 | OTHERS | $0 |
| ENBRIDGE PIPELINES LOUISIANA INTRASTATE L.L.C. | LA | 1969 | 2006 | 37 | 1250 | CORROSION | $318,431 |
| ATMOS PIPLINE - TEXAS | TX | 1986 | 2006 | 20 | 1250 | CORROSION | $1,379,869 |
| COLUMBIA GAS TRANSMISSION | OH | 1944 | 2006 | 62 | 750 | CORROSION | $942,096 |
| TENNESSEE GAS PIPELINE | TX | 1969 | 2006 | 37 | 400 | THIRD PARTY DAMAGE | $315,612 |
| BRIDGELINE HOLDINGS, L.P. | LA | 1960 | 2006 | 46 | 877 | CORROSION | $399,631 |
| ATMOS ENERGY CORPORATION., MID TEX DIVISION | TX | 1962 | 2006 | 44 | 910 | PIPELINE DESIGN | $614,810 |
| NORHTWEST PIPELINE COMPANY | WY | 1965 | 2006 | 41 | 250 | THIRD PARTY DAMAGE | $69,328 |
| COLORADO INTERSTATE GAS | WY | 1954 | 2006 | 52 | 935 | PIPELINE DESIGN | $252,092 |
| ANR PIPELINE | | 1989 | 2006 | 17 | 1264 | CORROSION | $128,430 |
| MISSISSIPPI RIVER TRANSMISSION | AR | 1994 | 2006 | 12 | 980 | PIPELINE DESIGN | $497,921 |
| ATMOS PIPLINE - TEXAS | TX | 1954 | 2006 | 52 | 680 | THIRD PARTY DAMAGE | $77,248 |
| NORTHERN NATURAL GAS COMPANY | KS | 2002 | 2006 | 4 | 894 | INCORRECT OPERATION | $82,416 |
| NORTHERN NATURAL GAS COMPANY | MN | 1958 | 2006 | 48 | 819 | OTHERS | $379,995 |
| ATMOS PIPLINE - TEXAS | TX | 1962 | 2006 | 44 | 910 | PIPELINE DESIGN | $238,824 |
| TENNESSEE GAS PIPELINE | KY | 1962 | 2006 | 44 | 910 | PIPELINE DESIGN | $238,824 |
| ATMOS PIPELINE - TEXAS | TX | 1995 | 2006 | 11 | 1200 | THIRD PARTY DAMAGE | $95,529 |
| ENTERPRISE PRODUCTS OPERATING LP | | 1987 | 2006 | 19 | 1008 | INCORRECT OPERATION | $209,103 |
| ENERGY TRANSFER COMPANY | TX | 1962 | 2006 | 44 | 910 | PIPELINE DESIGN | $291,895 |
| COLUMBIA GULF TRANSMISSION | | 1981 | 2006 | 25 | 500 | THIRD PARTY | $324,078 |

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|---|---|---|---|---|---|---|---|
| | | | | | | DAMAGE | |
| CRANBERRY PIPELINE CORPORATION | WV | 1990 | 2006 | 16 | 1200 | THIRD PARTY DAMAGE | $222,796 |
| STINGRAY PIPELINE COMPANY, L.L.C. | | 1954 | 2006 | 52 | 935 | CORROSION | $263,130 |
| COLORADO INTERSTATE GAS | CO | 1981 | 2006 | 25 | 1264 | CORROSION | $238,824 |
| ENOGEX INC | OK | 1981 | 2006 | 25 | 936 | CORROSION | $228,315 |
| SOUTHERN NATURAL GAS | GA | 1968 | 2006 | 38 | 1050 | CORROSION | $7,536 |
| TRANSCONTINENTAL GAS PIPE LINE COMPANY | LA | 1948 | 2006 | 58 | 720 | THIRD PARTY DAMAGE | $421,391 |
| SOUTHERN NATURAL GAS | GA | 1983 | 2006 | 23 | 1440 | PIPELINE DESIGN | $270,667 |
| ACADIAN GAS PIPELINE SYSTEM | LA | 1960 | 2006 | 46 | 290 | THIRD PARTY DAMAGE | $106,479 |
| GULF SOUTH PIPELINE COMPANY, LP | FL | 2006 | 2006 | 1 | 1100 | PIPELINE DESIGN | $29,745 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 1936 | 2006 | 70 | 490 | CORROSION | $90,222 |
| MISSISSIPPI RIVER TRANSMISSION | MO | 1971 | 2006 | 35 | 180 | CORROSION | $127,373 |
| COLUMBIA GULF TRANSMISSION | | 2006 | 2006 | 1 | 1440 | CORROSION | $636,863 |
| GULF SOUTH PIPELINE COMPANY, LP | TX | 1952 | 2006 | 54 | 1067 | CORROSION | $244,258 |
| SABCO OPERATING COMPANY | | 1969 | 2006 | 37 | 1250 | CORROSION | $238,824 |
| ONEOK WESTEX TRANSMISSION, L.P. | TX | 1971 | 2006 | 35 | 1253 | CORROSION | $1,061,438 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1928 | 2006 | 78 | 250 | THIRD PARTY DAMAGE | $33,575 |
| ANR PIPELINE | MS | 1977 | 2006 | 29 | 1250 | CORROSION | $140,641 |
| QUESTAR GAS COMPANY | UT | 1975 | 2006 | 31 | 1280 | CORROSION | $185,645 |
| PANHANDLE EASTERN PIPELINE COMPANY | MO | 1952 | 2006 | 54 | 500 | THIRD PARTY DAMAGE | $100,701 |
| ROCKY MOUNTAIN NATURAL GAS COMPANY | CO | 1995 | 2006 | 11 | 944 | THIRD PARTY DAMAGE | $42,458 |
| NW NATURAL | OR | 1982 | 2006 | 24 | 1000 | THIRD PARTY DAMAGE | $0 |
| STINGRAY PIPELINE COMPANY, L.L.C. | | 1962 | 2006 | 44 | 1000 | PIPELINE DESIGN | $95,529 |

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|---|---|---|---|---|---|---|---|
| NORTHERN NATURAL GAS COMPANY | MN | 2005 | 2006 | 1 | 2160 | PIPELINE DESIGN | $372 |
| NORTHERN NATURAL GAS COMPANY | TX | 2004 | 2006 | 2 | 860 | OTHERS | $477,647 |
| NORTHERN NATURAL GAS COMPANY | TX | 1986 | 2006 | 20 | 1104 | CORROSION | $238,824 |
| ENBRIDGE OFFSHORE (GAS GATHERING) L.L.C. | | 2003 | 2006 | 3 | 70 | PIPELINE DESIGN | $145,523 |
| MAVERICK-DIMMIT PIPELINE LTD | TX | 1968 | 2006 | 38 | 887 | CORROSION | $1,274,787 |
| TRANSCONTINENTAL GAS PIPE LINE CORPORATION | | 1977 | 2006 | 29 | 60 | CORROSION | $78,728 |
| CENTERPOINT ENERGY GAS TRANSMISSION | LA | 1979 | 2006 | 27 | 310 | THIRD PARTY DAMAGE | $63,457 |
| GULF SOUTH PIPELINE COMPANY, LP | | 1983 | 2006 | 23 | 1440 | CORROSION | $420,860 |
| NATURAL GAS PIPELINE CO. OF AMERICA | MO | 1998 | 2006 | 8 | 228 | THIRD PARTY DAMAGE | $212,288 |
| COLUMBIA GAS TRANSMISSION | WV | 1958 | 2006 | 48 | 792 | PIPELINE DESIGN | $159,746 |
| TENNESSEE GAS PIPELINE | MS | 2000 | 2006 | 6 | 720 | OTHERS | $169,830 |
| NORTHWEST PIPELINE CORPORATION | WA | 1979 | 2006 | 27 | 1440 | PIPELINE DESIGN | $159,096 |
| ATLANTA GAS LIGHT COMPANY | GA | 1958 | 2006 | 48 | 960 | CORROSION | $76,954 |
| DUKE ENERGY FIELD SERVICES (EASTRANS LIMITED PARTNERSHIP) | TX | 1958 | 2006 | 48 | 960 | CORROSION | $76,954 |
| SABCO OPERATING COMPANY | | 1968 | 2006 | 38 | 858 | THIRD PARTY DAMAGE | $1,836,288 |
| NATURAL GAS PIPELINE CO. OF AMERICA | OK | 1982 | 2006 | 24 | 1200 | THIRD PARTY DAMAGE | $111,451 |
| TRANSCONTINENTAL GAS PIPELINE COMPANY | MS | 1931 | 2006 | 75 | 500 | THIRD PARTY DAMAGE | $21,497 |
| ENBRIDGE PIPELINES (MIDLA) L.L.C. | LA | 1967 | 2006 | 39 | 1235 | PIPELINE DESIGN | $371,503 |
| COLUMBIA GAS TRANSMISSION | OH | 1960 | 2007 | 47 | 500 | CORROSION | $87,239 |
| TEXAS EASTERN TRANSMISSION LP | PA | 1990 | 2007 | 17 | 1636 | CORROSION | $43,314 |
| KEYSPAN ENERGY DELIVERY | NY | 2005 | 2007 | 2 | 600 | THIRD PARTY DAMAGE | $151,878 |

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|---|---|---|---|---|---|---|---|
| TENNESSEE GAS PIPELINE | LA | 1958 | 2007 | 49 | 960 | CORROSION | $75,301 |
| ANR PIPELINE | LA | 1980 | 2007 | 27 | 1253 | PIPELINE DESIGN | $545,280 |
| TRUNKLINE GAS COMPANY | LA | 1967 | 2007 | 40 | 720 | CORROSION | $519,314 |
| TENNESSEE GAS PIPELINE | LA | 1966 | 2007 | 41 | 720 | THIRD PARTY DAMAGE | $181,760 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 1951 | 2007 | 56 | 1200 | PIPELINE DESIGN | $1,408,896 |
| ENOGEX INC | OK | 1965 | 2007 | 42 | 600 | CORROSION | $0 |
| GULF SOUTH PIPELINE COMPANY, LP | TX | 1985 | 2007 | 22 | 1736 | THIRD PARTY DAMAGE | $5,814,244 |
| DUKE ENERGY FIELD SERVICES (DUKE ENERGY INTRASTATE NETWORK) | TX | 1980 | 2007 | 27 | 1440 | CORROSION | $238,129 |
| TENNESSEE GAS PIPELINE | OH | 1939 | 2007 | 68 | 475 | PIPELINE DESIGN | $171,374 |
| NORTHWEST PIPELINE CORPORATION | WA | 1948 | 2007 | 59 | 900 | PIPELINE DESIGN | $6,461,535 |
| NORTHERN NATURAL GAS COMPANY | KS | 1959 | 2007 | 48 | 716 | THIRD PARTY DAMAGE | $77,897 |
| TENNESSEE GAS PIPELINE | PA | 1980 | 2007 | 27 | 1440 | CORROSION | $235,768 |
| VENOCO INC. | CA | 1974 | 2007 | 33 | 1440 | THIRD PARTY DAMAGE | $2,077,259 |
| NATURAL GAS PIPELINE CO. OF AMERICA | OK | 1963 | 2007 | 44 | 900 | CORROSION | $213,750 |
| ATMOS PILELINE - TEXAS | TX | 1948 | 2007 | 59 | 750 | CORROSION | $1,121,185 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1937 | 2007 | 70 | 266 | CORROSION | $29,523 |
| TEXAS GAS TRANSMISSION, LLC | LA | 1966 | 2007 | 41 | 970 | CORROSION | $361,521 |
| MARKWEST PINNACLE L.P. | TX | 1969 | 2007 | 38 | 720 | CORROSION | $62,318 |
| NORTHERN NATURAL GAS COMPANY | SD | 1968 | 2007 | 39 | 1440 | THIRD PARTY DAMAGE | $155,794 |
| TENNESSEE GAS PIPELINE | LA | 1975 | 2007 | 32 | 1280 | CORROSION | $102,693 |
| NATURAL GAS PIPELINE COMPANY OF AMERICA | TX | 2005 | 2007 | 2 | 850 | PIPELINE DESIGN | $5,193 |
| STINGRAY PIPELINE COMPANY, L.L.C. | | 1950 | 2007 | 57 | 800 | PIPELINE DESIGN | $125,108 |

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|---|---|---|---|---|---|---|---|
| NORTHERN NATURAL GAS COMPANY | MN | 1932 | 2007 | 75 | 446 | CORROSION | $494,834 |
| TEXAS GAS TRANSMISSION, LLC | | 1989 | 2007 | 18 | 400 | INCORRECT OPERATION | $68,182 |
| ONYX PIPELINE COMPANY | TX | 1968 | 2007 | 39 | 1087 | THIRD PARTY DAMAGE | $383,893 |
| PUBLIC SERVICE COMPANY OF NE MEXICO | NM | 1952 | 2007 | 55 | 780 | CORROSION | $71,046 |
| DOMINION TRANSMISSION INC. | WV | 1991 | 2007 | 16 | 492 | INCORRECT OPERATION | $1,246 |
| COLUMBIA GULF TRANSMISSION | LA | 1967 | 2007 | 40 | 2000 | CORROSION | $64,395 |
| NORTHERN NATURAL GAS COMPANY | TX | 1979 | 2007 | 28 | 1264 | OTHERS | $451,804 |
| TENNESSEE GAS PIPELINE | KY | 1996 | 2007 | 11 | 863 | THIRD PARTY DAMAGE | $65,973 |
| SOUTHERN STAR CENTRAL GAS PIPELINE INC. | MO | 2004 | 2007 | 3 | 1050 | CORROSION | $623,177 |
| VIKING GAS TRANSMISSION COMPANY | WI | 2007 | 2007 | 1 | 753 | CORROSION | $245,001 |
| NORTHWEST PIPELINE CORPORATION | ID | 1940 | 2007 | 67 | 800 | CORROSION | $462,190 |
| COLUMBIA GAS TRANSMISSION | OH | 1958 | 2007 | 49 | 960 | CORROSION | $75,301 |
| PUBLIC SERVICE COMPANY OF NEW MEXICO | NM | 1973 | 2007 | 34 | 99 | CORROSION | $1,038,629 |
| COLUMBIA GULF TRANSMISSION | KY | 2007 | 2007 | 1 | 809 | THIRD PARTY DAMAGE | $232,061 |
| NATURAL GAS PIPELINE CO. OF AMERICA | IA | 1975 | 2007 | 32 | 1280 | CORROSION | $281,749 |
| DUKE ENERGY FIELD SERVICES (EASTRANS LIMITED PARTNERSHIP) | TX | 1989 | 2007 | 18 | 1440 | CORROSION | $0 |
| TENNESSEE GAS PIPELINE | LA | 1958 | 2007 | 49 | 960 | CORROSION | $75,301 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1975 | 2007 | 32 | 850 | INCORRECT OPERATION | $0 |
| COLUMBIA GULF TRANSMISSION | LA | 1950 | 2007 | 57 | 975 | THIRD PARTY DAMAGE | $96,592 |
| PACIFIC GAS & ELECTRIC COMPANY | CA | 1980 | 2007 | 27 | 1440 | CORROSION | $417,217 |
| DOMINION TRANSMISSION, INC. | PA | 1947 | 2007 | 60 | 738 | OTHERS | $83,090 |

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|---|---|---|---|---|---|---|---|
| NORTHWEST PIPELINE | ID | 1948 | 2007 | 59 | 970 | PIPELINE DESIGN | $87,754 |
| COLUMBIA GAS TRANSMISSION | WV | 1981 | 2007 | 26 | 1264 | CORROSION | $288,739 |
| NORTHWEST PIPELINE | ID | 1966 | 2007 | 41 | 470 | THIRD PARTY DAMAGE | $17,576 |
| ROCKY MOUNTAIN NATURAL GAS COMPANY | CO | 1975 | 2007 | 32 | 1280 | CORROSION | $253,159 |
| COLUMBIA GULF TRANSMISSION | MS | 1964 | 2007 | 43 | 900 | PIPELINE DESIGN | $266,798 |
| ONEOK WESTEX TRANSMISSION, L.P. | TX | 1967 | 2007 | 40 | 1000 | CORROSION | $260,335 |
| NORTHWEST PIPELINE | ID | 1990 | 2007 | 17 | 1440 | CORROSION | $104,902 |
| OKLAHOMA NATURAL GAS COMPANY | OK | 1983 | 2007 | 24 | 1440 | CORROSION | $411,816 |
| TRUNKLINE GAS COMPANY, LLC | | 2002 | 2007 | 5 | 1440 | THIRD PARTY DAMAGE | $62,318 |
| COLUMBIA GULF TRANSMISSION | LA | 1931 | 2007 | 76 | 780 | THIRD PARTY DAMAGE | $143,331 |
| TENNESSEE GAS PIPELINE | LA | 1972 | 2007 | 35 | 1440 | CORROSION | $216,035 |
| COLUMBIA GAS TRANSMISSION | PA | 1948 | 2007 | 59 | 900 | PIPELINE DESIGN | $57,770 |
| CROSSTEX CCNG TRANSMISSION LTD. | TX | 1977 | 2007 | 30 | 1300 | CORROSION | $1,003,315 |
| SOUTHERN STAR CENTRAL GAS PIPELINE | KS | 2007 | 2007 | 1 | 1000 | CORROSION | $0 |
| TEXAS EASTERN TRANSMISSION, LP | LA | 1958 | 2007 | 49 | 960 | CORROSION | $72,704 |
| ATMOS PIPELINE - TEXAS | TX | 2007 | 2007 | 1 | 1200 | PIPELINE DESIGN | $271,809 |
| MISSISSIPPI RIVER GAS TRANSMISSION | MO | 1982 | 2007 | 25 | 1200 | THIRD PARTY DAMAGE | $418,801 |
| CROSSTEX NORTH TEXAS PIPELINE, L.P. | TX | 1981 | 2007 | 26 | 720 | CORROSION | $337,554 |
| ATMOS PIPELINE - TEXAS | TX | 1979 | 2007 | 28 | 1250 | CORROSION | $228,706 |
| COLUMBIA GAS OF OHIO INC | OH | 1959 | 2007 | 48 | 1072 | CORROSION | ####### |
| NORTHERN NATURAL GAS COMPANY | MN | 1969 | 2007 | 38 | 1250 | PIPELINE DESIGN | $124,635 |
| KINDER MORGAN TEJAS PIPELINE | TX | 1982 | 2007 | 25 | 1200 | THIRD PARTY DAMAGE | $418,800 |
| SOUTHERN STAR CENTRAL GAS PIPELINE INC. | KS | 2003 | 2007 | 4 | 604 | CORROSION | $311,589 |

