DEVELOPMENT OF THE ALEOC BEAM PUMP FAILURE DATABASE

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Abstract

Sucker-rod pumping system is the most numerous among all artificial lift methods used in the Permian Basin. Therefore. continued efforts to improve and optimize sucker-rod performance are imperative for successful operation in this area. The Artificial Lift Energy Optimization Consortium (ALEOC) was formed by eleven oil companies operating in the Permian Basin with the primary goal of improving oil field operations through sharing experiences. The consortium members provided beam pump related data from about 25.000 wells, which is about a quarter of sucker-rod pumped wells in the entire Permian Basin. A database has been developed to combine these data into a single, uniform and consistent format. The database can be queried and analyzed either via the Internet or in the desktop environment. From the query results, one can calculate failure frequencies of pump, rod, and tubing, and summarize the results in various ways. Such analysis will suggest answers to questions like what component is the most/least likely to fail. which operating areas have typically high/low failures, and what is the performance of a company relative to the other companies. Knowing these facts should greatly benefit each company in making engineering and business decisions.

Introduction

Several authors have demonstrated the usefulness of databases in well optimization programs (Patterson et al., 1994, Lee and Mantecon. 1994). Their works. however, were mostly in-house projects confined within one company. and sometimes within one particular operating area. The present work, in contrast, covers a much wider scope. Data from individual companies varied in organization, information content. and formats such as MS Access. DBASE and MS Excel spreadsheet. The task of establishing a degree of uniformity among the different company databases posed a formidable problem. Heinze and Ge (1997) initiated the work of designing the suitable data-gathering format and identifying the common items from separate databases. Heinze and Rahman (1999) constructed the current database from these common parts. Data from different sources initially totaled approximately 64 megabytes. The new database is in MS Access format. and is about 500 kilobytes in size. This database has been made accessible via the Internet for the consortium msmbsrs.

Failure Frequency

Failures in a sucker rod pumping well can be ascribed to any one of the four major components- 1).Pump, 2).Rod. 3).Tubing. and 4).Surface equipment. However, failure of surface equipment is not considered in this study. Failure frequency provides a fair basis of comparison of performance among different companies. areas. and components. Failure frequency of component i is defined as:

$$ff_i = \frac{\sum Failure}{Averuge\ no.\ of\ wells} \quad (/\text{well}/\text{year})$$

The total failure frequency is defined as:

Total Failure Frequency = Pump failure frequency + Rod failure frequency + Tubing failure frequency

Results from Data Analysis

Figure 1 shows the year-by-year failure frequencies for pump, rod and tubing combined, i.e. the total failure frequency. Each series stands for one company, all operating areas inclusive. The number in parenthesis next to each company name in the legend denotes the average number of sucker-rod wells for that company. However, this number is an average over the years of data provided by that company, and the number of wells can vary significantly from year to year. It should also be noted that not every company has data for every year. Nevertheless. this plot provides an over-all picture of beam pump performance in the entire basin. Data points falling one standard deviation above average indicate bad performance, while those falling below one standard deviation of the average can be considered as good performance. It can be seen that most of the data points fall below the average line. The average values range from 0.9 to 0.25. The overall trend is downward which implies that sucker-rod performance is improving throughout the region. Company K however, experienced abnormally high failures between '92 and '96, and remarkable failure reduction in latter years. It would be worthwhile to learn how this was achieved.

Figures 2, 3 and 4 are subsets of figure 1. which is broken down for individual component failures. Figures 2, 3, and 4 respectively show the yearly failure frequencies for pump, rod and tubing. Conclusions drawn above also apply to these figures. One can easily notice the downward trend reflected on each figure, indicating improved performance with time.

Figure 5 shows total failure frequency in six different operating areas of company **A.** Such comparison is useful to identify operating areas where significant room for improvement may exist. It can be seen that Andrews and Midland areas had high rates of failure in the past, and increasing failures are encountered in the New Mexico area in recent years.

Figures 6 to 14 are similar to figure 5. The! are constructed to compare performance among the different operating areas of individual companies Figure 6 shows upward trends in Forsan and Midland areas of company B. whereas the rest of the areas show declining failure rates. Figure 7 shows somewhat steady situation in all areas of company C. Figure **8** shows steady decline in failure in all areas of company D, except McCamey. Figure 9 shows a high failure rate in Kermit area of company E. It appears in figure 10 that failure frequency data fall into two separate groups. which may indicate two different groups of operational parameters. Figure 11 shows that Company H has higher failure rates in at least three areas- South Huntley, Andrews and Dagger Draw. Figure 12 shows that company J is

experiencing unusually high failures in the Wolfcamp formation in the Adair area. Figures 13 and 14 illustrate steady improvements in all areas of companies K and L.

A sudden increase or decrease of failure frequency may also be caused by new purchase or sale of wells. Figure 15 is made to investigate whether that is the case for the remarkable improvement in the Andrews area for company L. Pump. rod. tubing and total failure frequency is plotted against the well counts in the Andrews area. It can be seen that the failure rates are declining despite an increase of wells. Thorough investigation of the features mentioned about figures 5 to 14 should reveal interesting facts regarding the operations and physical conditions of the wells. It is important to find the causes and remedies, which might be applied for failure control in other areas as well.

Figure 16 shows the average number of wells in different operating areas of company F. Similar plots can be made for each company. Such plots are useful to decide whether certain area has a greater/lesser impact on the company's overall performance.

Figures 17 to 22 concentrate on the New Mexico area. Such analysis is useful in that, one particular company can decide whether its failure rates are generic to that area, i.e., whether every other company has the same experience. If not, then obviously that particular company has a significant room for improvement in operations in that area.