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|---|---|---|---|---|---|---|---|
| GULF SOUTH PIPELINE COMPANY, LP | | 1993 | 2007 | 14 | 850 | CORROSION | $98,670 |
| PRAXAIR. INC. | TX | 1999 | 2007 | 8 | 1440 | THIRD PARTY DAMAGE | $140,920 |
| DAVIS PETROLEUM PIPELINE, LLC. | TX | 2001 | 2007 | 6 | 1200 | INCORRECT OPERATION | $70,731 |
| COLUMBIA GULF TRANSMISSION | LA | 1958 | 2007 | 49 | 960 | CORROSION | $72,704 |
| COLUMBIA GULF TRANSMISSION | LA | 2003 | 2007 | 4 | 840 | INCORRECT OPERATION | $111,133 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1978 | 2007 | 29 | 720 | CORROSION | $1,608,701 |
| CROSSTEX LIG, LLC | LA | 1967 | 2007 | 40 | 730 | CORROSION | $679,752 |
| SABCO OPERATING COMPANY | | 1980 | 2007 | 27 | 1440 | CORROSION | $206,919 |
| OKLAHOMA NATURAL GAS COMPANY | OK | 1986 | 2007 | 21 | 845 | CORROSION | $30,676 |
| DOMINION TRANSMISSION, INC. | WV | 1954 | 2007 | 53 | 625 | THIRD PARTY DAMAGE | $46,738 |
| COLORADO INTERSTATE GAS | WY | 1980 | 2007 | 27 | 1440 | CORROSION | $477,769 |
| BRIDGELINE GAS DISTRIBUTION LLC | LA | 1950 | 2007 | 57 | 840 | INCORRECT OPERATION | $127,232 |
| NATURAL GAS PIPELINE CO. OF AMERICA | OK | 1953 | 2007 | 54 | 324 | | $419,003 |
| PACIFIC GAS & ELECTRIC COMPANY | CA | 2005 | 2007 | 2 | 1000 | CORROSION | $2,294,643 |
| AIR PRODUCTS L.P. | TX | 1990 | 2007 | 17 | 800 | CORROSION | $314,681 |
| ENTERPRISE PRODUCTS OPERATING L.P. | TX | 1996 | 2007 | 11 | 1200 | THIRD PARTY DAMAGE | $10,494 |
| CONSUMERS ENERGY | MI | 1968 | 2007 | 39 | 960 | THIRD PARTY DAMAGE | $76,921 |
| TRANSCONTINENTAL GAS PIPE LINE COMPANY | LA | 1960 | 2007 | 47 | 1674 | CORROSION | $0 |
| ONEOK WESTEX TRANSMISSION | TX | 1981 | 2007 | 26 | 1264 | OTHERS | $490,233 |
| IBERVILLE PARISH NATURAL GAS SYSTEM | LA | 1964 | 2007 | 43 | 800 | CORROSION | $1,436,112 |
| SOUTHWEST GAS CORPORATION | NV | 1965 | 2007 | 42 | 1169 | CORROSION | $67,511 |
| TRANSCONTINENTAL GAS PIPE LINE COMPANY | | 1977 | 2007 | 30 | 1585 | CORROSION | $371,474 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 1990 | 2007 | 17 | 1440 | PIPELINE DESIGN | $145,408 |

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|---|---|---|---|---|---|---|---|
| WILLIAMS GAS PIPELINE - TRANSCO | MD | 2000 | 2007 | 7 | 973 | PIPELINE DESIGN | $159,389 |
| NORTHWEST PIPELINE | WY | 1959 | 2007 | 48 | 840 | CORROSION | $299,125 |
| COLUMBIA GAS TRANSMISSION CORPORATION | PA | 1980 | 2007 | 27 | 2000 | CORROSION | $3,012 |
| ENTERPRISE PRODUCTS OPERATING LLC. | | 1961 | 2007 | 46 | 1000 | CORROSION | $158,814 |
| PANTHER PIPELINE LTD | TX | 1983 | 2007 | 24 | 685 | THIRD PARTY DAMAGE | $52,451 |
| PANTHER PIPELINE, LTD. | TX | 1956 | 2007 | 51 | 800 | THIRD PARTY DAMAGE | $49,870 |
| ANR PIPELINE COMPANY | MI | 1969 | 2007 | 38 | 858 | PIPELINE DESIGN | $232,200 |
| SOUTHERN NATURAL GAS PIPELINE | LA | 1962 | 2007 | 45 | 900 | CORROSION | $595,861 |
| NORTHERN NATURAL GAS COMPANY | IA | 1977 | 2007 | 30 | 1300 | CORROSION | $852,714 |
| TENNESSEE GAS PIPELINE | LA | 1965 | 2007 | 42 | 1190 | CORROSION | $57,712 |
| NORTHERN NATURAL GAS COMPANY | KS | 1994 | 2007 | 13 | 1200 | CORROSION | $812,208 |
| PUBLIC SERVICE CO OF COLORADO | CO | 1987 | 2007 | 20 | 960 | THIRD PARTY DAMAGE | $95,554 |
| PUBLIC SERVICE COMPANY OF NEW MEXICO | NM | 1978 | 2007 | 29 | 1080 | CORROSION | $109,738 |
| PANTHER PIPELINE, LTD. | TX | 1967 | 2007 | 40 | 250 | CORROSION | $259,728 |
| PUBLIC SERVICE CO OF COLORADO | CO | 1954 | 2007 | 53 | 935 | CORROSION | $3,163,092 |
| COLUMBIA GULF TRANSMISSION | LA | 1965 | 2007 | 42 | 900 | CORROSION | $171,834 |
| PACIFIC GAS & ELECTRIC | CA | 1953 | 2007 | 54 | 650 | CORROSION | $594,781 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 1968 | 2007 | 39 | 1000 | OTHERS | $490,700 |
| SOUTHERN NATURAL GAS COMPANY | AL | 1961 | 2008 | 47 | 500 | CORROSION | $141,912 |
| ENOGEX INC | OK | 1984 | 2008 | 24 | 920 | PIPELINE DESIGN | $17,923 |
| BLUE DOLPHIN PIPE LINE COMPANY | | 1976 | 2008 | 32 | 275 | INCORRECT OPERATION | $86,800 |
| SOUTHERN NATURAL GAS COMPANY | | 1973 | 2008 | 35 | 1250 | CORROSION | $1,186,000 |
| ENTERPRISE PRODUCTS OPERATING L.P. | | 1948 | 2008 | 60 | 500 | PIPELINE DESIGN | $187,500 |
| STARR COUNTY GAS SYSTEM | TX | 1973 | 2008 | 35 | 1440 | CORROSION | $482,700 |

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|---|---|---|---|---|---|---|---|
| GULF SOUTH PIPELINE COMPANY, LP | MS | 2007 | 2008 | 1 | 720 | INCORRECT OPERATION | $10,325 |
| SOUTHERN STAR CENTRAL GAS PIPELINE, INC | KS | 1959 | 2008 | 49 | 975 | PIPELINE DESIGN | $124,100 |
| SOUTHERN CALIFORNIA GAS COMPANY | CA | 1964 | 2008 | 44 | 1024 | CORROSION | $847,302 |
| ENTERPRISE PRODUCTS OPERATING L.P. | | 1983 | 2008 | 25 | 1440 | CORROSION | $335,000 |
| NORTHERN NATUAL GAS COMPANY | IA | 2000 | 2008 | 8 | 1200 | CORROSION | $300,000 |
| SEA ROBIN PIPELINE COMPANY | | 2001 | 2008 | 7 | 1200 | PIPELINE DESIGN | $510,000 |
| ENERGY PARTNERS LTD | LA | 1965 | 2008 | 43 | 800 | CORROSION | $539,300 |
| PANHANDLE ENERGY | KS | 1947 | 2008 | 61 | 1000 | CORROSION | $52,003 |
| TENNESSEE GAS PIPELINE | TX | 1954 | 2008 | 54 | 1008 | OTHERS | ####### |
| AQUILA NETWORKS | KS | 1969 | 2008 | 39 | 1000 | CORROSION | $67,532 |
| ACADIAN GAS PIPELINE SYSTEM | LA | 2008 | 2008 | 1 | 1287 | CORROSION | $91,500 |
| BREITBURN ENERGY CORP | CA | 1950 | 2008 | 58 | 800 | CORROSION | $185,790 |
| TENNESSEE GAS PIPELINE | | 1951 | 2008 | 57 | 1200 | PIPELINE DESIGN | $138,000 |
| SABCO OPERATING COMPANY | | 1977 | 2008 | 31 | 1440 | CORROSION | $574,335 |
| REGENCY GAS SERVICES | LA | 1955 | 2008 | 53 | 275 | THIRD PARTY DAMAGE | $43,800 |
| NORTHERN NATURAL GAS COMPANY | TX | 1931 | 2008 | 77 | 500 | CORROSION | $69,783 |
| NORTHERN NATURAL GAS COMPANY | KS | 2007 | 2008 | 1 | 3640 | PIPELINE DESIGN | ####### |
| NORTHERN NATURAL GAS COMPANY | WI | 2003 | 2008 | 5 | 877 | THIRD PARTY DAMAGE | $302,000 |
| NORTHERN NATURAL GAS COMPANY | SD | 1958 | 2008 | 50 | 1100 | THIRD PARTY DAMAGE | $7,450,000 |
| CENTERPOINT ENERGRY - MISSISSIPPI RIVER TRANSMISSION CORP. | IL | 1954 | 2008 | 54 | 811 | OTHERS | $2,516,000 |
| FLORIDA GAS TRANSMISSION COMPANY LLC | FL | 1979 | 2008 | 29 | 128 | THIRD PARTY DAMAGE | $15,000 |
| GULF SOUTH PIPELINE COMPANY, LP | TX | 1972 | 2008 | 36 | 1200 | PIPELINE DESIGN | $528,000 |
| GRANITE STATE GAS TRANSMISSION INCORPORATED | ME | 1951 | 2008 | 57 | 525 | THIRD PARTY DAMAGE | $151,485 |

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|---|---|---|---|---|---|---|---|
| QUESTAR PIPELINE COMPANY | UT | 1952 | 2008 | 56 | 982 | OTHERS | $72,671 |
| THE PEOPLES GAS LIGHT AND COKE COMPANY | IL | 1971 | 2008 | 37 | 437 | THIRD PARTY DAMAGE | $94,000 |
| TENNESSEE GAS PIPELINE | | 1930 | 2008 | 78 | 500 | PIPELINE DESIGN | $283,192 |
| MONTEZUMA NATURAL GAS DEPT, CITY OF MONTEZUMA,IOWA | IA | 1951 | 2008 | 57 | 900 | THIRD PARTY DAMAGE | $100,000 |
| ENERGY TRANSFER COMPANY | TX | 1959 | 2008 | 49 | 915 | CORROSION | $72,100 |
| ENERGY TRANSFER COMPANY | TX | 1957 | 2008 | 51 | 400 | THIRD PARTY DAMAGE | $16,277 |
| PANHANDLE EASTERN PIPELINE COMPANY | IL | 1961 | 2008 | 47 | 425 | OTHERS | $530,000 |
| PANTHER PIPELINE, LTD. | TX | 1990 | 2008 | 18 | 200 | OTHERS | $6,877 |
| SEA ROBIN PIPELINE COMPANY | | 1963 | 2008 | 45 | 950 | THIRD PARTY DAMAGE | $85,203 |
| EL PASO NATURAL GAS COMPANY | AZ | 1959 | 2008 | 49 | 1168 | CORROSION | $575,000 |
| TRANSCONTINENTAL GAS PIPE LINE COMPANY | | 1961 | 2008 | 47 | 960 | | $23,947 |
| SABCO OPERATING COMPANY | | 1957 | 2008 | 51 | 400 | INCORRECT OPERATION | $14,497 |
| ENTERPRISE PRODUCTS OPERATING L.P. | | 1991 | 2008 | 17 | 1000 | INCORRECT OPERATION | $208,250 |
| PANTHER PIPELINE, LTD. | TX | 1992 | 2008 | 16 | 1440 | THIRD PARTY DAMAGE | $155,703 |
| MISSISSIPPI RIVER TRANSMISSION | LA | 1953 | 2008 | 55 | 500 | INCORRECT OPERATION | $100,000 |
| ANR PIPELINE COMPANY | WI | 1968 | 2008 | 40 | 1300 | PIPELINE DESIGN | $232,500 |
| BOSS EXPLORATION | TX | 1931 | 2008 | 77 | 500 | OTHERS | $818,910 |
| ENTERPRISE PRODUCTS OPERATING L.P. | | 1990 | 2008 | 18 | 1250 | CORROSION | $180,000 |
| KINDER MORGAN TEJAS | TX | 1959 | 2008 | 49 | 915 | CORROSION | $79,988 |
| MICHIGAN CONSOLIDATED GAS COMPANY | MI | 1967 | 2008 | 41 | 500 | THIRD PARTY DAMAGE | $210,428 |
| TENNESSEE GAS PIPELINE | | 1978 | 2008 | 30 | 500 | CORROSION | $374,322 |
| KANSAS GAS SERVICE | KS | 1969 | 2008 | 39 | 975 | OTHERS | $0 |
| SABCO OPERATING COMPANY | | 1952 | 2008 | 56 | 725 | PIPELINE DESIGN | $53,705 |

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|---|---|---|---|---|---|---|---|
| SOUTHERN STAR CENTRAL GAS PIPELINE INC. | KS | 1937 | 2008 | 71 | 800 | CORROSION | $1,046,359 |
| TENNESSEE GAS PIPELINE | LA | 1984 | 2008 | 24 | 3000 | CORROSION | $1,068,000 |
| TRANSCONTINENTAL GAS PIPE LINE COMPANY | | 1970 | 2008 | 38 | 1050 | CORROSION | $1,233,865 |
| TRANSCONTINENTAL GAS PIPE LINE COMPANY | | 2003 | 2008 | 5 | 720 | INCORRECT OPERATION | $23,000 |
| BOSS EXPLORATION | TX | 2001 | 2008 | 7 | 1480 | PIPELINE DESIGN | $168,238 |
| COLUMBIA GULF TRANSMISSION | | 1968 | 2008 | 40 | 899 | THIRD PARTY DAMAGE | $240,000 |
| GULF SOUTH PIPELINE COMPANY, LP | LA | 1959 | 2008 | 49 | 1130 | OTHERS | $7,160,000 |
| TENNESSEE GAS PIPELINE | | 1960 | 2008 | 48 | 1000 | CORROSION | $50,186 |
| SOUTHERN STAR CENTRAL GAS PIPELINE INC | KS | 1963 | 2008 | 45 | 900 | CORROSION | $430,000 |
| ANR PIPELINE COMPANY | LA | 1995 | 2008 | 13 | 1500 | OTHERS | $830,000 |
| GULF SOUTH PIPELINE COMPANY, LP | MS | 1986 | 2008 | 22 | 500 | THIRD PARTY DAMAGE | $32,000 |
| COLUMBIA GAS TRANSMISSION | MD | 1948 | 2008 | 60 | 900 | THIRD PARTY DAMAGE | $80,008 |
| PANTHER PIPELINE, LTD. | TX | 1968 | 2008 | 40 | 1250 | OTHERS | $248,171 |
| WILLIAMS GAS PIPELINE - TRANSCO | PA | 1967 | 2008 | 41 | 1168 | THIRD PARTY DAMAGE | ####### |
| SABCO OPERATING COMPANY | | 1955 | 2008 | 53 | 800 | CORROSION | $5,416,000 |
| ONEOK WESTEX TRANSMISSION | TX | 1969 | 2008 | 39 | 4240 | OTHERS | $0 |
| NORTHERN NATURAL GAS COMPANY | SD | 1968 | 2008 | 40 | 1440 | CORROSION | $0 |
| COLUMBIA GAS TRANSMISSION | OH | 1978 | 2008 | 30 | 1300 | OTHERS | $5,276,000 |
| COLUMBIA GULF TRANSMISSION | | 1972 | 2008 | 36 | 1200 | OTHERS | $1,370,000 |
| SOUTHERN NATURAL GAS COMPANY | LA | 1972 | 2008 | 36 | 1200 | OTHERS | ####### |
| TENNESSEE GAS PIPELINE | LA | 1977 | 2008 | 31 | 1250 | OTHERS | ####### |
| ONEOK WESTEX TRANSMISSION | TX | 2005 | 2008 | 3 | 1440 | OTHERS | $96,000 |

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|---|---|---|---|---|---|---|---|
| TENNESSEE GAS PIPELINE | TX | 1979 | 2008 | 29 | 1440 | OTHERS | ####### |
| WILLIAMS NORTHWEST PIPELINE | ID | 1989 | 2008 | 19 | 1300 | OTHERS | $7,889,000 |
| NORTHERN NATURAL GAS COMPANY | TX | 1974 | 2008 | 34 | 1200 | CORROSION | $6,886,709 |
| ACADIAN GAS PIPELINE SYSTEM | LA | 2003 | 2008 | 5 | 2875 | PIPELINE DESIGN | $278,459 |
| CAROLINA GAS TRANSMISSION | SC | 1968 | 2008 | 40 | 1300 | OTHERS | $5,000,000 |
| NORTHERN NATURAL GAS COMPANY | MN | 1972 | 2008 | 36 | 1306 | OTHERS | ####### |
| PANTHER PIPELINE, LTD. | TX | 1972 | 2008 | 36 | 1306 | OTHERS | $200,000 |
| COLUMBIA GULF TRANSMISSION | LA | 1972 | 2008 | 36 | 1250 | OTHERS | $1,286,209 |
| SOUTHERN STAR CENTRAL GAS PIPELINE | KS | 1979 | 2008 | 29 | 1200 | CORROSION | $7,700,000 |
| KINDER MORGAN TEJAS PIPELINE | TX | 1962 | 2008 | 46 | 1138 | OTHERS | ####### |
| ENTERPRISE PRODUCTS OPERATING LLC. | | 1954 | 2008 | 54 | 600 | CORROSION | $0 |
| PANHANDLE EASTERN PIPELINE COMPANY | IL | 1961 | 2008 | 47 | 1069 | OTHERS | $3,750,000 |
| PACIFIC GAS & ELECTRIC | CA | 1977 | 2008 | 31 | 1219 | OTHERS | $7,500,000 |
| GULF SOUTH PIPELINE COMPANY, LP | LA | 1950 | 2008 | 58 | 1225 | CORROSION | $350,000 |
| NORTHERN NATURAL GAS COMPANY | LA | 1957 | 2008 | 51 | 1100 | THIRD PARTY DAMAGE | $120,010 |
| TENNESSEE GAS PIPELINE | LA | 1967 | 2008 | 41 | 1300 | OTHERS | $350,000 |
| PACIFIC GAS & ELECTRIC COMPANY | CA | 1978 | 2008 | 30 | 1300 | OTHERS | $470,000 |
| SOUTHERN NATURAL GAS COMPANY | GA | 1973 | 2008 | 35 | 1250 | OTHERS | $425,000 |
| COLORADO INTERSTATE PIPELINE COMPANY | CO | 1929 | 2008 | 79 | 985 | PIPELINE DESIGN | $14,000 |
| WILLIAMS GAS PIPELINES/TRANSCO | AL | 2003 | 2008 | 5 | 1440 | OTHERS | $70,000 |
| CENTERPOINT ENERGY GAS TRANSMISSION | LA | 1945 | 2008 | 63 | 686 | THIRD PARTY DAMAGE | $70,589 |
| PUBLIC SERVICE COMPANY OF COLORADO | CO | 1997 | 2008 | 11 | 1480 | CORROSION | $1,380,660 |
| CONSUMERS ENERGY | MI | 1990 | 2008 | 18 | 1440 | OTHERS | $8,050,000 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | LA | 1970 | 2008 | 38 | 1008 | INCORRECT OPERATION | $58,233 |

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|---|---|---|---|---|---|---|---|
| NATURAL GAS PIPELINE COMPANY OF AMERICA | IL | 1974 | 2008 | 34 | 1250 | OTHERS | $70,000 |
| TEXAS GAS TRANSMISSION LLC | LA | 1990 | 2008 | 18 | 1250 | CORROSION | $906,000 |
| TRANSCONTINENTAL GAS PIPE LINE COMPANY | LA | 1989 | 2008 | 19 | 930 | INCORRECT OPERATION | $13,526 |
| UCAR PIPELINE INCORPORATED | TX | 1951 | 2008 | 57 | 760 | CORROSION | $51,002 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | | 1948 | 2008 | 60 | 1000 | OTHERS | $1,849,692 |
| ENERGY TRANSFER COMPANY | TX | 1974 | 2008 | 34 | 1000 | THIRD PARTY DAMAGE | $119,700 |
| TEXAS GAS TRANSMISSION LLC | KY | 1951 | 2008 | 57 | 450 | THIRD PARTY DAMAGE | $41,100 |
| CROSSTEX LIG, LLC | LA | 1970 | 2008 | 38 | 1250 | THIRD PARTY DAMAGE | $231,000 |
| LAMAR OIL & GAS | TX | 1967 | 2008 | 41 | 974 | PIPELINE DESIGN | $75,000 |
| NORTHERN NATURAL GAS CO | TX | 1988 | 2008 | 20 | 1440 | OTHERS | $134,900 |
| ALASKA PIPELINE COMPANY | AK | 1967 | 2008 | 41 | 1440 | CORROSION | $101,990 |
| ATMOS PIPELINE - TEXAS | TX | 1984 | 2008 | 24 | 1000 | INCORRECT OPERATION | $3,010 |
| NORTHERN NATURAL GAS CO | SD | 1990 | 2008 | 18 | 1000 | THIRD PARTY DAMAGE | $11,876 |
| COLUMBIA GULF TRANSMISSION CO | | 1993 | 2008 | 15 | 1050 | PIPELINE DESIGN | $40,000 |
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | IL | 2005 | 2008 | 3 | 100 | INCORRECT OPERATION | $1,000,000 |
| PANHANDLE EASTERN PIPELINE CO | KS | 2005 | 2008 | 3 | 840 | CORROSION | $86,350 |
| ANR PIPELINE CO | LA | 1946 | 2008 | 62 | 500 | PIPELINE DESIGN | $71,954 |
| SOUTHERN NATURAL GAS CO | GA | 1966 | 2009 | 43 | 960 | CORROSION | $1,109,800 |
| DOMINION TRANSMISSION INC | PA | 1958 | 2009 | 51 | 1800 | OTHERS | $29,011 |
| ATLANTA GAS LIGHT CO | GA | 1941 | 2009 | 68 | 500 | OTHERS | $247,796 |
| ENBRIDGE PIPELINES (EAST TEXAS) L.P. | TX | 1970 | 2009 | 39 | 1250 | OTHERS | $125,000 |
| ONEOK WESTEX TRANSMISSION, INC. | TX | 1971 | 2009 | 38 | 960 | PIPELINE DESIGN | $128,035 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1972 | 2009 | 37 | 800 | CORROSION | $4,366 |

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|---|---|---|---|---|---|---|---|
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | TX | 1958 | 2009 | 51 | 960 | CORROSION | $85,000 |
| SOUTHERN NATURAL GAS CO | AL | 1966 | 2009 | 43 | 960 | CORROSION | $0 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1978 | 2009 | 31 | 1654 | INCORRECT OPERATION | $9,385 |
| SEADRIFT PIPELINE CORP | TX | 1963 | 2009 | 46 | 400 | THIRD PARTY DAMAGE | $50,000 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1949 | 2009 | 60 | 1000 | OTHERS | $81,333 |
| ATMOS PIPELINE - TEXAS | TX | 1973 | 2009 | 36 | 1250 | OTHERS | $1,500,000 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | | 1972 | 2009 | 37 | 1250 | CORROSION | $1,731,541 |
| MARKWEST PINNACLE LP | TX | 1978 | 2009 | 31 | 1000 | OTHERS | $6,000,620 |
| PANHANDLE EASTERN PIPELINE CO | MI | 1990 | 2009 | 19 | 1050 | OTHERS | $201,000 |
| CENTERPOINT ENERGY GAS TRANSMISSION | OK | 1989 | 2009 | 20 | 1000 | OTHERS | ####### |
| TENNESSEE GAS PIPELINE CO (EL PASO) | | 2008 | 2009 | 1 | 350 | OTHERS | $53,123 |
| SOUTHERN NATURAL GAS CO | AL | 1990 | 2009 | 19 | 1300 | THIRD PARTY DAMAGE | $618,000 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | | 2007 | 2009 | 2 | 1250 | PIPELINE DESIGN | $2,283,650 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1958 | 2009 | 51 | 960 | CORROSION | $70,000 |
| CONSUMERS ENERGY | IA | 2007 | 2009 | 2 | 1000 | CORROSION | $8,000 |
| FLORIDA GAS TRANSMISSION CO | FL | 2008 | 2009 | 1 | 1008 | CORROSION | $132,000 |
| TEXAS GAS TRANSMISSION LLC | TN | 2003 | 2009 | 6 | 1000 | CORROSION | $39,900 |
| KINDER MORGAN TEXAS PIPELINE CO | TX | 1978 | 2009 | 31 | 1250 | CORROSION | $756,912 |
| ENTERPRISE PRODUCTS OPERATING LLC | | 1942 | 2009 | 67 | 712 | THIRD PARTY DAMAGE | $83,000 |
| WILLIAMS GAS PIPELINE - TRANSCO | PA | 1957 | 2009 | 52 | 894 | CORROSION | $86,092 |
| UGI PENN NATURAL GAS | PA | 1983 | 2009 | 26 | 1440 | OTHERS | $3,000,000 |
| ANR PIPELINE CO | MI | 1997 | 2009 | 12 | 2467 | CORROSION | $0 |
| SOUTHERN NATURAL GAS CO | MS | 1959 | 2009 | 50 | 975 | CORROSION | $62,000 |
| COLUMBIA GULF TRANSMISSION CO | TN | 1990 | 2009 | 19 | 1250 | CORROSION | $200,000 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1993 | 2009 | 16 | 1100 | CORROSION | $150,000 |

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|---|---|---|---|---|---|---|---|
| TRANS - COLORADO PIPELINE CO | CO | 1965 | 2009 | 44 | 900 | CORROSION | $85,135 |
| WILLIAMS GAS PIPELINE - TRANSCO | GA | 1985 | 2009 | 24 | 350 | THIRD PARTY DAMAGE | $110,863 |
| TEXAS GAS TRANSMISSION LLC | LA | 1958 | 2009 | 51 | 960 | CORROSION | $55,000 |
| SOUTHERN NATURAL GAS CO | AL | 1972 | 2009 | 37 | 1260 | CORROSION | $450,000 |
| SOUTHERN STAR CENTRAL GAS PIPELINE, INC | KS | 1958 | 2009 | 51 | 960 | CORROSION | $55,000 |
| WILLIAMS GAS PIPELINE - TRANSCO | TX | 1959 | 2009 | 50 | 936 | OTHERS | $115,360 |
| PACIFIC GAS & ELECTRIC CO | CA | 1966 | 2009 | 43 | 960 | CORROSION | $0 |
| ATLANTA GAS LIGHT CO | GA | 1967 | 2009 | 42 | 1070 | CORROSION | $179,000 |
| NORTHERN NATURAL GAS CO | KS | 1953 | 2009 | 56 | 800 | OTHERS | $83,474 |
| ENTERPRISE PRODUCTS OPERATING LLC | | 1959 | 2009 | 50 | 866 | OTHERS | $606,360 |
| VIKING GAS TRANSMISSION CO | ND | 1940 | 2009 | 69 | 800 | CORROSION | $1,284,500 |
| SOUTHERN NATURAL GAS CO | LA | 1966 | 2009 | 43 | 895 | THIRD PARTY DAMAGE | $316,630 |
| BRIDGELINE HOLDINGS, LP | LA | 2009 | 2009 | 1 | 931 | THIRD PARTY DAMAGE | $1,519,750 |
| CRANBERRY PIPELINE CORP (WV) | WV | 2008 | 2009 | 1 | 858 | OTHERS | $461,854 |
| SOUTHERN NATURAL GAS CO | LA | 1950 | 2009 | 59 | 822 | THIRD PARTY DAMAGE | $40,000 |
| NEW JERSEY NATURAL GAS CO | NJ | 1959 | 2009 | 50 | 975 | PIPELINE DESIGN | $279,320 |
| MISSISSIPPI RIVER TRANSMISSION CORP | MO | 1956 | 2009 | 53 | 809 | CORROSION | $69,000 |
| GULF SOUTH PIPELINE COMPANY, LP | LA | 1981 | 2009 | 28 | 2500 | CORROSION | $48,912 |
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | IL | 1940 | 2009 | 69 | 800 | OTHERS | $722,850 |
| NORTHERN NATURAL GAS CO | NE | 2007 | 2009 | 2 | 1071 | PIPELINE DESIGN | $9,227,057 |
| MISSISSIPPI RIVER TRANSMISSION CORP | TX | 1950 | 2009 | 59 | 850 | OTHERS | $0 |
| FLORIDA GAS TRANSMISSION CO | FL | 1956 | 2009 | 53 | 811 | PIPELINE DESIGN | $0 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 2004 | 2009 | 5 | 1440 | CORROSION | $130,000 |

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|---|---|---|---|---|---|---|---|
| NORTHERN NATURAL GAS CO | MN | 1981 | 2009 | 28 | 1200 | CORROSION | $114,426 |
| NORTHERN NATURAL GAS CO | KS | 1966 | 2009 | 43 | 658 | CORROSION | $252,421 |
| MISSISSIPPI RIVER TRANSMISSION CORP | IL | 1965 | 2009 | 44 | 1090 | CORROSION | $692,449 |
| NORTHERN NATURAL GAS CO | MN | 1975 | 2009 | 34 | 374 | OTHERS | $454,850 |
| WILLIAMS GAS PIPELINE - TRANSCO | LA | 1948 | 2009 | 61 | 624 | PIPELINE DESIGN | $88,968 |
| NORTHERN NATURAL GAS CO | IA | 2009 | 2009 | 1 | 1332 | PIPELINE DESIGN | $275,500 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1971 | 2009 | 38 | 900 | CORROSION | $57,442 |
| CENTERPOINT ENERGY GAS TRANSMISSION | OK | 1970 | 2009 | 39 | 1182 | CORROSION | $275 |
| PRAXAIR, INC | TX | 1983 | 2009 | 26 | 1200 | INCORRECT OPERATION | $115,050 |
| MIDWESTERN GAS TRANSMISSION COMPANY | IN | 2006 | 2009 | 3 | 1300 | CORROSION | $35,000 |
| STONE ENERGY | LA | 1958 | 2009 | 51 | 960 | CORROSION | $65,000 |
| MISSISSIPPI RIVER TRANSMISSION CORP | AR | 1952 | 2009 | 57 | 600 | CORROSION | $8,000 |
| CENTERPOINT ENERGY GAS TRANSMISSION | TX | 1974 | 2009 | 35 | 1000 | | $2,503 |
| TEXAS EASTERN TRANSMISSION LP (SPECTRA ENERGY CORP) | OH | 1948 | 2009 | 61 | 200 | THIRD PARTY DAMAGE | $63,000 |
| ANR PIPELINE CO | LA | 1967 | 2009 | 42 | 2000 | CORROSION | $100,000 |
| NORTHERN NATURAL GAS CO | NE | 1978 | 2009 | 31 | 850 | OTHERS | $0 |
| WILLIAMS GAS PIPELINE - TRANSCO | TX | 1980 | 2009 | 29 | 1440 | CORROSION | $1,565 |
| PACIFIC GAS & ELECTRIC CO | CA | 1984 | 2009 | 25 | 1440 | OTHERS | $170,000 |
| GULF SOUTH PIPELINE COMPANY, LP | MS | 1992 | 2009 | 17 | 1300 | THIRD PARTY DAMAGE | $800,000 |
| FLORIDA GAS TRANSMISSION CO | FL | 1987 | 2009 | 22 | 480 | CORROSION | $50,000 |
| OKLAHOMA NATURAL GAS CO | OK | 1981 | 2009 | 28 | 850 | CORROSION | $200,000 |
| SOUTHERN STAR CENTRAL GAS PIPELINE, INC | KS | 1978 | 2009 | 31 | 1300 | CORROSION | $300,000 |
| GULF SOUTH PIPELINE COMPANY, LP | LA | 2009 | 2009 | 1 | 2650 | CORROSION | $102,000 |

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|---|---|---|---|---|---|---|---|
| ONEOK GAS TRANSPORTATION, LLC | OK | 1947 | 2009 | 62 | 837 | THIRD PARTY DAMAGE | $504,105 |
| PANHANDLE EASTERN PIPELINE CO | MO | 1956 | 2009 | 53 | 850 | PIPELINE DESIGN | $132,430 |
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | TX | 2007 | 2009 | 2 | 1200 | CORROSION | $200,000 |
| ENERGY TRANSFER COMPANY | TX | 1981 | 2009 | 28 | 1200 | CORROSION | $107,028 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1978 | 2009 | 31 | 1300 | OTHERS | $150,000 |
| TRUNKLINE GAS CO | LA | 1950 | 2009 | 59 | 750 | OTHERS | $70,000 |
| ENTERPRISE PRODUCTS OPERATING LLC | TX | 1961 | 2009 | 48 | 800 | THIRD PARTY DAMAGE | $21,500 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | LA | 1998 | 2001 | 3 | 3440 | OTHERS | 119015.05 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1998 | 1999 | 1 | 3440 | OTHERS | 124260.36 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1961 | 1998 | 37 | 275 | THIRD PARTY DAMAGE | 2517829.5 |
| ENTERPRISE PRODUCTS OPERATING LLC | | 1984 | 1993 | 9 | 1050 | THIRD PARTY DAMAGE | 4823489.5 |
| WILLIAMS ENERGY, LLC | LA | 1960 | 1994 | 34 | 1000 | CORROSION | 67456.801 |
| CENTERPOINT ENERGY GAS TRANSMISSION | LA | 1952 | 2001 | 49 | 750 | CORROSION | 259274.28 |
| COLUMBIA GAS TRANSMISSION CORP | OH | 1962 | 1998 | 36 | 600 | THIRD PARTY DAMAGE | 214015.5 |
| ANR PIPELINE CO | LA | 1969 | 1997 | 28 | 200 | OTHERS | 0 |
| WILLIAMS GAS PIPELINE - TRANSCO | | 1987 | 1997 | 10 | 1300 | THIRD PARTY DAMAGE | 96220.598 |
| WILLIAMS GAS PIPELINE - TRANSCO | VA | 1948 | 1996 | 48 | 650 | THIRD PARTY DAMAGE | 105562.16 |
| DOMINION TRANSMISSION INC | PA | 1965 | 1995 | 30 | 350 | OTHERS | 0 |
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | LA | 1993 | 1995 | 2 | 1933 | OTHERS | 145346.06 |
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | LA | 1993 | 1995 | 2 | 1480 | OTHERS | 277478.85 |
| WILLIAMS GAS PIPELINE - TRANSCO | LA | 1951 | 1993 | 42 | 800 | PIPELINE DESIGN | 0 |
| LAMAR OIL & GAS | TX | 1950 | 1992 | 42 | 780 | OTHERS | 2622745 |
| ANR PIPELINE CO | LA | 1979 | 1992 | 13 | 667 | THIRD PARTY DAMAGE | 281879.19 |
| TRUNKLINE GAS CO | | 1958 | 1986 | 28 | 1200 | OTHERS | 2222315.8 |

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|---|---|---|---|---|---|---|---|
| TRUNKLINE GAS CO | | 1948 | 1998 | 50 | 500 | THIRD PARTY DAMAGE | 82458.915 |
| SEA ROBIN PIPELINE CO | | 1979 | 1996 | 17 | 750 | OTHERS | 0 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | LA | 1948 | 1996 | 48 | 500 | CORROSION | 0 |
| ENTERPRISE PRODUCTS OPERATING LLC | | 1986 | 1996 | 10 | 1003 | THIRD PARTY DAMAGE | 0 |
| ANR PIPELINE CO | LA | 1966 | 1994 | 28 | 270 | PIPELINE DESIGN | 0 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | LA | 1966 | 1989 | 23 | 800 | THIRD PARTY DAMAGE | 12273.286 |
| ENTERPRISE PRODUCTS OPERATING LLC | | 1985 | 1986 | 1 | 2552 | CORROSION | 0 |
| ANR PIPELINE CO | LA | 1959 | 2001 | 42 | 1000 | OTHERS | 0 |
| SEA ROBIN PIPELINE CO | | 1968 | 2001 | 33 | 1000 | THIRD PARTY DAMAGE | 105923.39 |
| SEA ROBIN PIPELINE CO | | 1964 | 1999 | 35 | 720 | THIRD PARTY DAMAGE | 111834.32 |
| SEA ROBIN PIPELINE CO | | 1967 | 1998 | 31 | 1000 | PIPELINE DESIGN | 755348.84 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | LA | 1929 | 1994 | 65 | 720 | THIRD PARTY DAMAGE | 33728.401 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | LA | 1939 | 1991 | 52 | 450 | THIRD PARTY DAMAGE | 95937.367 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | LA | 1979 | 1991 | 12 | 830 | THIRD PARTY DAMAGE | 130035.59 |
| WILLIAMS GAS PIPELINE - TRANSCO | LA | 1951 | 1991 | 40 | 858 | CORROSION | 140149.47 |
| LAVACA PIPELINE CO | TX | 1950 | 1991 | 41 | 858 | PIPELINE DESIGN | 103595.02 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | LA | 1950 | 1991 | 41 | 840 | THIRD PARTY DAMAGE | 339537.37 |
| TRUNKLINE GAS CO | | 1957 | 1990 | 33 | 720 | PIPELINE DESIGN | 149907.69 |
| DOMINION TRANSMISSION INC | PA | 1968 | 1990 | 22 | 720 | THIRD PARTY DAMAGE | 149907.69 |
| TEXAS EASTERN TRANSMISSION LP (SPECTRA ENERGY CORP) | MS | 1920 | 1989 | 69 | 470 | PIPELINE DESIGN | 273637.99 |
| ANR PIPELINE CO | LA | 1968 | 1986 | 18 | 100 | OTHERS | 128210.53 |
| ANR PIPELINE CO | LA | 1953 | 1986 | 33 | 800 | PIPELINE | 317941.59 |