Figures 17, 18. 19 and 20 illustrate the total. pump. rod and tubing failure frequency respectively. It can be seen that while company L had unusual failure rates, the over all scenario is somewhat static in New Mexico. Figure 21 combines failure frequency with well and failure counts. This figure further corroborates the notion that the over-all performance has been static. Figure 22 shows the number of wells of each company in New Mexico. Similarly. figures 23 to 28 concentrate on Andrews Area. It is seen that the over-all performance in this are3 has significantly improved with time.

Figure 29 is a performance comparison among eight different areas. The numbers in parenthesis next to the area names in the legend denote the number of companies in those areas. It is seen that Andrews had the highest failure rates in the past. Such comparison should indicate whether certain areas have typically higher/lower rates of failure. From here, an operator may select a more favorable area for investment.

Figures 30, 31 and 32 shows the economic value of the failure reductions. It is assumed that each pump fail costs $2,000, each rod parting costs 51.000 and each tubing failure costs $5,000. Therefore, reduction of one failure results in saving of that amount. The difference of failure frequency of a component between successive years is multiplied by the average number of wells and the cost of that component failure to obtain the amount said. The projected saving is calculated using the "best fit" line, while the actual saving comes from the actual failure frequency data points. It can be seen that theoretically the companies together have saved a significant amount of money from failure reduction.

Conclusions and Suggestions

From the above analysis, the following conclusions and suggestions may be presented:

- Sucker-rod pumping system is vulnerable to failure; failure of any component may result in complete failure of the system.
- Failure frequency plots are useful graphical means for comparing oil-field performance, and for diagnosing problematic operations.
- From the analysis of the available data. downhole pump has the highest probability to fail. Intensive study of pump principle and design of new downhole pumps are necessary.
- Tubing has a fairly high failure frequency. more work should be done on the motion and load of the tubing string relative to its cost of repair.
- Continue the research work until detailed causes of failures are figured out and better solutions are made to make the sucker rod pumping system more efficient and more effective.
- The comparison of each company was constructive for targeting areas where potential existed for improvement and spurred discussion on operating practices and philosophy.
- After discussion with each company some individual comments suggested reasons for the variance in performance:
    - Recent purchase of wells in arc3 – generally indicated by higher than normal failures initially followed by dramatic improvements.
    - Recent changes (reduction/addition) in manpower or changes in operating policy in an area – indicated by increasingly higher then normal failures or dramatic reduction in failures.

Acknowledgements

The authors would like to thank the ALEOC member companies for providing the data.

References

Heinze, L.R. and G.e, Z., "Application of Fault Tree Analysis to Sucker-Rod Pumping System," 48th ATM of the Petroleum Society of CIM. June 10. 1997, Calargy, Canada.

Lee, W. and Mantecon, J.C., "Sucker-rod pumping wells Optimization Using a Spreadsheet Database on Barrow Island, Western Australia," Proceedings. SPE Asia Pacific Oil and Gas Conference, 7-10 Nov. 1994, Melbourne, Australia.

Patterson, J.C., Curfew. J.V. and Bucaram. S.M.. "An Updated Data Gathering System to Optimize Production Operations." Proceedings, 69th SPE ATCE, 25-28 Sept., 1994, New Orleans, LA