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|---|---|---|---|---|---|---|---|
| | | | | | | DESIGN | |
| TENNESSEE GAS PIPELINE CO (EL PASO) | LA | 1943 | 1986 | 43 | 830 | CORROSION | 907730.53 |
| ENERGY TRANSFER COMPANY | TX | 1951 | 1986 | 35 | 800 | PIPELINE DESIGN | 251897.79 |
| GULF SOUTH PIPELINE COMPANY, LP | | 1964 | 1998 | 34 | 650 | PIPELINE DESIGN | 0 |
| ONEOK GAS TRANSPORTATION, LLC | OK | 1930 | 1997 | 67 | 375 | OTHERS | 80274.087 |
| CHEVRON U.S.A. INC | GM | 1996 | 1996 | 1 | 720 | OTHERS | 73461.152 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | | 1955 | 1996 | 41 | 501 | THIRD PARTY DAMAGE | 64821.714 |
| COLUMBIA GAS TRANSMISSION CORP | VA | 1947 | 1990 | 43 | 530 | PIPELINE DESIGN | 76452.923 |
| COLUMBIA GULF TRANSMISSION CO | MS | 1929 | 1988 | 59 | 415 | CORROSION | 0 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | | 1929 | 1987 | 58 | 550 | CORROSION | 20241.691 |
| WILLIAMS GAS PIPELINE - TRANSCO | TX | 1951 | 2001 | 50 | 845 | CORROSION | 877735.98 |
| CENTERPOINT ENERGY GAS TRANSMISSION | LA | 1959 | 2001 | 42 | 845 | OTHERS | 635540.36 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | NY | 1950 | 2000 | 50 | 650 | THIRD PARTY DAMAGE | 188790 |
| COLUMBIA GAS TRANSMISSION CORP | PA | 1947 | 1990 | 43 | 809 | CORROSION | 449723.08 |
| REGENCY INTRASTATE GAS LLC | LA | 1953 | 1986 | 33 | 845 | PIPELINE DESIGN | 0 |
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | IL | 1955 | 1999 | 44 | 650 | THIRD PARTY DAMAGE | 62130.178 |
| WILLISTON BASIN INTERSTATE PIPELINE CO | MT | 1957 | 1998 | 41 | 809 | THIRD PARTY DAMAGE | 31472.868 |
| DOMINION TRANSMISSION, INC | MD | 1950 | 1996 | 46 | 809 | OTHERS | 77786.056 |
| CAROLINA GAS TRANSMISSION | SC | 1965 | 1993 | 28 | 300 | THIRD PARTY DAMAGE | 6890.6993 |
| ENTERPRISE PRODUCTS OPERATING LLC | | 1950 | 1993 | 43 | 809 | PIPELINE DESIGN | 0 |
| WILLIAMS GAS PIPELINE - TRANSCO | LA | 1943 | 1993 | 50 | 650 | THIRD PARTY DAMAGE | 68906.993 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1941 | 1993 | 52 | 650 | THIRD PARTY DAMAGE | 68906.993 |
| CENTERPOINT ENERGY GAS TRANSMISSION | AR | 1992 | 1993 | 1 | 809 | THIRD PARTY | 68906.993 |

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|---|---|---|---|---|---|---|---|
| | | | | | | DAMAGE | |
| DOMINION TRANSMISSION, INC | WV | 1953 | 1993 | 40 | 475 | THIRD PARTY DAMAGE | 0 |
| CORNHUSKER ENERGY LEXINGTON, L.L.C. | NE | 1970 | 1993 | 23 | 1080 | THIRD PARTY DAMAGE | 68906.993 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1958 | 1993 | 35 | 809 | THIRD PARTY DAMAGE | 68906.993 |
| SOUTHERN NATURAL GAS CO | MS | 1950 | 1989 | 39 | 650 | THIRD PARTY DAMAGE | 0 |
| CHEVRON U.S.A. INC | GM | 1950 | 1986 | 36 | 650 | THIRD PARTY DAMAGE | 0 |
| COLUMBIA GAS TRANSMISSION CORP | WV | 1967 | 2001 | 34 | 720 | THIRD PARTY DAMAGE | 142818.06 |
| ENTERPRISE PRODUCTS OPERATING LLC | | 1965 | 2000 | 35 | 850 | THIRD PARTY DAMAGE | 182700 |
| SOUTHERN NATURAL GAS CO | MS | 1965 | 1999 | 34 | 400 | THIRD PARTY DAMAGE | 151597.63 |
| ANR PIPELINE CO | LA | 1955 | 1999 | 44 | 800 | THIRD PARTY DAMAGE | 127988.17 |
| NORTHWEST PIPELINE CORP (WGP) | WA | 1945 | 1998 | 53 | 400 | THIRD PARTY DAMAGE | 440620.16 |
| J - W GATHERING CO | LA | 1930 | 1998 | 68 | 300 | THIRD PARTY DAMAGE | 5035658.9 |
| PANTHER PIPELINE, LTD. | TX | 1958 | 1997 | 39 | 650 | THIRD PARTY DAMAGE | 127419.19 |
| CHEVRON U.S.A. INC | GM | 1958 | 1996 | 38 | 840 | THIRD PARTY DAMAGE | 101121.87 |
| CENTERPOINT ENERGY GAS TRANSMISSION | LA | 1957 | 1996 | 39 | 800 | THIRD PARTY DAMAGE | 648217.14 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1957 | 1996 | 39 | 800 | THIRD PARTY DAMAGE | 82971.794 |
| DOMINION PEOPLES | PA | 1930 | 1995 | 65 | 135 | THIRD PARTY DAMAGE | 0 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | | 1952 | 1995 | 43 | 313 | THIRD PARTY DAMAGE | 356758.52 |

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| TENNESSEE GAS PIPELINE CO (EL PASO) | | 1931 | 1995 | 64 | 460 | THIRD PARTY DAMAGE | 198199.18 |
| CENTERPOINT ENERGY GAS TRANSMISSION | TX | 1929 | 1993 | 64 | 200 | OTHERS | 0 |
| ENTERPRISE PRODUCTS OPERATING LLC | TX | 1947 | 1993 | 46 | 650 | THIRD PARTY DAMAGE | 689069.93 |
| TGG PIPELINE LTD | TX | 1931 | 1993 | 62 | 317 | THIRD PARTY DAMAGE | 761598.67 |
| DOMINION PEOPLES | PA | 1950 | 1991 | 41 | 584 | THIRD PARTY DAMAGE | 144483.99 |
| ANR PIPELINE CO | LA | 1947 | 1990 | 43 | 584 | THIRD PARTY DAMAGE | 314806.15 |
| NORTHERN NATURAL GAS CO | TX | 1930 | 1990 | 60 | 228 | THIRD PARTY DAMAGE | 101937.23 |
| PANTHER PIPELINE, LTD. | TX | 1944 | 1988 | 44 | 228 | PIPELINE DESIGN | 116292.27 |
| VECTOR PIPELINE, L.P. | IL | 1975 | 1988 | 13 | 985 | CORROSION | 258427.26 |
| TRANSWESTERN PIPELINE COMPANY LLC | AZ | 1955 | 1986 | 31 | 800 | OTHERS | 150433.68 |
| CENTERPOINT ENERGY GAS TRANSMISSION | OK | 1962 | 1986 | 24 | 600 | THIRD PARTY DAMAGE | 2307789.5 |
| WILLIAMS GAS PIPELINE - TRANSCO | | 1971 | 2001 | 30 | 1000 | OTHERS | 0 |
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | IA | 1998 | 1999 | 1 | 2035 | OTHERS | 0 |
| PACIFIC GAS & ELECTRIC CO | CA | 1991 | 1994 | 3 | 1000 | OTHERS | 0 |
| EL PASO NATURAL GAS CO | AZ | 1947 | 1993 | 46 | 584 | THIRD PARTY DAMAGE | 86133.741 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | | 1968 | 1992 | 24 | 1000 | CORROSION | 0 |
| HAMPSHIRE GAS CO | WV | 1950 | 1991 | 41 | 1172 | THIRD PARTY DAMAGE | 0 |
| FLORIDA GAS TRANSMISSION CO | FL | 1936 | 1991 | 55 | 375 | THIRD PARTY DAMAGE | 86690.391 |
| DOMINION TRANSMISSION, INC | MD | 1956 | 1991 | 35 | 1000 | CORROSION | 86690.391 |
| MONTANA - DAKOTA UTILITIES CO | SD | 1961 | 1990 | 29 | 400 | THIRD PARTY DAMAGE | 82449.231 |
| PACIFIC GAS & ELECTRIC CO | CA | 1990 | 1990 | 1 | 1258 | THIRD PARTY | 31780.431 |

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|---|---|---|---|---|---|---|---|
| | | | | | | DAMAGE | |
| COLUMBIA GAS TRANSMISSION CORP | WV | 1961 | 1987 | 26 | 675 | THIRD PARTY DAMAGE | 83299.138 |
| PANHANDLE EASTERN PIPELINE CO | IL | 1955 | 1987 | 32 | 200 | OTHERS | 0 |
| SOUTHERN STAR CENTRAL GAS PIPELINE, INC | KS | 1967 | 1986 | 19 | 650 | OTHERS | 85473.684 |
| PANTHER PIPELINE, LTD. | TX | 1960 | 1986 | 26 | 250 | THIRD PARTY DAMAGE | 0 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | | 1962 | 1986 | 24 | 500 | THIRD PARTY DAMAGE | 85473.684 |
| PANTHER PIPELINE, LTD. | TX | 1990 | 2001 | 11 | 820 | THIRD PARTY DAMAGE | 166621.07 |
| TENNESSEE GAS PIPELINE CO (EL PASO) | KY | 1998 | 2000 | 2 | 1285 | OTHERS | 112056 |
| CHEVRON U.S.A. INC | GM | 1995 | 1995 | 1 | 2160 | OTHERS | 0 |
| WILLIAMS GAS PIPELINE - TRANSCO | LA | 1950 | 1994 | 44 | 920 | OTHERS | 630046.52 |
| ATMOS PIPELINE - TEXAS | TX | 1955 | 1993 | 38 | 809 | PIPELINE DESIGN | 503710.12 |
| FLORIDA GAS TRANSMISSION CO | FL | 1957 | 1989 | 32 | 500 | CORROSION | 519521.93 |
| PANHANDLE EASTERN PIPELINE CO | IN | 1983 | 1988 | 5 | 809 | THIRD PARTY DAMAGE | 140519.83 |
| NORTHERN NATURAL GAS CO | WI | 1987 | 1987 | 1 | 1000 | PIPELINE DESIGN | 169930.24 |
| CPS ENERGY | TX | 1987 | 2000 | 13 | 1000 | OTHERS | 0 |
| COLUMBIA GAS TRANSMISSION CORP | WV | 1997 | 1997 | 1 | 1250 | OTHERS | 0 |
| ANR PIPELINE CO | IN | 1951 | 1995 | 44 | 920 | PIPELINE DESIGN | 0 |
| DOMINION TRANSMISSION, INC | WV | 1978 | 1992 | 14 | 800 | THIRD PARTY DAMAGE | 0 |
| FLORIDA GAS TRANSMISSION CO | FL | 1978 | 1990 | 12 | 650 | PIPELINE DESIGN | 0 |
| NORTHWEST PIPELINE CORP (WGP) | UT | 1973 | 1989 | 16 | 854 | OTHERS | 0 |
| CENTERPOINT ENERGY GAS TRANSMISSION | LA | 1956 | 1987 | 31 | 809 | PIPELINE DESIGN | 39983.586 |
| WILLIAMS GAS PIPELINE - TRANSCO | LA | 1955 | 1986 | 31 | 809 | THIRD PARTY DAMAGE | 80687.158 |

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| PANHANDLE EASTERN PIPELINE CO | MO | 1991 | 1993 | 2 | 1440 | OTHERS | 125410.73 |
| REGENCY INTRASTATE GAS LP | LA | 1952 | 1990 | 38 | 760 | PIPELINE DESIGN | 7495.3846 |
| OREMET-WAH-CHANG | MD | 1952 | 1989 | 37 | 760 | THIRD PARTY DAMAGE | 0 |
| ANR PIPELINE CO | LA | 1943 | 2001 | 58 | 375 | THIRD PARTY DAMAGE | 616664.57 |
| LAMAR OIL & GAS | TX | 1982 | 2000 | 18 | 975 | THIRD PARTY DAMAGE | 253344 |
| NORTHWEST PIPELINE CORP (WGP) | WA | 1959 | 2000 | 41 | 936 | CORROSION | 320334 |
| TEXAS EASTERN TRANSMISSION LP (SPECTRA ENERGY CORP) | LA | 1997 | 1998 | 1 | 650 | OTHERS | 331094.57 |
| DOMINION EAST OHIO | OH | 1985 | 1996 | 11 | 975 | THIRD PARTY DAMAGE | 150386.38 |
| KINDER MORGAN TEXAS PIPELINE CO | TX | 1961 | 1993 | 32 | 975 | THIRD PARTY DAMAGE | 0 |
| ONEOK WESTEX TRANSMISSION, INC. | TX | 1959 | 1992 | 33 | 975 | PIPELINE DESIGN | 563758.39 |
| EL PASO NATURAL GAS CO | AZ | 1959 | 1988 | 29 | 713 | THIRD PARTY DAMAGE | 403792.6 |
| NORTHERN NATURAL GAS CO | MI | 1968 | 2001 | 33 | 974 | CORROSION | 0 |
| COLUMBIA GAS TRANSMISSION CORP | KY | 1994 | 1996 | 2 | 1014 | THIRD PARTY DAMAGE | 89453.965 |
| EL PASO NATURAL GAS CO | TX | 1959 | 1995 | 36 | 763 | THIRD PARTY DAMAGE | 38318.507 |
| MIDCONTINENT EXPRESS PIPELINE LLC | LA | 1941 | 1990 | 49 | 465 | THIRD PARTY DAMAGE | 16040.123 |
| SOUTHERN STAR CENTRAL GAS PIPELINE, INC | OK | 1959 | 1987 | 28 | 975 | CORROSION | 0 |
| TARGA MIDSTREAM SERVICES, L.P. | | 1969 | 1996 | 27 | 1082 | THIRD PARTY DAMAGE | 162054.28 |
| COLUMBIA GAS TRANSMISSION CORP | PA | 1962 | 1986 | 24 | 800 | OTHERS | 256421.05 |
| CHESAPEAKE MIDSTREAM PARTNERS, L.P. | AR | 1986 | 1998 | 12 | 720 | THIRD PARTY DAMAGE | 75534.884 |

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|---|---|---|---|---|---|---|---|
| PANTHER PIPELINE, LTD. | TX | 1983 | 1998 | 15 | 300 | THIRD PARTY DAMAGE | 59856.36 |
| VINTAGE PRODUCTION CALIFORNIA LLC | CA | 1930 | 1997 | 67 | 500 | PIPELINE DESIGN | 0 |
| ATMOS PIPELINE - TEXAS | TX | 1930 | 1997 | 67 | 500 | PIPELINE DESIGN | 0 |
| LAVACA PIPELINE CO | | 1930 | 1997 | 67 | 500 | PIPELINE DESIGN | 0 |
| CENTERPOINT ENERGY GAS TRANSMISSION | OK | 1975 | 1992 | 17 | 500 | THIRD PARTY DAMAGE | 140939.6 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1961 | 1999 | 38 | 960 | THIRD PARTY DAMAGE | 180406.15 |
| TEXAS GAS TRANSMISSION LLC | LA | 1950 | 1995 | 45 | 800 | PIPELINE DESIGN | 99099.588 |
| WILLIAMS GAS PIPELINE - TRANSCO | LA | 1931 | 1994 | 63 | 500 | CORROSION | 94439.521 |
| ENTERPRISE PRODUCTS OPERATING LLC | | 1962 | 1994 | 32 | 500 | CORROSION | 134913.6 |
| ENTERPRISE PRODUCTS OPERATING LLC | | 1985 | 1992 | 7 | 712 | THIRD PARTY DAMAGE | 126845.64 |
| ANR PIPELINE CO | LA | 1988 | 1989 | 1 | 712 | OTHERS | 155476.13 |
| ANR PIPELINE CO | LA | 1961 | 1986 | 25 | 500 | PIPELINE DESIGN | 170947.37 |
| PEOPLES GAS SYSTEM INC | FL | 1966 | 1998 | 32 | 960 | THIRD PARTY DAMAGE | 65463.566 |
| WILLIAMS GAS PIPELINE - TRANSCO | | 1933 | 1998 | 65 | 500 | THIRD PARTY DAMAGE | 73017.054 |
| ANR PIPELINE CO | | 1961 | 1992 | 31 | 150 | THIRD PARTY DAMAGE | 21140.94 |
| STECKMAN RIDGE, LP | PA | 1931 | 1991 | 60 | 500 | THIRD PARTY DAMAGE | 72241.993 |
| EL PASO NATURAL GAS CO | AZ | 1974 | 1991 | 17 | 712 | PIPELINE DESIGN | 77732.384 |
| NORTHWEST PIPELINE CORP (WGP) | ID | 1979 | 2001 | 22 | 850 | OTHERS | 0 |
| ENTERPRISE PRODUCTS OPERATING LLC | TX | 1956 | 1995 | 39 | 850 | PIPELINE DESIGN | 924929.49 |
| ENTERPRISE PRODUCTS OPERATING LLC | TX | 1962 | 1995 | 33 | 911 | PIPELINE DESIGN | 400362.33 |
| GULF SOUTH PIPELINE COMPANY, LP | MS | 1962 | 1994 | 32 | 910 | CORROSION | 229622.95 |
| KINDER MORGAN TEXAS PIPELINE CO | TX | 1992 | 1993 | 1 | 911 | OTHERS | 117141.89 |

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| TEXAS GAS TRANSMISSION LLC | LA | 1962 | 1993 | 31 | 910 | THIRD PARTY DAMAGE | 234283.77 |
| WILLIAMS GAS PIPELINE - TRANSCO | | 1955 | 1988 | 33 | 850 | THIRD PARTY DAMAGE | 121137.78 |
| ANR PIPELINE CO | LA | 1957 | 2001 | 44 | 811 | OTHERS | 76425.513 |
| NATIONAL FUEL GAS SUPPLY CORP | NY | 1966 | 2001 | 35 | 708 | OTHERS | 130464.3 |
| NORTHERN NATURAL GAS CO | IA | 1948 | 2000 | 52 | 900 | CORROSION | 1254540 |
| BP PIPELINES (ALASKA), INC | AK | 1954 | 2000 | 46 | 800 | OTHERS | 121800 |
| BP EXPLORATION ( ALASKA), INC | AK | 1973 | 1999 | 26 | 1440 | CORROSION | 2236686.4 |
| ENSTAR NATURAL GAS CO | AK | 1983 | 1998 | 15 | 858 | CORROSION | 498656.12 |
| ENSTAR NATURAL GAS CO | AK | 1972 | 1998 | 26 | 2000 | CORROSION | 434325.58 |
| ENSTAR NATURAL GAS CO | AK | 1962 | 1998 | 36 | 960 | OTHERS | 0 |
| SOUTHERN NATURAL GAS CO | AL | 1961 | 1997 | 36 | 850 | THIRD PARTY DAMAGE | 192402.97 |
| CONECUH - MONROE COUNTIES GAS DIST | AL | 1971 | 1997 | 26 | 250 | PIPELINE DESIGN | 955643.9 |
| SOUTHERN NATURAL GAS CO | AL | 1951 | 1995 | 44 | 900 | CORROSION | 2312323.7 |
| TRANSCO GAS PIPELINE CORP | AL | 1956 | 1994 | 38 | 900 | OTHERS | 165943.73 |
| KOCH GATEWAY | AL | 1957 | 1992 | 35 | 687 | OTHERS | 422818.79 |
| MARSHALL COUNTY GAS DISTRICT | AL | 1966 | 1989 | 23 | 415 | PIPELINE DESIGN | 0 |
| EXXON CO USA | AL | 1966 | 1987 | 21 | 858 | OTHERS | 266557.24 |
| EXXON CO USA | AL | 1967 | 1987 | 20 | 900 | CORROSION | 99958.966 |
| TRANSCO GAS PIPELINE CORP | AL | 1961 | 1987 | 26 | 400 | THIRD PARTY DAMAGE | 166598.28 |
| TRANSCO GAS PIPELINE CORP | AL | 1951 | 1986 | 35 | 900 | PIPELINE DESIGN | 106500.21 |
| DECATUR UTILITIES - DECATUR GAS DEPARTMENT | AL | 1963 | 1986 | 23 | 845 | THIRD PARTY DAMAGE | 102568.42 |
| SOUTHERN NATURAL GAS CO | AL | 1975 | 1997 | 22 | 858 | CORROSION | 0 |
| CHILDERSBURG GAS BOARD | AL | 1961 | 1997 | 36 | 960 | THIRD PARTY DAMAGE | 70080.552 |
| SOUTHERN NATURAL GAS CO | AL | 1967 | 1996 | 29 | 1675 | CORROSION | 0 |

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| SOUTHERN NATURAL GAS CO | AL | 1965 | 1994 | 29 | 852 | CORROSION | 63814.134 |
| SOUTHERN NATURAL GAS CO | AL | 1972 | 1990 | 18 | 2000 | OTHERS | 74953.846 |
| SOUTHERN NATURAL GAS CO | AL | 1949 | 1990 | 41 | 975 | PIPELINE DESIGN | 74953.846 |
| MOBILE GAS SERVICE CORP | AL | 1965 | 1988 | 23 | 562 | OTHERS | 80758.52 |
| SOUTHEAST ALABAMA GAS DISTRICT | AL | 1973 | 1988 | 15 | 250 | THIRD PARTY DAMAGE | 0 |
| COLLET VENTURES INC-COPELAND PLANT | AL | 1961 | 1988 | 27 | 287 | PIPELINE DESIGN | 0 |
| RELIANT ENERGY GAS TRANSMISSION | AR | 1960 | 2000 | 40 | 850 | THIRD PARTY DAMAGE | 115784.3 |
| RELIANT ENERGY GAS TRANSMISSION | AR | 1990 | 2000 | 10 | 944 | PIPELINE DESIGN | 91350 |
| ARKANSAS WESTERN GAS CO | AR | 1946 | 1998 | 52 | 420 | THIRD PARTY DAMAGE | 188837.21 |
| NORAM GAS TRANSMISSION, A NorAm Energy Company | AR | 1982 | 1997 | 15 | 913.5 | THIRD PARTY DAMAGE | 1274191.9 |
| NORAM GAS TRANSMISSION, A NorAm Energy Company | AR | 1960 | 1995 | 35 | 900 | PIPELINE DESIGN | 132132.78 |
| ARKLA ENERGY RESOURCES | AR | 1954 | 1991 | 37 | 320 | THIRD PARTY DAMAGE | 577935.94 |
| LOUISIANA - NEVADA TRANSIT | AR | 1966 | 2001 | 35 | 600 | THIRD PARTY DAMAGE | 5950.7524 |
| TEXAS EASTERN GAS PIPELINE CO | AR | 1956 | 1993 | 37 | 858 | THIRD PARTY DAMAGE | 79932.111 |
| NATURAL GAS PIPELINE CO OF AMERICA | AR | 1978 | 2001 | 23 | 500 | CORROSION | 952120.38 |
| NATURAL GAS PIPELINE CO OF AMERICA | AR | 1960 | 2001 | 41 | 712 | PIPELINE DESIGN | 96402.189 |
| TEXAS GAS TRANSMISSION CORP | AR | 1976 | 2001 | 25 | 270 | THIRD PARTY DAMAGE | 119015.05 |
| MISSISSIPPI RIVER TRANSMISSION CORP | AR | 1962 | 2000 | 38 | 900 | CORROSION | 913500 |
| MISSISSIPPI RIVER TRANSMISSION CORP | AR | 1963 | 2000 | 37 | 780 | OTHERS | 255171 |
| ARKANSAS LOUISIANA GAS CO (ARKLA GAS CO) | AR | 1937 | 1999 | 62 | 800 | CORROSION | 372781.07 |

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| ARKLA ENERGY RESOURCES | AR | 1962 | 1996 | 34 | 900 | CORROSION | 557466.74 |
| ARKLA ENERGY RESOURCES | AR | 1949 | 1995 | 46 | 900 | OTHERS | 290692.12 |
| ARKLA ENERGY RESOURCES | AR | 1941 | 1994 | 53 | 712 | OTHERS | 186990.25 |
| TEXAS EASTERN GAS PIPELINE CO | AR | 1967 | 1993 | 26 | 650 | OTHERS | 1033604.9 |
| ARKANSAS LOUISIANA GAS CO (ARKLA GAS CO) | AR | 1972 | 1993 | 21 | 650 | OTHERS | 0 |
| NORAM GAS TRANSMISSION, A NorAm Energy Company | AR | 1958 | 1993 | 35 | 712 | OTHERS | 0 |
| NORAM GAS TRANSMISSION, A NorAm Energy Company | AR | 1954 | 1993 | 39 | 860 | PIPELINE DESIGN | 358316.36 |
| MISSISSIPPI RIVER TRANSMISSION CORP | AR | 1965 | 1992 | 27 | 991 | CORROSION | 257919.46 |
| NORAM GAS TRANSMISSION | AR | 1950 | 1992 | 42 | 870 | CORROSION | 150805.37 |
| ARKLA ENERGY RESOURCES | AR | 1970 | 1991 | 21 | 400 | THIRD PARTY DAMAGE | 332313.17 |
| ARKLA ENERGY RESOURCES | AR | 1931 | 1987 | 56 | 712 | THIRD PARTY DAMAGE | 117526.75 |
| ARKLA ENERGY RESOURCES | AR | 1951 | 1986 | 35 | 800 | CORROSION | 256421.05 |
| EL PASO NATURAL GAS CO | AZ | 1929 | 2001 | 72 | 550 | OTHERS | 59507.524 |
| EL PASO NATURAL GAS CO | AZ | 1957 | 2001 | 44 | 400 | OTHERS | 59507.524 |
| EL PASO NATURAL GAS CO | AZ | 1970 | 2001 | 31 | 430 | PIPELINE DESIGN | 0 |
| EL PASO NATURAL GAS CO | AZ | 1946 | 2001 | 55 | 795 | THIRD PARTY DAMAGE | 82120.383 |
| EL PASO NATURAL GAS CO | AZ | 1930 | 2001 | 71 | 550 | PIPELINE DESIGN | 59507.524 |
| EL PASO NATURAL GAS CO | AZ | 1954 | 1997 | 43 | 973 | OTHERS | 63709.593 |
| EL PASO NATURAL GAS CO | AZ | 1954 | 1996 | 42 | 720 | CORROSION | 0 |
| EL PASO NATURAL GAS CO | AZ | 1917 | 1995 | 78 | 250 | CORROSION | 0 |
| BLACK MOUNTAIN GAS CO | AZ | 1963 | 1993 | 30 | 375 | THIRD PARTY DAMAGE | 0 |
| EL PASO NATURAL GAS CO | AZ | 1948 | 1993 | 45 | 280 | THIRD PARTY | 0 |

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|---|---|---|---|---|---|---|---|
| | | | | | | DAMAGE | |
| EL PASO NATURAL GAS CO | AZ | 1949 | 1991 | 42 | 285 | OTHERS | 0 |
| EL PASO NATURAL GAS CO | AZ | 1946 | 1991 | 45 | 820 | THIRD PARTY DAMAGE | 4767.9715 |
| EL PASO NATURAL GAS CO | AZ | 1946 | 1990 | 44 | 260 | THIRD PARTY DAMAGE | 0 |
| EL PASO NATURAL GAS CO | AZ | 1948 | 1990 | 42 | 720 | OTHERS | 74953.846 |
| EL PASO NATURAL GAS CO | AZ | 1953 | 1989 | 36 | 200 | OTHERS | 15547.613 |
| EL PASO NATURAL GAS CO | AZ | 1930 | 1989 | 59 | 535 | THIRD PARTY DAMAGE | 0 |
| EL PASO NATURAL GAS CO | AZ | 1961 | 1986 | 25 | 480 | THIRD PARTY DAMAGE | 0 |
| EL PASO NATURAL GAS CO | AZ | 1999 | 2000 | 1 | 374 | THIRD PARTY DAMAGE | 72836.4 |
| PACIFIC GAS & ELECTRIC CO | CA | 1952 | 1996 | 44 | 750 | PIPELINE DESIGN | 534779.14 |
| PACIFIC GAS & ELECTRIC CO | CA | 1963 | 1992 | 29 | 320 | THIRD PARTY DAMAGE | 2818.7919 |
| PACIFIC GAS & ELECTRIC CO | CA | 1965 | 1991 | 26 | 360 | THIRD PARTY DAMAGE | 26585.053 |
| PACIFIC GAS & ELECTRIC CO | CA | 1955 | 1989 | 34 | 650 | OTHERS | 4664283.9 |
| PACIFIC GAS & ELECTRIC CO | CA | 1956 | 1989 | 33 | 392 | OTHERS | 131215.63 |
| PACIFIC GAS & ELECTRIC CO | CA | 1931 | 1987 | 56 | 374 | OTHERS | 0 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1957 | 1986 | 29 | 1000 | OTHERS | 2222315.8 |
| PACIFIC GAS & ELECTRIC CO | CA | 1950 | 1998 | 48 | 810 | PIPELINE DESIGN | 80570.543 |
| PACIFIC GAS & ELECTRIC CO | CA | 1965 | 1995 | 30 | 438 | THIRD PARTY DAMAGE | 66066.392 |
| PACIFIC GAS & ELECTRIC CO | CA | 1953 | 1991 | 38 | 780 | THIRD PARTY DAMAGE | 72241.993 |
| PACIFIC GAS & ELECTRIC CO | CA | 1985 | 1990 | 5 | 665 | THIRD PARTY DAMAGE | 0 |
| PACIFIC GAS & ELECTRIC CO | CA | 1959 | 1990 | 31 | 650 | PIPELINE DESIGN | 74953.846 |

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|---|---|---|---|---|---|---|---|
| PACIFIC GAS & ELECTRIC CO | CA | 1985 | 1987 | 2 | 1123 | THIRD PARTY DAMAGE | 0 |
| PACIFIC GAS & ELECTRIC CO | CA | 1971 | 1986 | 15 | 750 | OTHERS | 0 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1931 | 1986 | 55 | 410 | THIRD PARTY DAMAGE | 0 |
| PACIFIC GAS & ELECTRIC CO | CA | 1966 | 1986 | 20 | 300 | THIRD PARTY DAMAGE | 0 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1952 | 2001 | 49 | 936 | PIPELINE DESIGN | 106677.95 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1981 | 2001 | 20 | 1440 | CORROSION | 146388.51 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1972 | 2001 | 29 | 1440 | THIRD PARTY DAMAGE | 327291.38 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1956 | 2001 | 45 | 1133 | THIRD PARTY DAMAGE | 678385.77 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1926 | 2001 | 75 | 245 | CORROSION | 535567.72 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1958 | 2001 | 43 | 1100 | OTHERS | 107113.54 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1954 | 2001 | 47 | 935 | CORROSION | 92831.737 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1997 | 2001 | 4 | 1235 | THIRD PARTY DAMAGE | 154719.56 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1977 | 2001 | 24 | 1306 | THIRD PARTY DAMAGE | 749794.8 |
| PACIFIC GAS & ELECTRIC CO | CA | 1967 | 2001 | 34 | 1012 | CORROSION | 535567.72 |
| PACIFIC GAS & ELECTRIC CO | CA | 1959 | 2001 | 42 | 1170 | CORROSION | 1487688.1 |
| PACIFIC GAS & ELECTRIC CO | CA | 1971 | 2000 | 29 | 1300 | THIRD PARTY DAMAGE | 8986350.2 |
| WILD GOOSE STORAGE INC | CA | 1970 | 2000 | 30 | 850 | OTHERS | 1096200 |
| CHEVRON PIPELINE CO | CA | 1958 | 2000 | 42 | 1008 | CORROSION | 304500 |
| UNION ISLAND PIPELINE CO | CA | 1968 | 2000 | 32 | 1300 | CORROSION | 144942 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1972 | 2000 | 28 | 2447 | CORROSION | 121800 |
| STOCKER RESOURCES INC | CA | 1953 | 2000 | 47 | 1150 | THIRD PARTY DAMAGE | 609000 |

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|---|---|---|---|---|---|---|---|
| ARCO OIL & GAS CO - DIV OF ATLANTIC RICHFIELD | CA | 1979 | 2000 | 21 | 1728 | CORROSION | 182700 |
| PACIFIC GAS & ELECTRIC CO | CA | 1971 | 2000 | 29 | 1250 | CORROSION | 96222 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1977 | 2000 | 23 | 1440 | CORROSION | 146160 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1944 | 2000 | 56 | 625 | PIPELINE DESIGN | 231420 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1977 | 1999 | 22 | 1440 | CORROSION | 310650.89 |
| PACIFIC GAS & ELECTRIC CO | CA | 1972 | 1999 | 27 | 1815 | CORROSION | 248520.71 |
| EXXON CO USA | CA | 1930 | 1999 | 69 | 500 | THIRD PARTY DAMAGE | 205029.59 |
| SOUTHERN CALIFORNIA GAS CO | CA | 1978 | 1999 | 21 | 1440 | CORROSION | 434911.24 |
| STANDARD PACIFIC GAS LINE INC | CA | 1979 | 1998 | 19 | 1200 | OTHERS | 944186.05 |
| PACIFIC GAS & ELECTRIC CO | CA | 1972 | 1998 | 26 | 1403 | CORROSION | 103231.01 |
| PEOPLES NATURAL GAS CO | CO | 1981 | 1998 | 17 | 1440 | THIRD PARTY DAMAGE | 3776744.2 |
| TRANS - COLORADO PIPELINE CO | CO | 1998 | 1998 | 1 | 1182 | PIPELINE DESIGN | 755348.84 |
| YOUNG GAS STORAGE COMPANY., LTD. | CO | 1970 | 1998 | 28 | 1440 | CORROSION | 125891.47 |
| COLORADO INTERSTATE GAS CO | CO | 1972 | 1998 | 26 | 1403 | CORROSION | 132186.05 |
| ROCKY MOUNTAIN NATURAL GAS CO INC | CO | 1966 | 1998 | 32 | 1100 | CORROSION | 123877.21 |
| NORTHWEST PIPELINE CORP | CO | 1973 | 1998 | 25 | 1440 | CORROSION | 314728.68 |
| EL PASO NATURAL GAS CO | CO | 1998 | 1998 | 1 | 1440 | PIPELINE DESIGN | 188837.21 |
| NORTHWEST PIPELINE CORP | CO | 1966 | 1998 | 32 | 1100 | OTHERS | 125891.47 |
| NATURAL GAS PIPELINE CO OF AMERICA | CO | 1970 | 1998 | 28 | 1525 | CORROSION | 254300.78 |
| PUBLIC SERVICE CO OF COLORADO | CO | 1958 | 1998 | 40 | 1440 | THIRD PARTY DAMAGE | 755348.84 |
| ROCKY MOUNTAIN NATURAL GAS CO INC | CO | 1996 | 1998 | 2 | 1780 | THIRD PARTY DAMAGE | 3147286.8 |
| ROCKY MOUNTAIN NATURAL GAS CO INC | CO | 1968 | 1998 | 30 | 1235 | THIRD PARTY DAMAGE | 484682.17 |