Heinze, L.R., Rahman. M.M. and Ge. Z.: "Sucker Rod Pumping Failures in the Permian Basin", Paper SPE 56661, Presented at the SPE Annual Tschnical Conference and Exhibition, 3-6 October 1999, , Houston, TX.
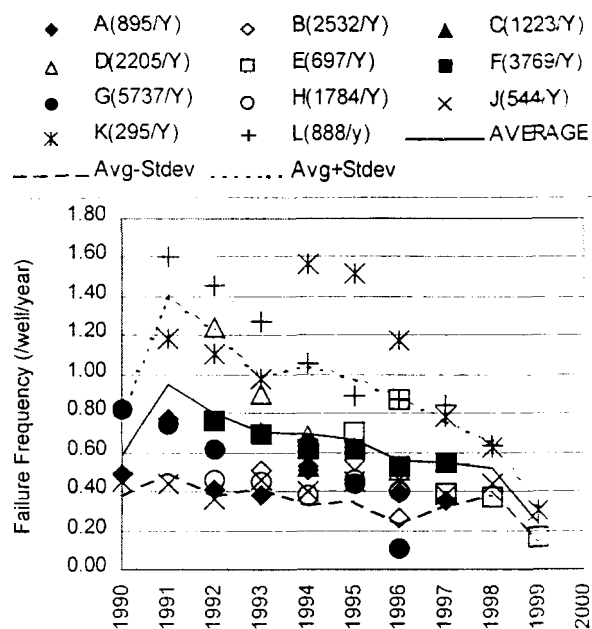
Figure 1 - Total Failure Frequency for Each Company
in the Permian Basin
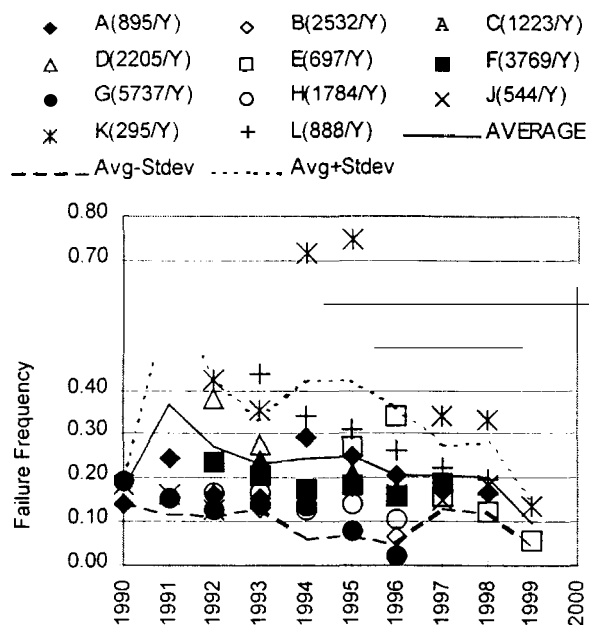
Figure 3 - Rod Failure Frequency for Each Company
in the Permian Basin
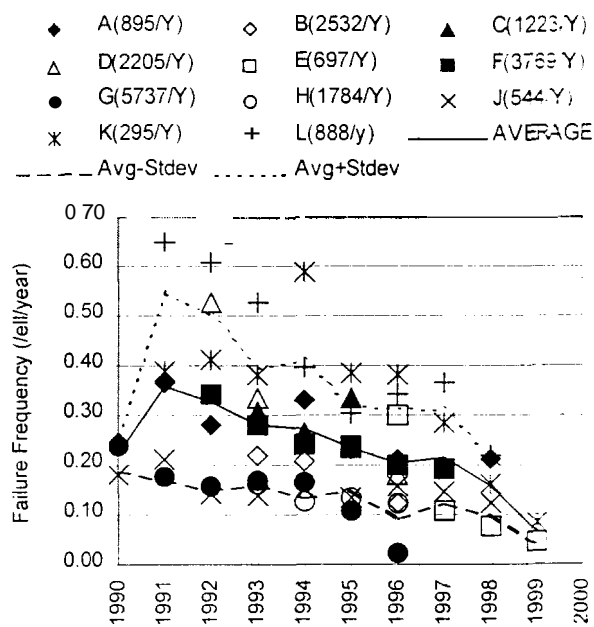
Figure 2 - Pump Failure Frequency for Each Company
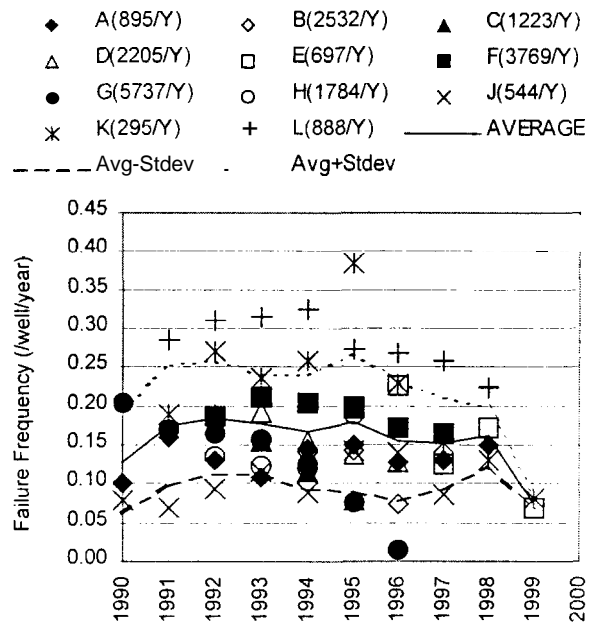in the Permian Basin

Figure 4 - Tubing Failure Frequency for Each
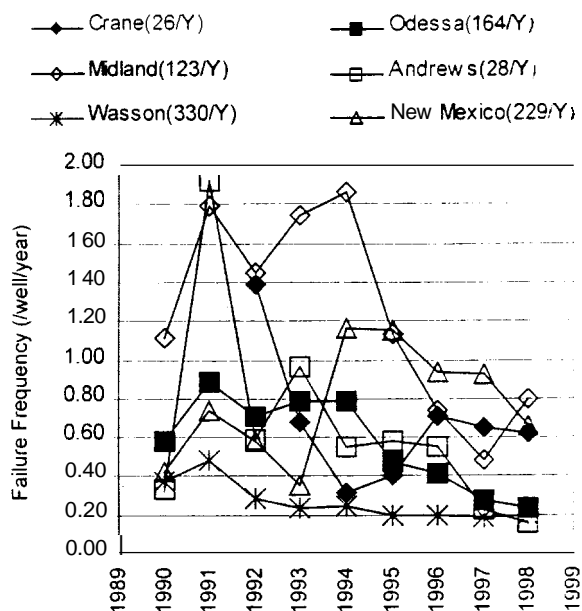Company in the Permian Basin

Crane(26/Y)   Odessa(164/Y)
Midland(123/Y)   Andrew s(28/Y)
Wasson(330/Y)   New Mexico(229/Y)

Figure 5 - Failure Frequency Comparison Among
Different Operating Areas of Company A

MSAU_Andrew s   Fullerton-Andrews
Rodertson_seminole   Denver City
GordonaLake   Sandhills
Midland   Levelland
Monahans   Forsan

Figure 6 - Failure Frequency Comparison Among
Different Operating Areas of Company B