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| K N INTERSTATE GAS TRANSMISSION CO | CO | 1971 | 1997 | 26 | 1250 | CORROSION | 101935.35 |
| COLORADO INTERSTATE GAS CO | CO | 1970 | 1997 | 27 | 1250 | THIRD PARTY DAMAGE | 254838.37 |
| K N ENERGY INC(KANSAS NEBRASKA GAS CO) | CO | 1978 | 1997 | 19 | 1343 | CORROSION | 254838.37 |
| COLORADO INTERSTATE GAS CO | CO | 1989 | 1997 | 8 | 1440 | THIRD PARTY DAMAGE | 95564.39 |
| WESTERN GAS SUPPLY CO | CO | 1979 | 1997 | 18 | 1440 | CORROSION | 165644.94 |
| NORTHWEST PIPELINE CORP | CO | 1958 | 1997 | 39 | 1050 | THIRD PARTY DAMAGE | 95564.39 |
| NORTHWEST PIPELINE CORP | CO | 1979 | 1997 | 18 | 1440 | CORROSION | 159273.98 |
| IROQUOIS GAS TRANSMISSION SYSTEM | CT | 1997 | 1997 | 1 | 1440 | PIPELINE DESIGN | 114677.27 |
| TENNESSEE GAS PIPELINE CO | CT | 1972 | 1997 | 25 | 1440 | THIRD PARTY DAMAGE | 254838.37 |
| TENNESSEE GAS PIPELINE CO | CT | 1982 | 1996 | 14 | 1200 | PIPELINE DESIGN | 103714.74 |
| GULF SOUTH PIPELINE CO | FL | 1978 | 1996 | 18 | 1300 | THIRD PARTY DAMAGE | 175018.63 |
| FLORIDA GAS TRANSMISSION CO (ENRON) | FL | 1957 | 1996 | 39 | 1058 | THIRD PARTY DAMAGE | 291697.71 |
| FLORIDA GAS TRANSMISSION CO (ENRON) | FL | 1952 | 1996 | 44 | 605 | THIRD PARTY DAMAGE | 342276.8 |
| FLORIDA GAS TRANSMISSION CO (ENRON) | FL | 1972 | 1996 | 24 | 1630 | THIRD PARTY DAMAGE | 1076040.4 |
| FLORIDA GAS TRANSMISSION CO | FL | 1975 | 1996 | 21 | 1440 | CORROSION | 103714.74 |
| FLORIDA GAS TRANSMISSION CO | FL | 1985 | 1996 | 11 | 1133 | THIRD PARTY DAMAGE | 142607.77 |
| FLORIDA GAS TRANSMISSION CO | FL | 1973 | 1996 | 23 | 1200 | PIPELINE DESIGN | 222193.28 |
| FLORIDA GAS TRANSMISSION CO | FL | 1985 | 1996 | 11 | 1300 | PIPELINE DESIGN | 97232.571 |
| FLORIDA GAS TRANSMISSION CO | FL | 1967 | 1996 | 29 | 175 | OTHERS | 544502.4 |
| FLORIDA GAS TRANSMISSION CO | FL | 1959 | 1996 | 37 | 1256 | THIRD PARTY DAMAGE | 259286.85 |

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| FLORIDA GAS TRANSMISSION CO (ENRON) | FL | 1957 | 1996 | 39 | 1035 | THIRD PARTY DAMAGE | 482273.55 |
| FLORIDA GAS TRANSMISSION CO | FL | 1980 | 1995 | 15 | 1728 | THIRD PARTY DAMAGE | 369971.79 |
| FLORIDA GAS TRANSMISSION CO | FL | 1994 | 1995 | 1 | 1440 | THIRD PARTY DAMAGE | 330331.96 |
| UNITED GAS PIPELINE CO | FL | 1988 | 1995 | 7 | 1440 | THIRD PARTY DAMAGE | 1294901.3 |
| FLORIDA GAS TRANSMISSION CO | FL | 1978 | 1995 | 17 | 1200 | THIRD PARTY DAMAGE | 198199.18 |
| SOUTH GEORGIA NATURAL GAS CO | GA | 1974 | 1995 | 21 | 1440 | CORROSION | 298620.09 |
| TRANSCO GAS PIPELINE CORP | GA | 1973 | 1995 | 22 | 1250 | PIPELINE DESIGN | 330331.96 |
| SOUTHERN NATURAL GAS CO | GA | 1956 | 1995 | 39 | 780 | THIRD PARTY DAMAGE | 817901.93 |
| ATLANTA GAS LIGHT CO | GA | 1972 | 1995 | 23 | 1300 | PIPELINE DESIGN | 336938.6 |
| SOUTHERN NATURAL GAS CO | GA | 1994 | 1994 | 1 | 1250 | THIRD PARTY DAMAGE | 563905.13 |
| SOUTHERN NATURAL GAS CO | GA | 1961 | 1994 | 33 | 1069 | THIRD PARTY DAMAGE | 0 |
| SOUTHERN NATURAL GAS CO | GA | 1972 | 1994 | 22 | 1440 | CORROSION | 269827.2 |
| GASCO INC | HI | 1978 | 1994 | 16 | 1440 | THIRD PARTY DAMAGE | 134913.6 |
| NORTHERN NATURAL GAS CO (ENRON) | IA | 1971 | 1994 | 23 | 1250 | CORROSION | 202370.4 |
| NORTHERN NATURAL GAS CO (ENRON) | IA | 1959 | 1994 | 35 | 990 | CORROSION | 674568.01 |
| NORTHERN NATURAL GAS CO (ENRON) | IA | 1968 | 1994 | 26 | 1300 | CORROSION | 304920.93 |
| NORTHERN NATURAL GAS CO (ENRON) | IA | 1970 | 1994 | 24 | 780 | CORROSION | 101185.2 |
| NATURAL GAS PIPELINE CO OF AMERICA | IA | 1956 | 1994 | 38 | 1133 | THIRD PARTY DAMAGE | 876938.41 |
| NATURAL GAS PIPELINE CO OF AMERICA | IA | 1970 | 1994 | 24 | 780 | CORROSION | 93090.385 |
| NORTHERN NATURAL GAS CO | IA | 1971 | 1994 | 23 | 1250 | CORROSION | 202370.4 |
| NORTHERN NATURAL GAS CO (ENRON) | IA | 1958 | 1994 | 36 | 910 | THIRD PARTY | 1198309.4 |

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| | | | | | | DAMAGE | |
| NORTHERN NATURAL GAS CO (ENRON) | IA | 1961 | 1994 | 33 | 780 | OTHERS | 6745680.1 |
| CORNING MUNICIPAL UTILITIES | IA | 1975 | 1994 | 19 | 936 | CORROSION | 101185.2 |
| NORTHERN NATURAL GAS CO (ENRON) | IA | 1982 | 1994 | 12 | 1200 | CORROSION | 202370.4 |
| NATURAL GAS PIPELINE CO OF AMERICA | IA | 1972 | 1994 | 22 | 1440 | CORROSION | 168642 |
| NORTHWEST PIPELINE CORP (WGP) | ID | 1978 | 1994 | 16 | 1200 | CORROSION | 128167.92 |
| NORTHWEST PIPELINE CORP | ID | 1959 | 1994 | 35 | 990 | PIPELINE DESIGN | 161896.32 |
| NORTHWEST PIPELINE CORP | ID | 1958 | 1994 | 36 | 1008 | OTHERS | 446564.02 |
| NORTHWEST PIPELINE CORP | ID | 1954 | 1993 | 39 | 1014 | THIRD PARTY DAMAGE | 137813.99 |
| PACIFIC GAS TRANSMISSION CO | ID | 1993 | 1993 | 1 | 1200 | PIPELINE DESIGN | 137813.99 |
| NORTHWEST PIPELINE CORP | ID | 1984 | 1993 | 9 | 1440 | PIPELINE DESIGN | 482348.95 |
| NORTHWEST PIPELINE CORP | ID | 1974 | 1993 | 19 | 750 | CORROSION | 413441.96 |
| NORTHWEST PIPELINE CORP (WGP) | ID | 1977 | 1993 | 16 | 1200 | THIRD PARTY DAMAGE | 689069.93 |
| PANHANDLE EASTERN PIPELINE CO | IL | 1973 | 1993 | 20 | 1306 | OTHERS | 283896.81 |
| PANHANDLE EASTERN PIPELINE CO | IL | 1963 | 1992 | 29 | 605 | OTHERS | 138120.81 |
| ILLINOIS POWER CO | IL | 1958 | 1992 | 34 | 1232 | THIRD PARTY DAMAGE | 4228187.9 |
| PANHANDLE EASTERN PIPELINE CO | IL | 1960 | 1992 | 32 | 750 | THIRD PARTY DAMAGE | 5637583.9 |
| NORTHERN ILLINOIS GAS CO | IL | 1975 | 1992 | 17 | 1250 | THIRD PARTY DAMAGE | 1057047 |
| NATURAL GAS PIPELINE CO OF AMERICA | IL | 1973 | 1992 | 19 | 1148 | THIRD PARTY DAMAGE | 2114094 |
| PEOPLES GAS LIGHT & COKE CO | IL | 1978 | 1992 | 14 | 1440 | PIPELINE DESIGN | 169127.52 |
| PANHANDLE EASTERN PIPELINE CO | IL | 1970 | 1992 | 22 | 1250 | CORROSION | 1298617.5 |
| ILLINOIS POWER CO | IL | 1966 | 1992 | 26 | 1000 | OTHERS | 352348.99 |
| CENTRAL ILLINOIS PUBLIC SERVICE | IL | 1973 | 1992 | 19 | 1440 | PIPELINE DESIGN | 176174.5 |

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| TRUNKLINE GAS CO | IL | 1939 | 1992 | 53 | 475 | OTHERS | 140939.6 |
| TRUNKLINE GAS CO | IL | 1971 | 1992 | 21 | 1440 | THIRD PARTY DAMAGE | 91610.738 |
| NATURAL GAS PIPELINE CO OF AMERICA | IL | 1977 | 1991 | 14 | 1440 | CORROSION | 173380.78 |
| ILLINOIS POWER CO | IL | 1958 | 1991 | 33 | 840 | THIRD PARTY DAMAGE | 108362.99 |
| ILLINOIS POWER CO | IL | 1967 | 1991 | 24 | 1100 | CORROSION | 466683.27 |
| ANR PIPELINE CO (AMERICAN NATURAL RESOURCE) | IL | 1968 | 1991 | 23 | 1216 | THIRD PARTY DAMAGE | 433451.96 |
| ANR PIPELINE CO (AMERICAN NATURAL RESOURCE) | IL | 1945 | 1991 | 46 | 897 | CORROSION | 497276.31 |
| NATURAL GAS PIPELINE CO OF AMERICA | IL | 1970 | 1991 | 21 | 1250 | CORROSION | 147084.7 |
| TRUNKLINE GAS CO | IL | 1940 | 1991 | 51 | 650 | THIRD PARTY DAMAGE | 151708.19 |
| ILLINOIS POWER CO | IL | 1943 | 1991 | 48 | 1029 | THIRD PARTY DAMAGE | 722419.93 |
| NATURAL GAS PIPELINE CO OF AMERICA | IL | 1990 | 1991 | 1 | 1250 | THIRD PARTY DAMAGE | 180604.98 |
| PANHANDLE EASTERN PIPELINE CO | IL | 1967 | 1990 | 23 | 1200 | PIPELINE DESIGN | 0 |
| NATURAL GAS PIPELINE CO OF AMERICA | IL | 1970 | 1990 | 20 | 1200 | PIPELINE DESIGN | 239852.31 |
| MISSISSIPPI RIVER TRANSMISSION CORP | IL | 1951 | 1990 | 39 | 1071 | THIRD PARTY DAMAGE | 749538.46 |
| NATURAL GAS PIPELINE CO OF AMERICA | IL | 1962 | 1990 | 28 | 935 | THIRD PARTY DAMAGE | 134916.92 |
| PANHANDLE EASTERN PIPELINE CO | IL | 1977 | 1990 | 13 | 750 | OTHERS | 0 |
| PEOPLES GAS LIGHT & COKE CO | IL | 1970 | 1990 | 20 | 1200 | PIPELINE DESIGN | 299815.38 |
| ANR PIPELINE CO (AMERICAN NATURAL RESOURCE) | IL | 1981 | 1990 | 9 | 1373 | CORROSION | 331296 |
| NORTHERN ILLINOIS GAS CO | IL | 1980 | 1990 | 10 | 1200 | CORROSION | 134916.92 |
| NORTH SHORE GAS CO | IL | 1970 | 1990 | 20 | 1200 | OTHERS | 0 |
| PEOPLES GAS LIGHT & COKE CO | IL | 1956 | 1990 | 34 | 1133 | THIRD PARTY DAMAGE | 1199261.5 |

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| ANR PIPELINE CO | IN | 1950 | 1990 | 40 | 750 | THIRD PARTY DAMAGE | 1499076.9 |
| ANR PIPELINE CO | IN | 1970 | 1990 | 20 | 1250 | CORROSION | 94441.846 |
| INDIANA GAS CO INC | IN | 1958 | 1990 | 32 | 975 | CORROSION | 224861.54 |
| CITIZENS GAS & COKE UTILITY | IN | 1988 | 1990 | 2 | 1440 | PIPELINE DESIGN | 147282.81 |
| TRUNKLINE GAS CO | IN | 1976 | 1990 | 14 | 1964 | THIRD PARTY DAMAGE | 299815.38 |
| NORTHERN INDIANA PUBLIC SERVICE CO | IN | 1951 | 1990 | 39 | 845 | THIRD PARTY DAMAGE | 749538.46 |
| SOUTHERN INDIANA GAS & ELECTRIC CO | IN | 1941 | 1989 | 48 | 755 | THIRD PARTY DAMAGE | 186571.36 |
| ANR PIPELINE CO | IN | 1950 | 1989 | 39 | 910 | THIRD PARTY DAMAGE | 217666.58 |
| TEXAS GAS TRANSMISSION CORP | IN | 1982 | 1989 | 7 | 1440 | THIRD PARTY DAMAGE | 7310487.6 |
| WILLIAMS GAS PIPELINE CENTRAL, INC. | KS | 1978 | 1989 | 11 | 1100 | PIPELINE DESIGN | 202118.97 |
| NATURAL GAS PIPELINE CO OF AMERICA (KMI) | KS | 1980 | 1989 | 9 | 1200 | CORROSION | 155476.13 |
| WILLIAMS GAS PIPELINE CENTRAL, INC. | KS | 1976 | 1989 | 13 | 750 | OTHERS | 884534.8 |
| PANHANDLE EASTERN PIPELINE CO | KS | 1968 | 1989 | 21 | 1440 | THIRD PARTY DAMAGE | 777380.65 |
| PANHANDLE EASTERN PIPELINE CO | KS | 1958 | 1989 | 31 | 960 | CORROSION | 93285.678 |
| PANHANDLE EASTERN PIPELINE CO | KS | 1985 | 1989 | 4 | 1200 | PIPELINE DESIGN | 583035.49 |
| PANHANDLE EASTERN PIPELINE CO | KS | 1965 | 1989 | 24 | 1461 | CORROSION | 388690.32 |
| PANHANDLE EASTERN PIPELINE CO | KS | 1957 | 1988 | 31 | 1058 | THIRD PARTY DAMAGE | 129213.63 |
| NATURAL GAS PIPELINE CO OF AMERICA | KS | 1969 | 1988 | 19 | 1201 | THIRD PARTY DAMAGE | 156671.53 |
| NORTHERN NATURAL GAS CO (ENRON) | KS | 1984 | 1988 | 4 | 1440 | THIRD PARTY DAMAGE | 5473812.5 |
| K N ENERGY INC(KANSAS NEBRASKA GAS CO) | KS | 1970 | 1988 | 18 | 1440 | CORROSION | 113061.93 |
| NATURAL GAS PIPELINE CO OF AMERICA | KS | 1981 | 1988 | 7 | 1440 | THIRD PARTY DAMAGE | 96910.224 |

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| NORTHERN NATURAL GAS CO (ENRON) | KS | 1965 | 1988 | 23 | 1300 | THIRD PARTY DAMAGE | 323034.08 |
| NORTHERN NATURAL GAS CO (ENRON) | KS | 1955 | 1988 | 33 | 1085 | PIPELINE DESIGN | 108216.42 |
| NORTHERN NATURAL GAS CO (ENRON) | KS | 1956 | 1988 | 32 | 1140 | PIPELINE DESIGN | 209972.15 |
| CENTANA ENERGY CORP | KS | 1959 | 1987 | 28 | 1015 | THIRD PARTY DAMAGE | 184924.09 |
| KANSAS NATURAL INC | KS | 1974 | 1987 | 13 | 1200 | THIRD PARTY DAMAGE | 333196.55 |
| NATURAL GAS PIPELINE CO OF AMERICA | KS | 1979 | 1987 | 8 | 1440 | CORROSION | 136610.59 |
| NORTHERN NATURAL GAS CO | KS | 1974 | 1987 | 13 | 1250 | CORROSION | 333196.55 |
| WILLIAMS GAS PIPELINE CENTRAL, INC. | KS | 1979 | 1986 | 7 | 1647 | THIRD PARTY DAMAGE | 153852.63 |
| WILLIAMS GAS PIPELINE CENTRAL, INC. | KS | 1965 | 1986 | 21 | 1300 | PIPELINE DESIGN | 170947.37 |
| NORTHERN NATURAL GAS CO (ENRON) | KS | 1952 | 1986 | 34 | 936 | PIPELINE DESIGN | 737166.08 |
| KINDER MORGAN GP, INC. | KS | 1963 | 1986 | 23 | 1000 | OTHERS | 158820.36 |
| WILLIAMS GAS PIPELINE CENTRAL, INC. | KS | 1959 | 1986 | 27 | 1105 | THIRD PARTY DAMAGE | 444463.16 |
| K N INTERSTATE GAS TRANSMISSION CO | KS | 1955 | 1986 | 31 | 60 | OTHERS | 25642.105 |
| WILLIAMS NATURAL GAS CO | KS | 1969 | 1986 | 17 | 1440 | THIRD PARTY DAMAGE | 205136.84 |
| WILLIAMS NATURAL GAS CO | KS | 1969 | 2001 | 32 | 1250 | THIRD PARTY DAMAGE | 83310.534 |
| WILLIAMS NATURAL GAS CO | KS | 1970 | 2001 | 31 | 1300 | OTHERS | 89261.286 |
| WILLIAMS NATURAL GAS CO | KS | 1952 | 2001 | 49 | 1015 | THIRD PARTY DAMAGE | 60497.729 |
| K N ENERGY INC(KANSAS NEBRASKA GAS CO) | KS | 1951 | 2001 | 50 | 1042 | THIRD PARTY DAMAGE | 61887.825 |
| WILLIAMS NATURAL GAS CO | KS | 1969 | 2001 | 32 | 1000 | THIRD PARTY DAMAGE | 59507.524 |
| COLORADO INTERSTATE GAS CO | KS | 1997 | 2001 | 4 | 1235 | CORROSION | 0 |