Levelland   New Mexico +Seminole
Wasson   +Sundown   Denver city
+Andrew   s
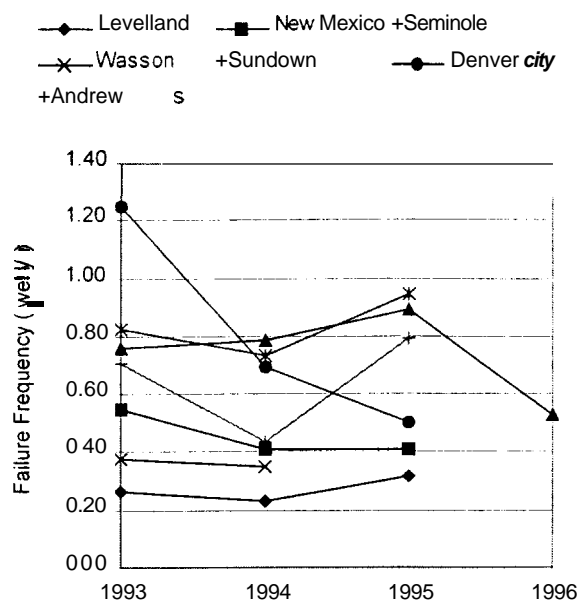
Figure 7 - Failure Frequency Comparison Among
Different Operating Areas of Company C

Cedar Creek   New Mexico   Denver
w asson   +Andrew   s   TXL
Monahans   McCamey   Levelland
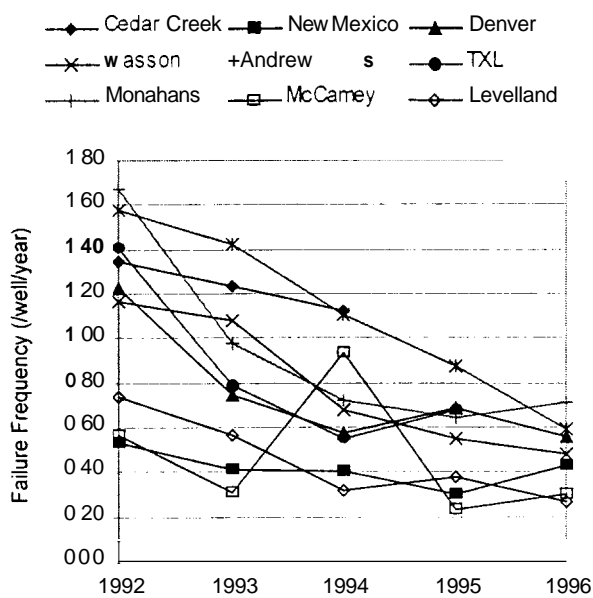
Figure 8 - Failure Frequency Comparison Among
Different Operating Areas of Company D
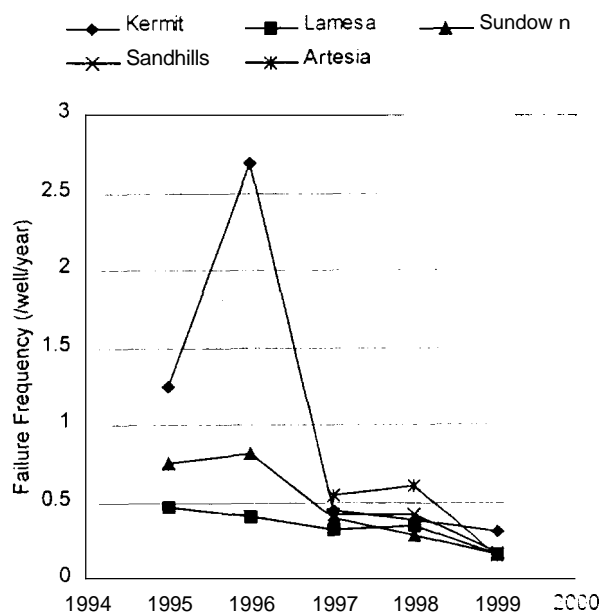
Figure 9 - Failure Frequency Comparison Among
Different Operating Areas of Company E
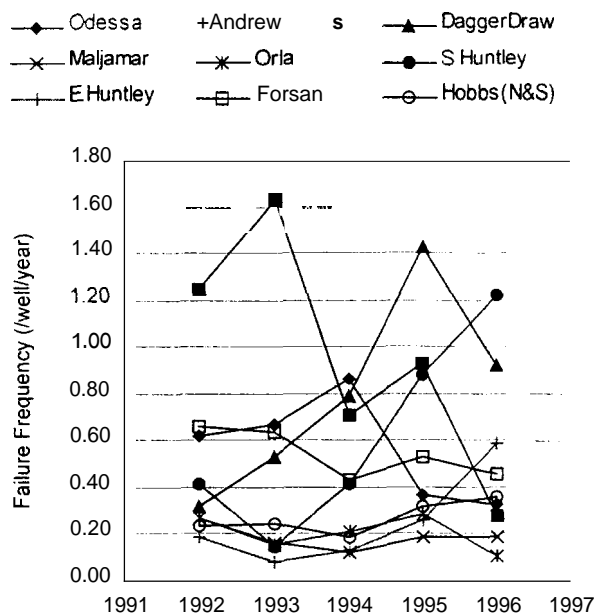
Figure 11 - Failure Frequency Comparison Among
Different Operating Areas of Company H
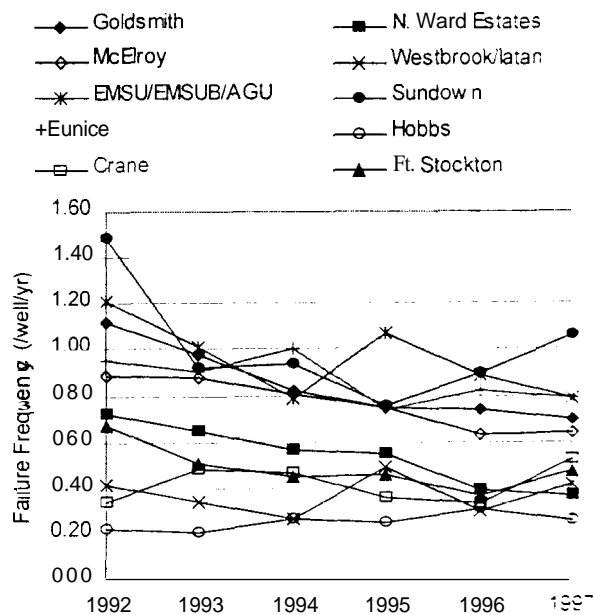
Figure 10- Failure Frequency Comparison Among
Different Operating Areas of Company F
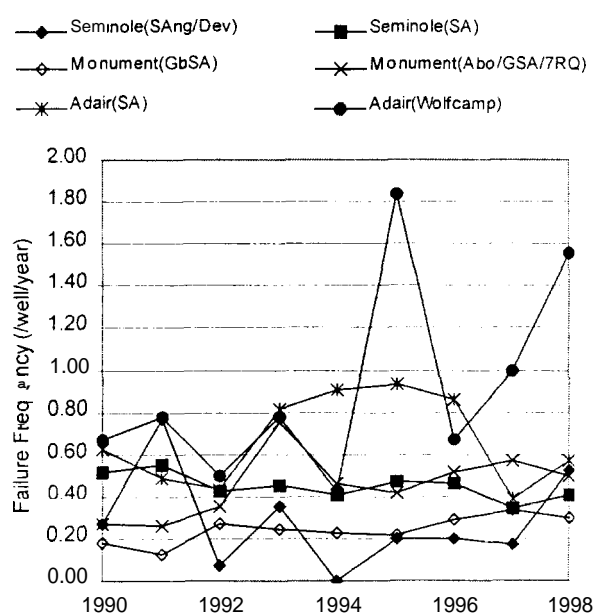
Figure 12 - Failure Frequency Comparison Among
Different Operating Areas of Company J
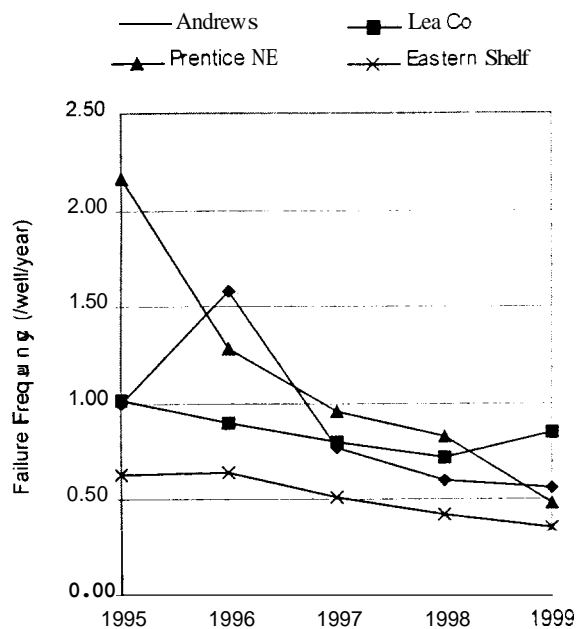
Figure 13 - Failure Frequency Comparison Among Different Operating Areas of Company K

Figure 15 - Well Counts versus Failure Frequency for Company L in Andrews Area

Figure 14 - Failure Frequency Comparison Among Different Operating Areas of Company L
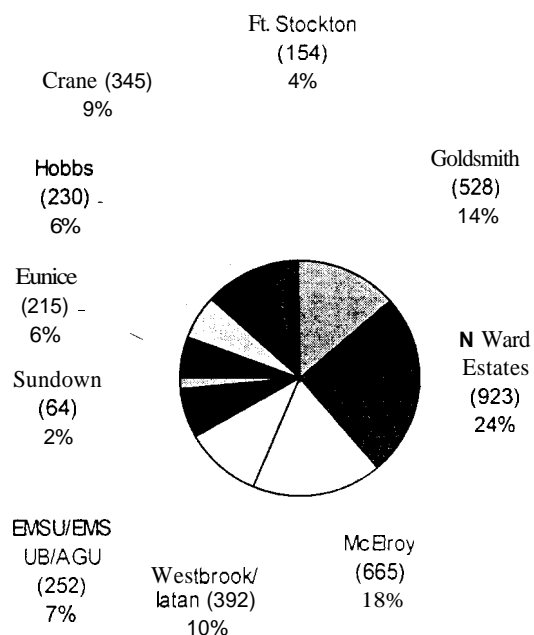
Figure 16 - Average Number of Beam Pump Wells of Company F in Different Operating Areas
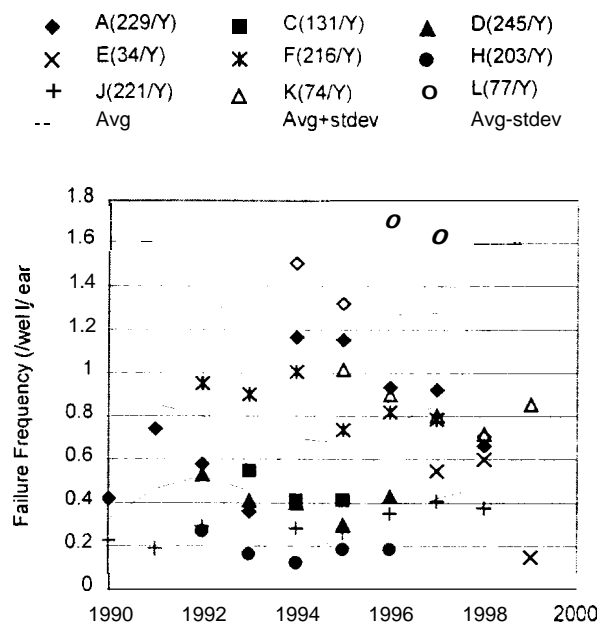
Figure 17 - Total Failure Frequency for Each Company
in the New Mexico Area
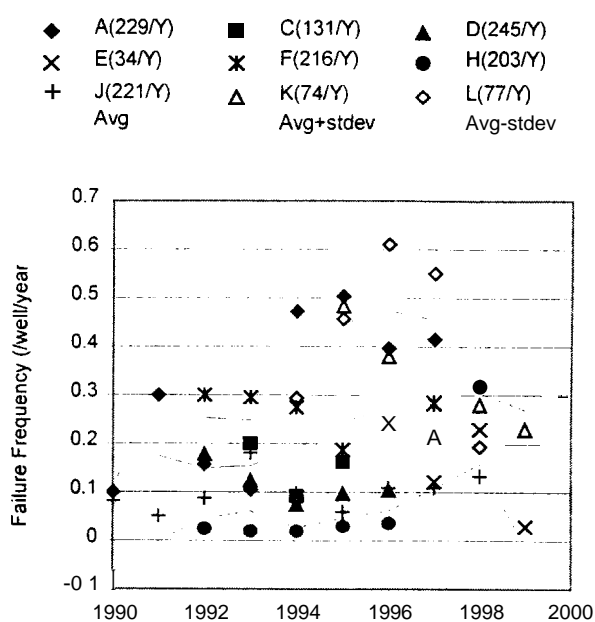
Figure 19 - Rod Failure Frequency for Each Company