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| WILLIAMS NATURAL GAS CO | KS | 1950 | 2001 | 51 | 1000 | THIRD PARTY DAMAGE | 0 |
| K N ENERGY INC(KANSAS NEBRASKA GAS CO) | KS | 1975 | 2001 | 26 | 1320 | THIRD PARTY DAMAGE | 35704.514 |
| WILLIAMS NATURAL GAS CO | KS | 1958 | 2001 | 43 | 1440 | OTHERS | 0 |
| WILLIAMS NATURAL GAS CO | KS | 1978 | 2000 | 22 | 1300 | CORROSION | 60900 |
| WILLIAMS NATURAL GAS CO | KS | 1931 | 2000 | 69 | 490 | PIPELINE DESIGN | 60900 |
| WILLIAMS NATURAL GAS CO | KS | 1966 | 2000 | 34 | 1100 | CORROSION | 65772 |
| KANSAS POWER & LIGHT CO | KS | 1977 | 2000 | 23 | 1440 | OTHERS | 87696 |
| WILLIAMS NATURAL GAS CO | KS | 1989 | 2000 | 11 | 1250 | THIRD PARTY DAMAGE | 69426 |
| KN ENERGY INC (KANSAS NEBRASKA NATURAL GAS CO INC) | KS | 1920 | 2000 | 80 | 450 | CORROSION | 0 |
| COLUMBIA GAS TRANSMISSION CORP | KY | 1958 | 1999 | 41 | 850 | CORROSION | 0 |
| TENNESSEE GAS PIPELINE CO | KY | 1975 | 1999 | 24 | 1440 | PIPELINE DESIGN | 74556.213 |
| ASHLAND EXPLORATION CO | KY | 1972 | 1999 | 27 | 1250 | THIRD PARTY DAMAGE | 86982.249 |
| WESTERN KENTUCKY GAS CO | KY | 1951 | 1999 | 48 | 900 | OTHERS | 62130.178 |
| COLUMBIA GAS TRANSMISSION CORP | KY | 1958 | 1998 | 40 | 1060 | THIRD PARTY DAMAGE | 62945.736 |
| TENNESSEE GAS PIPELINE CO | KY | 1989 | 1998 | 9 | 1730 | THIRD PARTY DAMAGE | 62945.736 |
| UNION LIGHT HEAT & POWER CO | KY | 1993 | 1998 | 5 | 1247 | PIPELINE DESIGN | 81829.457 |
| COLUMBIA GAS TRANSMISSION CORP | KY | 1979 | 1998 | 19 | 1440 | CORROSION | 73017.054 |
| TEXAS EASTERN GAS PIPELINE CO | KY | 1976 | 1998 | 22 | 1440 | PIPELINE DESIGN | 88124.031 |
| TENNESSEE GAS PIPELINE CO | KY | 1953 | 1998 | 45 | 1100 | OTHERS | 0 |
| COLUMBIA GAS TRANSMISSION CORP | KY | 1963 | 1998 | 35 | 968 | OTHERS | 0 |
| TENNESSEE GAS PIPELINE CO | KY | 1970 | 1998 | 28 | 1250 | THIRD PARTY DAMAGE | 62945.736 |

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| DELTA NATURAL GAS CO INC | KY | 1958 | 1998 | 40 | 995 | OTHERS | 62945.736 |
| TENNESSEE GAS PIPELINE CO | KY | 1986 | 1997 | 11 | 1008 | PIPELINE DESIGN | 63709.593 |
| KENTUCKY - WEST VIRGINIA GAS CO | KY | 1966 | 1997 | 31 | 854 | CORROSION | 63709.593 |
| KENTUCKY - WEST VIRGINIA GAS CO | KY | 1977 | 1997 | 20 | 1300 | CORROSION | 65279.397 |
| COLUMBIA GAS TRANSMISSION CORP | KY | 1966 | 1997 | 31 | 1100 | CORROSION | 63709.593 |
| TENNESSEE GAS PIPELINE CO | KY | 1983 | 1996 | 13 | 1440 | OTHERS | 64821.714 |
| WESTERN KENTUCKY GAS CO | KY | 1979 | 1996 | 17 | 1440 | CORROSION | 87379.67 |
| DELTA NATURAL GAS CO INC | KY | 1995 | 1996 | 1 | 3680 | THIRD PARTY DAMAGE | 0 |
| GULF SOUTH PIPELINE CO | LA | 1996 | 1996 | 1 | 1200 | THIRD PARTY DAMAGE | 64821.714 |
| WILLIAMS ENERGY GROUP-FIELD SERVICES | LA | 1929 | 1996 | 67 | 500 | CORROSION | 28521.554 |
| TENNESSEE GAS PIPELINE CO | LA | 1969 | 1996 | 27 | 1250 | PIPELINE DESIGN | 64821.714 |
| TENNESSEE GAS PIPELINE CO | LA | 1984 | 1996 | 12 | 1730 | THIRD PARTY DAMAGE | 64821.714 |
| TENNESSEE GAS PIPELINE CO | LA | 1995 | 1995 | 1 | 3680 | THIRD PARTY DAMAGE | 0 |
| GULF SOUTH PIPELINE CO | LA | 1961 | 1995 | 34 | 750 | THIRD PARTY DAMAGE | 0 |
| MID LOUISIANA GAS CO | LA | 1993 | 1995 | 2 | 1238 | THIRD PARTY DAMAGE | 66066.392 |
| SOUTHERN NATURAL GAS CO | LA | 1986 | 1995 | 9 | 1440 | PIPELINE DESIGN | 66066.392 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1965 | 1995 | 30 | 1440 | CORROSION | 66066.392 |
| TEXAS EASTERN TRANSMISSION CORP (DUKE) | LA | 1994 | 1994 | 1 | 975 | PIPELINE DESIGN | 70155.073 |
| WILLIAMS ENERGY GROUP-FIELD SERVICES | LA | 1978 | 1994 | 16 | 1440 | THIRD PARTY DAMAGE | 67456.801 |
| DYNEGY MIDSTREAM SERVICES, L.P. | LA | 1978 | 1994 | 16 | 1440 | OTHERS | 13491.36 |
| SEA ROBIN PIPELINE CO | LA | 1982 | 1994 | 12 | 1440 | PIPELINE DESIGN | 26982.72 |

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| WILLIAMS FIELD SERVICES | LA | 1972 | 1994 | 22 | 1440 | CORROSION | 87693.841 |
| WILLIAMS ENERGY GROUP-FIELD SERVICES | LA | 1958 | 1994 | 36 | 1168 | CORROSION | 80948.161 |
| EL PASO FIELD SERVICES | LA | 1972 | 1994 | 22 | 1440 | CORROSION | 67456.801 |
| TRUNKLINE GAS CO | LA | 1958 | 1994 | 36 | 1247 | OTHERS | 67456.801 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1958 | 1993 | 35 | 1247 | OTHERS | 68906.993 |
| ANR PIPELINE CO | LA | 1971 | 1993 | 22 | 1250 | CORROSION | 68906.993 |
| TENNESSEE GAS PIPELINE CO | LA | 1989 | 1993 | 4 | 1440 | THIRD PARTY DAMAGE | 68906.993 |
| SOUTHERN NATURAL GAS CO | LA | 1960 | 1993 | 33 | 1008 | OTHERS | 68906.993 |
| TENNESSEE GAS PIPELINE CO | LA | 1956 | 1993 | 37 | 1130 | THIRD PARTY DAMAGE | 75797.692 |
| TENNESSEE GAS PIPELINE CO | LA | 1975 | 1993 | 18 | 1250 | CORROSION | 0 |
| ANR PIPELINE CO | LA | 1977 | 1993 | 16 | 815 | OTHERS | 71663.272 |
| WILLIAMS ENERGY GROUP-FIELD SERVICES | LA | 1979 | 1992 | 13 | 1440 | CORROSION | 73288.591 |
| TENNESSEE GAS PIPELINE CO | LA | 1969 | 1992 | 23 | 1200 | THIRD PARTY DAMAGE | 0 |
| WILLIAM FIELD SERVICES | LA | 1968 | 1992 | 24 | 1200 | CORROSION | 70469.799 |
| SEA ROBIN PIPELINE CO | LA | 1958 | 1992 | 34 | 1168 | PIPELINE DESIGN | 75402.685 |
| MID LOUISIANA GAS CO | LA | 1983 | 1992 | 9 | 1200 | CORROSION | 74838.926 |
| SOUTHERN NATURAL GAS CO | LA | 1986 | 1992 | 6 | 1000 | THIRD PARTY DAMAGE | 0 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1991 | 1991 | 1 | 1055 | CORROSION | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1927 | 1991 | 64 | 376 | THIRD PARTY DAMAGE | 72241.993 |
| TENNESSEE GAS PIPELINE CO | LA | 1980 | 1991 | 11 | 1200 | CORROSION | 72241.993 |
| TENNESSEE GAS PIPELINE CO | LA | 1951 | 1991 | 40 | 780 | OTHERS | 0 |
| CHEVRON USA INC | LA | 1969 | 1990 | 21 | 1200 | THIRD PARTY DAMAGE | 0 |
| DUKE ENERGY CORP | LA | 1984 | 1990 | 6 | 1200 | CORROSION | 74953.846 |
| TENNESSEE GAS PIPELINE CO | LA | 1978 | 1990 | 12 | 1440 | CORROSION | 0 |
| ANR PIPELINE CO | LA | 1971 | 1989 | 18 | 1000 | THIRD PARTY | 0 |

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| | | | | | | DAMAGE | |
| TENNESSEE GAS PIPELINE CO | LA | 1930 | 1989 | 59 | 185 | THIRD PARTY DAMAGE | 0 |
| SEA ROBIN PIPELINE CO | LA | 1963 | 1989 | 26 | 1100 | THIRD PARTY DAMAGE | 77738.065 |
| ANR PIPELINE CO | LA | 1971 | 1989 | 18 | 1000 | CORROSION | 0 |
| SOUTHERN NATURAL GAS CO | LA | 1971 | 1989 | 18 | 750 | OTHERS | 0 |
| BASIN EXPLORATION INC | LA | 1983 | 1989 | 6 | 1148 | THIRD PARTY DAMAGE | 77738.065 |
| EQUITABLE RESOURCES (a.k.a EquiTable Gas Co) | LA | 1969 | 1989 | 20 | 1273 | CORROSION | 77738.065 |
| SEA ROBIN PIPELINE CO | LA | 1981 | 1988 | 7 | 3526 | OTHERS | 88672.855 |
| EQUITABLE RESOURCES (a.k.a EquiTable Gas Co) | LA | 1981 | 1988 | 7 | 975 | OTHERS | 83181.276 |
| TENNESSEE GAS PIPELINE CO | LA | 1940 | 1988 | 48 | 650 | THIRD PARTY DAMAGE | 0 |
| MARATHON ASHLAND PIPE LINE LLC | LA | 1966 | 1988 | 22 | 1440 | CORROSION | 19382.045 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1952 | 1988 | 36 | 1200 | THIRD PARTY DAMAGE | 80758.52 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1942 | 1988 | 46 | 800 | CORROSION | 24227.556 |
| SOUTHERN NATURAL GAS CO | LA | 1962 | 1988 | 26 | 860 | OTHERS | 0 |
| SOUTHERN NATURAL GAS CO | LA | 1966 | 1987 | 21 | 780 | THIRD PARTY DAMAGE | 0 |
| ANR PIPELINE CO | LA | 1974 | 1987 | 13 | 1250 | CORROSION | 0 |
| SOUTHERN NATURAL GAS CO | LA | 1970 | 1987 | 17 | 1300 | PIPELINE DESIGN | 83299.138 |
| TRUNKLINE GAS CO | LA | 1940 | 1986 | 46 | 650 | THIRD PARTY DAMAGE | 0 |
| ANR PIPELINE CO | LA | 1967 | 1986 | 19 | 1100 | THIRD PARTY DAMAGE | 85473.684 |
| BRIDGELINE GAS DISTRIBUTION CO | LA | 1940 | 1986 | 46 | 650 | THIRD PARTY DAMAGE | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1951 | 1996 | 45 | 730 | THIRD PARTY DAMAGE | 103714.74 |
| ANR PIPELINE CO | LA | 1953 | 1995 | 42 | 750 | THIRD PARTY DAMAGE | 422824.91 |

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| TENNESSEE GAS PIPELINE CO | LA | 1951 | 1989 | 38 | 610 | THIRD PARTY DAMAGE | 77738.065 |
| TRUNKLINE GAS CO | LA | 1968 | 2000 | 32 | 750 | OTHERS | 0 |
| KOCH GATEWAY PIPELINE CO | LA | 1951 | 1993 | 42 | 815 | OTHERS | 79932.111 |
| TRUNKLINE GAS CO | LA | 1952 | 1987 | 35 | 750 | THIRD PARTY DAMAGE | 63598.892 |
| TENNESSEE GAS PIPELINE CO | LA | 1955 | 1994 | 39 | 650 | THIRD PARTY DAMAGE | 94439.521 |
| TENNESSEE GAS PIPELINE CO | LA | 1931 | 1989 | 58 | 340 | THIRD PARTY DAMAGE | 0 |
| NATURAL GAS PIPELINE CO OF AMERICA | LA | 2001 | 2001 | 1 | 850 | OTHERS | 0 |
| ANR PIPELINE CO | LA | 1973 | 2000 | 27 | 1440 | CORROSION | 2436 |
| ANR PIPELINE CO | LA | 1968 | 1999 | 31 | 958 | THIRD PARTY DAMAGE | 202544.38 |
| TENNESSEE GAS PIPELINE CO | LA | 1957 | 1999 | 42 | 800 | PIPELINE DESIGN | 869822.49 |
| SOUTHERN NATURAL GAS CO | LA | 1966 | 1996 | 30 | 858 | THIRD PARTY DAMAGE | 583395.42 |
| SOUTHERN NATURAL GAS CO | LA | 1994 | 1995 | 1 | 1200 | PIPELINE DESIGN | 0 |
| TEXAS EASTERN GAS PIPELINE CO | LA | 1962 | 1994 | 32 | 845 | OTHERS | 2023704 |
| TEXAS EASTERN GAS PIPELINE CO | LA | 1959 | 1991 | 32 | 800 | THIRD PARTY DAMAGE | 0 |
| TRUNKLINE GAS CO | LA | 1952 | 1989 | 37 | 970 | THIRD PARTY DAMAGE | 466428.39 |
| TENNESSEE GAS PIPELINE CO | LA | 1975 | 1987 | 12 | 1050 | OTHERS | 0 |
| TRANSCO GAS PIPELINE CORP | LA | 1947 | 1997 | 50 | 800 | CORROSION | 29306.413 |
| TRANSCO GAS PIPELINE CORP | LA | 1968 | 1997 | 29 | 1142 | THIRD PARTY DAMAGE | 0 |
| TRANSCO GAS PIPELINE CORP | LA | 1956 | 1994 | 38 | 858 | OTHERS | 76900.753 |
| HALL-HOUSTON OIL COMPANY | LA | 1939 | 1992 | 53 | 544 | THIRD PARTY DAMAGE | 70469.799 |
| TENNESSEE GAS PIPELINE CO | LA | 1981 | 1989 | 8 | 974 | OTHERS | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1971 | 1986 | 15 | 960 | THIRD PARTY | 0 |

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| | | | | | | DAMAGE | |
| COLUMBIA GULF TRANSMISSION CO | LA | 1961 | 2000 | 39 | 50 | CORROSION | 157122 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1972 | 1998 | 26 | 974 | OTHERS | 1780105.4 |
| TRANSCO GAS PIPELINE CORP | LA | 1968 | 1997 | 29 | 974 | OTHERS | 127419.19 |
| NATURAL GAS PIPELINE CO OF AMERICA | LA | 1932 | 1996 | 64 | 490 | PIPELINE DESIGN | 129643.43 |
| CHEVRON PIPELINE CO | LA | 1960 | 1995 | 35 | 877 | OTHERS | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1974 | 1990 | 16 | 750 | THIRD PARTY DAMAGE | 0 |
| CHEVRON PIPELINE CO | LA | 1960 | 1990 | 30 | 950 | THIRD PARTY DAMAGE | 91443.692 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1965 | 1989 | 24 | 950 | OTHERS | 142571.61 |
| TRANSCO GAS PIPELINE CORP | LA | 1980 | 1989 | 9 | 1076 | OTHERS | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1997 | 2000 | 3 | 1550 | OTHERS | 0 |
| MID - LOUISIANA GAS CO | LA | 1971 | 1998 | 27 | 60 | THIRD PARTY DAMAGE | 75534.884 |
| TRANSCO GAS PIPELINE CORP | LA | 1932 | 1997 | 65 | 960 | THIRD PARTY DAMAGE | 0 |
| NATURAL GAS PIPELINE CO OF AMERICA | LA | 1963 | 1996 | 33 | 950 | THIRD PARTY DAMAGE | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1961 | 1994 | 33 | 832 | PIPELINE DESIGN | 0 |
| NATURAL GAS PIPELINE CO OF AMERICA | LA | 1970 | 1987 | 17 | 802 | CORROSION | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1931 | 2001 | 70 | 625 | PIPELINE DESIGN | 434404.92 |
| TRUNKLINE GAS CO | LA | 1948 | 1997 | 49 | 900 | CORROSION | 637095.93 |
| TRANSCO GAS PIPELINE CORP | LA | 1937 | 1996 | 59 | 800 | CORROSION | 233358.17 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1929 | 1993 | 64 | 450 | OTHERS | 264602.85 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1961 | 1996 | 35 | 235 | THIRD PARTY DAMAGE | 77786.056 |
| NATURAL GAS PIPELINE CO OF AMERICA | LA | 1930 | 1994 | 64 | 570 | THIRD PARTY DAMAGE | 22935.312 |
| TRANSCO GAS PIPELINE CORP | LA | 1946 | 1992 | 46 | 250 | THIRD PARTY | 70469.799 |