in the New Mexico Area
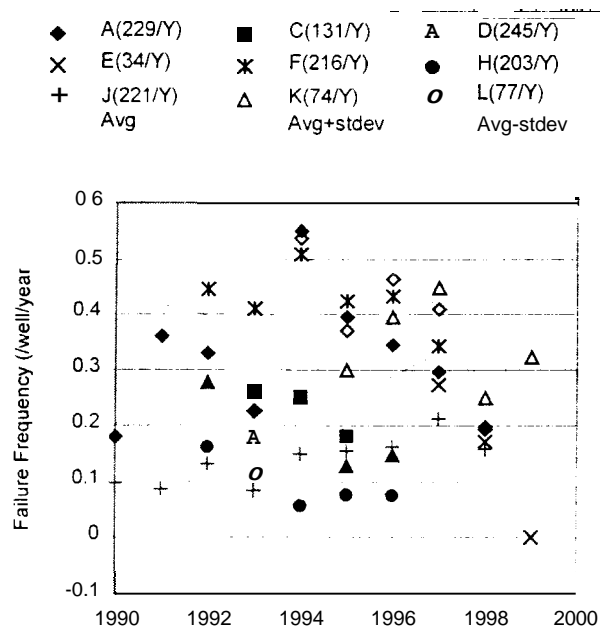
Figure IS - Pump Failure Frequency for Each
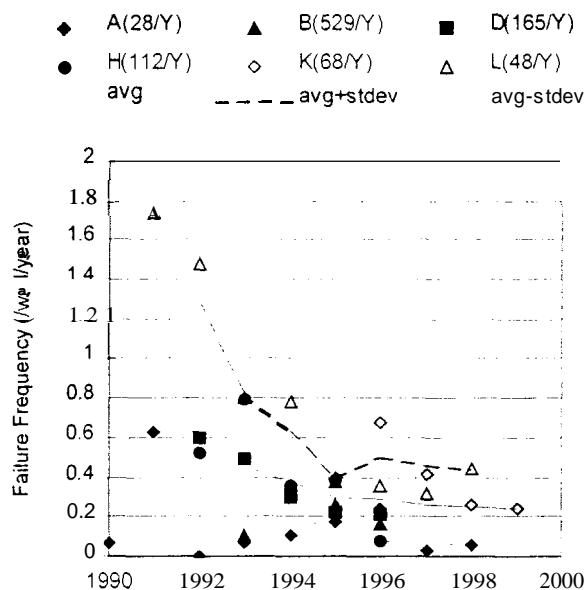Company in the New Mexico Area
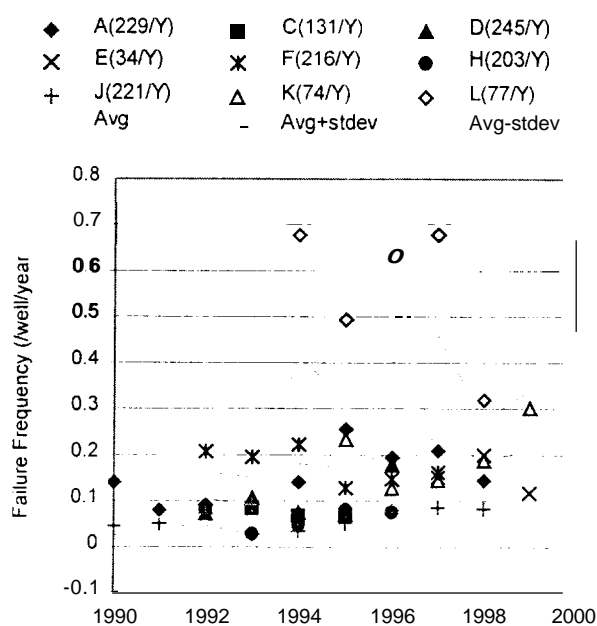
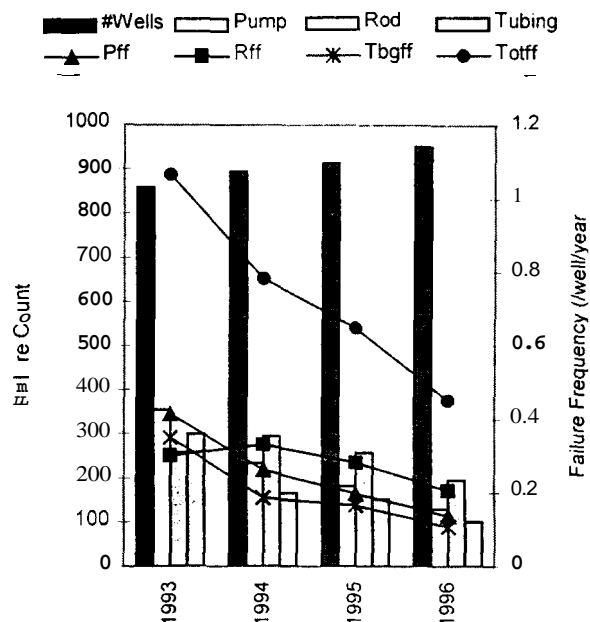Figure 20 - Tubing Failure Frequency for Each
Company in the New Mexico Area
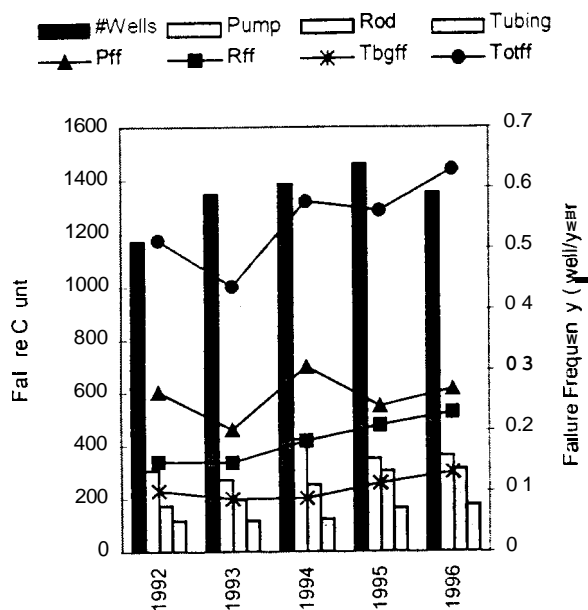
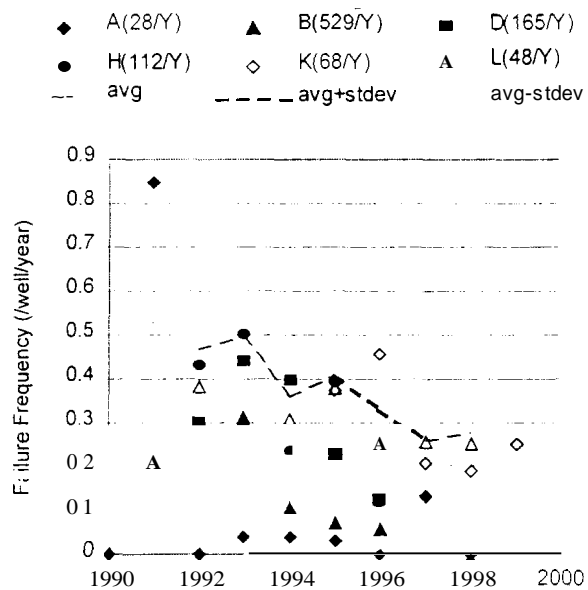Figure 21 - Well and Failure Counts versus Failure
Frequency in the New Mexico Area