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|---|---|---|---|---|---|---|---|
| | | | | | | DAMAGE | |
| TENNESSEE GAS PIPELINE CO | LA | 1937 | 1988 | 51 | 800 | THIRD PARTY DAMAGE | 0 |
| MID - LOUISIANA GAS CO | LA | 1931 | 1986 | 55 | 465 | THIRD PARTY DAMAGE | 51284.211 |
| NATURAL GAS PIPELINE CO OF AMERICA | LA | 1940 | 2001 | 61 | 700 | OTHERS | 126155.95 |
| SEA ROBIN PIPELINE CO | LA | 1931 | 2000 | 69 | 417 | CORROSION | 98049 |
| UNITED GAS PIPELINE CO | LA | 1975 | 2000 | 25 | 960 | OTHERS | 130935 |
| TENNESSEE GAS PIPELINE CO | LA | 1949 | 2000 | 51 | 840 | OTHERS | 0 |
| TRANSCO GAS PIPELINE CORP | LA | 1930 | 2000 | 70 | 430 | OTHERS | 95943.078 |
| TRANSCO GAS PIPELINE CORP | LA | 1930 | 2000 | 70 | 430 | OTHERS | 133980 |
| TENNESSEE GAS PIPELINE CO | LA | 1939 | 2000 | 61 | 475 | OTHERS | 158340 |
| SOUTHERN NATURAL GAS CO | LA | 1931 | 1999 | 68 | 417 | CORROSION | 149112.43 |
| SOUTHERN NATURAL GAS CO | LA | 1949 | 1997 | 48 | 750 | PIPELINE DESIGN | 178386.86 |
| ANR PIPELINE CO | LA | 1962 | 1997 | 35 | 936 | OTHERS | 4459671.5 |
| TENNESSEE GAS PIPELINE CO | LA | 1948 | 1996 | 48 | 230 | THIRD PARTY DAMAGE | 162054.28 |
| TENNESSEE GAS PIPELINE CO | LA | 1992 | 1996 | 4 | 674 | OTHERS | 134829.16 |
| UNITED GAS PIPELINE CO | LA | 1966 | 1995 | 29 | 1008 | OTHERS | 0 |
| NERCO OIL & GAS INC | LA | 1963 | 1995 | 32 | 1200 | PIPELINE DESIGN | 990995.88 |
| SOUTHERN NATURAL GAS CO | LA | 1959 | 1994 | 35 | 975 | THIRD PARTY DAMAGE | 101185.2 |
| MONTEREY PIPELINE CO | LA | 1946 | 1994 | 48 | 500 | OTHERS | 169316.57 |
| ANR PIPELINE CO | LA | 1952 | 1994 | 42 | 750 | CORROSION | 1602099 |
| CHEVRON USA INC | LA | 1964 | 1993 | 29 | 1000 | OTHERS | 0 |
| UNITED GAS PIPELINE CO | LA | 1948 | 1992 | 44 | 750 | OTHERS | 138120.81 |
| ANR PIPELINE CO | LA | 1959 | 1991 | 32 | 936 | OTHERS | 0 |
| ACADIAN GAS PIPELINE SYSTEM | LA | 1930 | 1990 | 60 | 385 | THIRD PARTY DAMAGE | 804544.09 |
| UNITED GAS PIPELINE CO | LA | 1948 | 1990 | 42 | 750 | OTHERS | 0 |
| ANR PIPELINE CO | LA | 1970 | 1989 | 19 | 858 | OTHERS | 1554761.3 |

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|---|---|---|---|---|---|---|---|
| SOUTHERN NATURAL GAS CO | LA | 1930 | 1988 | 58 | 500 | THIRD PARTY DAMAGE | 355337.49 |
| SOUTHERN NATURAL GAS CO | LA | 1956 | 1988 | 32 | 858 | PIPELINE DESIGN | 92064.713 |
| TENNESSEE GAS PIPELINE CO | LA | 1962 | 1986 | 24 | 920 | OTHERS | 1170989.5 |
| TEXAS EASTERN GAS PIPELINE CO | LA | 1942 | 2000 | 58 | 500 | CORROSION | 0 |
| UNITED GAS PIPELINE CO | LA | 1959 | 1998 | 39 | 300 | PIPELINE DESIGN | 0 |
| SOUTHERN NATURAL GAS CO | LA | 1960 | 1998 | 38 | 750 | THIRD PARTY DAMAGE | 3776.7442 |
| TENNESSEE GAS PIPELINE CO | LA | 1966 | 1998 | 32 | 445 | THIRD PARTY DAMAGE | 74821.079 |
| NATURAL GAS PIPELINE CO OF AMERICA | LA | 1954 | 1997 | 43 | 935 | PIPELINE DESIGN | 76451.512 |
| SEA ROBIN PIPELINE CO | LA | 1949 | 1997 | 48 | 680 | PIPELINE DESIGN | 76957.366 |
| TEXAS GAS TRANSMISSION CORP | LA | 1952 | 1994 | 42 | 780 | PIPELINE DESIGN | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1927 | 1993 | 66 | 250 | THIRD PARTY DAMAGE | 63394.433 |
| TENNESSEE GAS PIPELINE CO | LA | 1988 | 1992 | 4 | 250 | THIRD PARTY DAMAGE | 43691.275 |
| ANR PIPELINE CO (AMERICAN NATURAL RESOURCE) | LA | 1972 | 1990 | 18 | 3500 | PIPELINE DESIGN | 0 |
| TRANSCO GAS PIPELINE CORP | LA | 1971 | 1990 | 19 | 1100 | THIRD PARTY DAMAGE | 0 |
| UNITED GAS PIPELINE CO | LA | 1977 | 1989 | 12 | 120 | CORROSION | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1951 | 1989 | 38 | 780 | PIPELINE DESIGN | 77738.065 |
| UNITED GAS PIPELINE CO | LA | 1962 | 2001 | 39 | 500 | THIRD PARTY DAMAGE | 178522.57 |
| UNITED GAS PIPELINE CO | LA | 1962 | 1999 | 37 | 500 | THIRD PARTY DAMAGE | 141656.8 |
| TRANSCO GAS PIPELINE CORP | LA | 1931 | 1996 | 65 | 720 | THIRD PARTY DAMAGE | 120568.39 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1940 | 1996 | 56 | 750 | THIRD PARTY DAMAGE | 238543.91 |

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| NATURAL GAS PIPELINE CO OF AMERICA | LA | 1962 | 1991 | 29 | 662 | THIRD PARTY DAMAGE | 210595.52 |
| NATURAL GAS PIPELINE CO OF AMERICA | LA | 1931 | 1986 | 55 | 500 | CORROSION | 273515.79 |
| TRANSCO GAS PIPELINE CORP | LA | 1964 | 2001 | 37 | 590 | THIRD PARTY DAMAGE | 59507.524 |
| CHEVRON USA INC | LA | 1930 | 1997 | 67 | 450 | THIRD PARTY DAMAGE | 0 |
| TRANSCO GAS PIPELINE CORP | LA | 1957 | 1996 | 39 | 623 | THIRD PARTY DAMAGE | 64821.714 |
| TRANSCO GAS PIPELINE CORP | LA | 1964 | 1987 | 23 | 590 | THIRD PARTY DAMAGE | 19825.195 |
| SOUTHERN NATURAL GAS CO | LA | 1931 | 1986 | 55 | 751 | THIRD PARTY DAMAGE | 51797.053 |
| CHEVRON USA INC | LA | 1959 | 1995 | 36 | 780 | THIRD PARTY DAMAGE | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1958 | 1993 | 35 | 650 | THIRD PARTY DAMAGE | 137813.99 |
| TENNESSEE GAS PIPELINE CO | LA | 1959 | 1991 | 32 | 763 | THIRD PARTY DAMAGE | 115587.19 |
| SOUTHERN NATURAL GAS CO | LA | 1959 | 1989 | 30 | 771 | THIRD PARTY DAMAGE | 0 |
| CHEVRON USA INC | LA | 1985 | 1986 | 1 | 750 | PIPELINE DESIGN | 598315.79 |
| TENNESSEE GAS PIPELINE CO | LA | 1951 | 1997 | 46 | 750 | THIRD PARTY DAMAGE | 305806.05 |
| ANR PIPELINE CO (AMERICAN NATURAL RESOURCE) | LA | 1954 | 1989 | 35 | 1000 | THIRD PARTY DAMAGE | 466428.39 |
| TENNESSEE GAS PIPELINE CO | LA | 1931 | 1988 | 57 | 712 | OTHERS | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1949 | 1993 | 44 | 500 | THIRD PARTY DAMAGE | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1985 | 1993 | 8 | 1440 | THIRD PARTY DAMAGE | 0 |
| STINGRAY PIPELINE CO | LA | 1952 | 1993 | 41 | 150 | OTHERS | 0 |
| ANR PIPELINE CO (AMERICAN NATURAL RESOURCE) | LA | 1942 | 1992 | 50 | 712 | CORROSION | 70469.799 |

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|---|---|---|---|---|---|---|---|
| FLORIDA GAS TRANSMISSION CO | LA | 1968 | 1991 | 23 | 673 | THIRD PARTY DAMAGE | 36120.996 |
| STINGRAY PIPELINE CO | LA | 1947 | 1990 | 43 | 300 | THIRD PARTY DAMAGE | 8994.4615 |
| STINGRAY PIPELINE CO | LA | 1952 | 1990 | 38 | 400 | PIPELINE DESIGN | 0 |
| SEA ROBIN PIPELINE CO | LA | 1956 | 1989 | 33 | 545 | THIRD PARTY DAMAGE | 0 |
| UNITED GAS PIPELINE CO | LA | 1967 | 1988 | 21 | 545 | THIRD PARTY DAMAGE | 0 |
| ANR PIPELINE CO (AMERICAN NATURAL RESOURCE) | LA | 1960 | 1988 | 28 | 725 | THIRD PARTY DAMAGE | 0 |
| UNITED GAS PIPELINE CO | LA | 1947 | 1986 | 39 | 500 | OTHERS | 0 |
| UNITED GAS PIPELINE CO | LA | 1985 | 1990 | 5 | 638 | PIPELINE DESIGN | 99408.284 |
| UNITED GAS PIPELINE CO | LA | 1961 | 1994 | 33 | 975 | THIRD PARTY DAMAGE | 33728401 |
| ST JOHN THE BAPTIST PARISH UTILITIES | LA | 1979 | 1989 | 10 | 400 | OTHERS | 466428.39 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1965 | 1988 | 23 | 230 | OTHERS | 137289.48 |
| TENNESSEE GAS PIPELINE CO | LA | 1990 | 2000 | 10 | 1200 | THIRD PARTY DAMAGE | 85260 |
| ANR PIPELINE CO | LA | 1961 | 1989 | 28 | 1136 | CORROSION | 0 |
| GULF SOUTH PIPELINE CO | LA | 1962 | 1986 | 24 | 795 | THIRD PARTY DAMAGE | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1965 | 1986 | 21 | 1050 | OTHERS | 85473.684 |
| RELIANT ENERGY GAS TRANSMISSION | LA | 1961 | 1986 | 25 | 1170 | THIRD PARTY DAMAGE | 0 |
| DYNEGY MIDSTREAM SERVICES, L.P. | LA | 1950 | 2000 | 50 | 837 | CORROSION | 1215924.5 |
| LOUISIANA INTRASTATE GAS CO, L.L.C. | LA | 1954 | 1999 | 45 | 845 | PIPELINE DESIGN | 217207.1 |
| MID LOUISIANA GAS CO | LA | 1983 | 1998 | 15 | 836 | OTHERS | 188837.21 |
| BASIN EXPLORATION INC | LA | 1953 | 1996 | 43 | 836 | CORROSION | 311144.23 |
| ANR PIPELINE CO | LA | 1960 | 1994 | 34 | 1008 | THIRD PARTY DAMAGE | 2968099.2 |

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| KOCH GATEWAY PIPELINE CO | LA | 1964 | 1993 | 29 | 400 | THIRD PARTY DAMAGE | 310081.47 |
| ANR PIPELINE CO | LA | 1947 | 1993 | 46 | 850 | CORROSION | 148839.1 |
| LOUISIANA RESOURCES PIPELINE CO, L.P. | LA | 1953 | 1992 | 39 | 836 | CORROSION | 191266.31 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1976 | 1991 | 15 | 792 | OTHERS | 433451.96 |
| RELIANT ENERGY - ARKLA | LA | 1960 | 1990 | 30 | 836 | PIPELINE DESIGN | 555106.69 |
| BASIN EXPLORATION INC | LA | 1950 | 1990 | 40 | 845 | THIRD PARTY DAMAGE | 313621.88 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1976 | 1990 | 14 | 600 | THIRD PARTY DAMAGE | 224861.54 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1978 | 1989 | 11 | 1100 | OTHERS | 932856.78 |
| TRUNKLINE GAS CO | LA | 1966 | 1988 | 22 | 550 | THIRD PARTY DAMAGE | 116885.04 |
| SOUTHERN NATURAL GAS CO | LA | 1971 | 1987 | 16 | 750 | OTHERS | 832991.38 |
| SOUTHERN NATURAL GAS CO | LA | 1976 | 1990 | 14 | 750 | PIPELINE DESIGN | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1936 | 1990 | 54 | 850 | THIRD PARTY DAMAGE | 74953.846 |
| ANR PIPELINE CO | LA | 1953 | 1990 | 37 | 697 | THIRD PARTY DAMAGE | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1971 | 1988 | 17 | 820 | OTHERS | 0 |
| MID LOUISIANA GAS CO | LA | 1956 | 2000 | 44 | 400 | THIRD PARTY DAMAGE | 92775.06 |
| MID LOUISIANA GAS CO | LA | 1958 | 1999 | 41 | 300 | THIRD PARTY DAMAGE | 226278.11 |
| KOCH GATEWAY PIPELINE CO | LA | 1996 | 1998 | 2 | 720 | THIRD PARTY DAMAGE | 163482.67 |
| SOUTHERN NATURAL GAS CO | LA | 1994 | 1994 | 1 | 960 | PIPELINE DESIGN | 0 |
| FLORIDA GAS TRANSMISSION CO | LA | 1989 | 1989 | 1 | 830 | PIPELINE DESIGN | 0 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1963 | 1986 | 23 | 700 | THIRD PARTY DAMAGE | 0 |
| WILLIAM FIELD SERVICES | LA | 1951 | 2000 | 49 | 878 | PIPELINE DESIGN | 121800 |
| FOREST OIL CORP | LA | 1953 | 1994 | 41 | 915 | CORROSION | 149936.23 |

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| COLUMBIA GULF TRANSMISSION CO | LA | 1953 | 1993 | 40 | 926 | CORROSION | 381744.74 |
| LOUISIANA INTRASTATE GAS CO, L.L.C. | LA | 1959 | 1990 | 31 | 650 | THIRD PARTY DAMAGE | 325299.69 |
| NATURAL GAS PIPELINE CO OF AMERICA | LA | 1962 | 1997 | 35 | 470 | THIRD PARTY DAMAGE | 76451.512 |
| NATURAL GAS PIPELINE CO OF AMERICA | LA | 1962 | 1996 | 34 | 490 | THIRD PARTY DAMAGE | 77786.056 |
| ANR PIPELINE CO | LA | 1965 | 1996 | 31 | 350 | THIRD PARTY DAMAGE | 0 |
| VASTAR RESOURCES, INC. | LA | 1991 | 1993 | 2 | 760 | THIRD PARTY DAMAGE | 55125.594 |
| TRUNKLINE GAS CO | LA | 1951 | 1993 | 42 | 350 | OTHERS | 0 |
| VASTAR RESOURCES, INC | LA | 1958 | 1992 | 34 | 350 | OTHERS | 0 |
| VASTAR RESOURCES, INC | LA | 1950 | 1990 | 40 | 823 | THIRD PARTY DAMAGE | 0 |
| NORAM GAS TRANSMISSION | LA | 1958 | 1990 | 32 | 350 | OTHERS | 0 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1991 | 2001 | 10 | 1000 | THIRD PARTY DAMAGE | 602857.63 |
| SOUTHERN NATURAL GAS CO | LA | 1952 | 1998 | 46 | 1000 | THIRD PARTY DAMAGE | 4280310.1 |
| VASTAR RESOURCES, INC. | LA | 1910 | 1996 | 86 | 256 | OTHERS | 259286.85 |
| ARAN ENERGY CORPORATION | LA | 1978 | 1995 | 17 | 675 | OTHERS | 376578.43 |
| SOUTHERN NATURAL GAS CO | LA | 1951 | 1992 | 41 | 809 | THIRD PARTY DAMAGE | 217046.98 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1951 | 1991 | 40 | 1200 | CORROSION | 404555.16 |
| MOBIL EXPLORATION & PRODUCING US INC | LA | 1968 | 1989 | 21 | 720 | THIRD PARTY DAMAGE | 155476.13 |
| ARAN ENERGY CORPORATION | LA | 1909 | 1988 | 79 | 185 | OTHERS | 0 |
| FLORIDA GAS TRANSMISSION CO | LA | 1958 | 1988 | 30 | 650 | OTHERS | 145365.34 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1962 | 1997 | 35 | 175 | THIRD PARTY DAMAGE | 63709.593 |
| TENNESSEE GAS PIPELINE CO | LA | 1948 | 1996 | 48 | 900 | OTHERS | 0 |

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| TENNESSEE GAS PIPELINE CO | LA | 1951 | 1993 | 42 | 200 | THIRD PARTY DAMAGE | 68906.993 |
| TENNESSEE GAS PIPELINE CO | LA | 1943 | 1990 | 47 | 630 | THIRD PARTY DAMAGE | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1956 | 1990 | 34 | 1100 | PIPELINE DESIGN | 74953.846 |
| TRANSCO GAS PIPELINE CORP | LA | 1951 | 1989 | 38 | 800 | CORROSION | 77738.065 |
| TENNESSEE GAS PIPELINE CO | LA | 1958 | 1987 | 29 | 250 | THIRD PARTY DAMAGE | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1995 | 2001 | 6 | 100 | OTHERS | 127941.18 |
| TENNESSEE GAS PIPELINE CO | LA | 1989 | 2001 | 12 | 1050 | PIPELINE DESIGN | 161384.41 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1991 | 2000 | 9 | 850 | OTHERS | 2375100 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1972 | 2000 | 28 | 720 | CORROSION | 182700 |
| TENNESSEE GAS PIPELINE CO | LA | 1990 | 1999 | 9 | 1000 | PIPELINE DESIGN | 99408.284 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1973 | 1999 | 26 | 960 | THIRD PARTY DAMAGE | 0 |
| TENNESSEE GAS PIPELINE CO | LA | 1997 | 1999 | 2 | 1000 | OTHERS | 90710.059 |
| COLUMBIA GULF TRANSMISSION CO | LA | 1980 | 1998 | 18 | 1114 | THIRD PARTY DAMAGE | 503565.89 |
| UNITED GAS PIPELINE CO | LA | 1953 | 1996 | 43 | 440 | THIRD PARTY DAMAGE | 104749.3 |
| ANR PIPELINE CO | LA | 1948 | 1996 | 48 | 712 | CORROSION | 129643.43 |
| TRUNKLINE GAS CO | LA | 1929 | 1994 | 65 | 595 | CORROSION | 107930.88 |
| NATURAL GAS PIPELINE CO OF AMERICA | LA | 1967 | 1993 | 26 | 1000 | OTHERS | 55125.594 |
| TRANSCO GAS PIPELINE CORP | LA | 1979 | 1993 | 14 | 700 | OTHERS | 826883.91 |
| STINGRAY PIPELINE CO | LA | 1943 | 1992 | 49 | 625 | CORROSION | 183221.48 |
| BRIDGELINE GAS DISTRIBUTION CO | LA | 1982 | 1991 | 9 | 800 | THIRD PARTY DAMAGE | 60972.242 |
| TENNESSEE GAS PIPELINE CO | LA | 1965 | 1991 | 26 | 820 | OTHERS | 577935.94 |
| UNITED GAS PIPELINE CO | LA | 1970 | 1990 | 20 | 60 | OTHERS | 0 |
| NATURAL GAS PIPELINE CO OF AMERICA | LA | 1968 | 1988 | 20 | 939 | OTHERS | 48455.112 |

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|---|---|---|---|---|---|---|---|
| TRANSCO GAS PIPELINE CORP | LA | 1918 | 1987 | 69 | 375 | OTHERS | 583093.97 |