Figure 23 - Total Failure Frequency of Each Company
in Andrews Area

Figure 22 - Average Number of Beam Pump Wells of
Each Company in the New Mexico Area
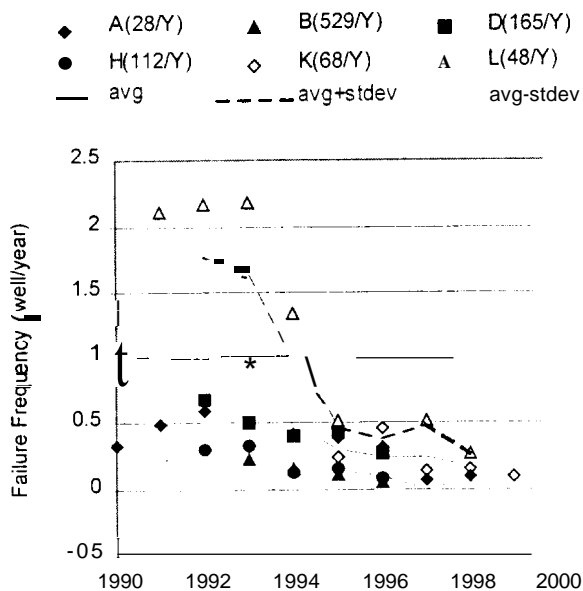
Figure 24 - Pump Failure Frequency for Each
Company in Andrews Area

Figure 25 - Rod Failure Frequency for Each Company in Andrews Area

Figure 26 - Tubing Failure Frequency for Each Company in Andrews Area

Figure 27 - Well and Failure Counts versus Failure Frequency in the Andrews Area
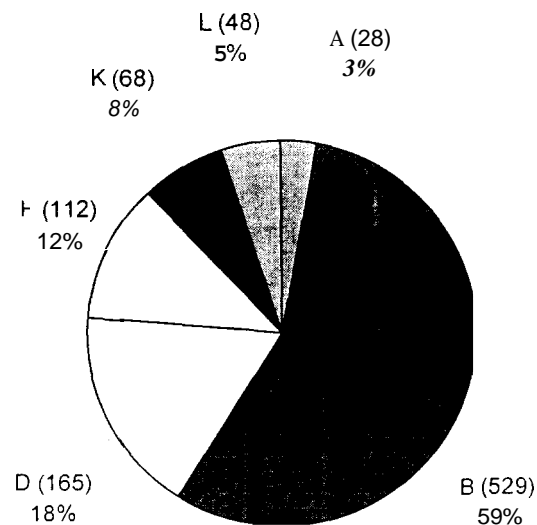

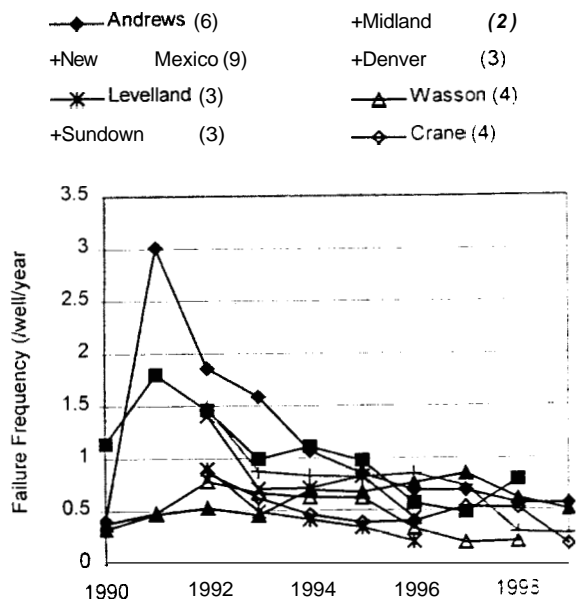Figure 28 - Average Number of Beam Pump Wells of Each Company in the Andrews Area

Figure 29 - Failure Frequency Comparison among
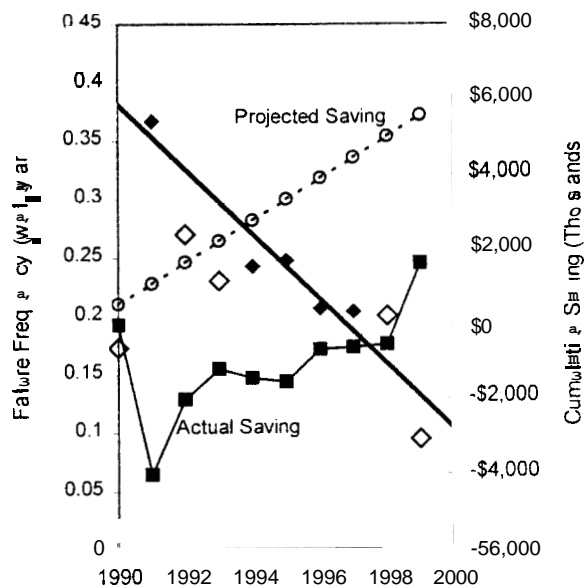Different Operating Areas

Figure 31 - Cumulative Saving from Rod Failure
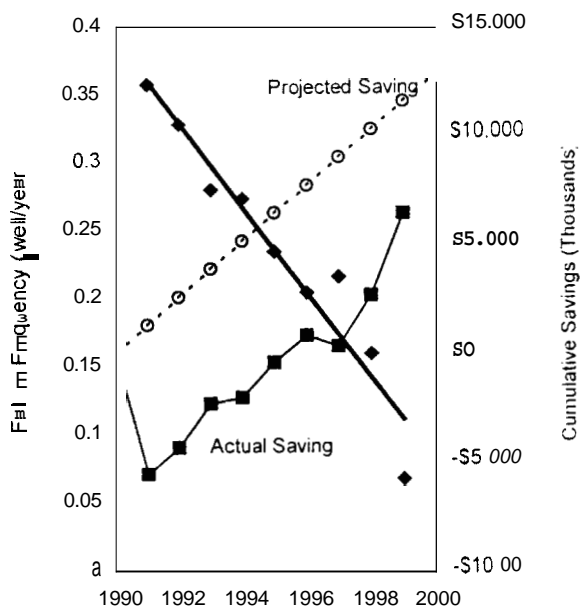Reduction

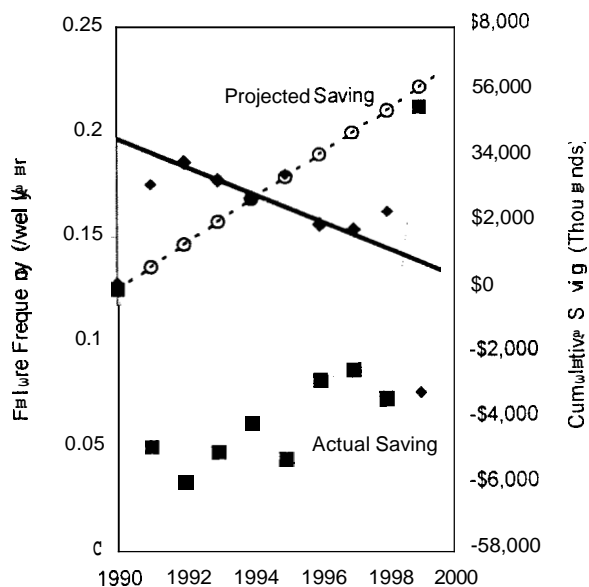Figure 30 - Cumulative Saving from Pump Fnilure
Reduction

Figure 32 - Cuinulative Saving from Tubing Failure
Reduction