DESIGN AND IMPLEMENTATION OF A MECHANICAL SEAL IMPROVEMENT PROGRAM AT AN OIL REFINERY

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ABSTRACT

A mechanical seal improvement program was initiated at a major oil refinery. The program was intended to improve seal reliability, reduce emissions, improve safety, and reduce costs. A partnership agreement was reached between the refinery and a major mechanical seal manufacturer. In preparation for the program, extensive research was conducted to ensure that all relevant information was readily available. A computer database was set up to organize the information and document changes as they were implemented. A document was generated detailing preferred seal designs and piping plans for various classifications of operating conditions, based on past experience and established engineering principles.

The actual program focused on several areas. All mechanical seal failures were closely investigated in order to determine the root cause of failure and to make recommendations for changes that would improve seal reliability. Additionally, a list was generated of the pumps with the worst history of seal reliability. At least two of these "worst seals" were addressed each month in an attempt to identify and correct the cause of premature failure. Pumps that were determined to be current or future environmental emissions problems were addressed at the rate of at least two per month in a similar fashion. As much as possible, all seal designs were standardized such that each seal was capable of being installed in the greatest number of pumps possible. In conjunction with this standardization, an attempt was made to identify and eliminate obsolete warehouse stock items. Additional training was provided to mechanics and unit operators to ensure that seals were being installed and operated properly.

Over the course of 32 months, 191 pumps out of a population of over 1200 were converted to cartridges. During the same period of time, the seal mean time between failures for the entire population increased by 54 percent, and the average monthly maintenance cost associated with mechanical seal failures decreased by 17 percent. In addition, due to standardization and consolidation efforts, the net value of warehouse stock of seals and seal parts was reduced by 11 percent and the number of warehouse stock items was reduced by 34 percent.

Several important conclusions were reached as a result of the success of the program. Cartridge seals, when properly applied, have an inherent advantage over noncartridge designs in terms of reliability and ease of installation. In order to be successful, any seal improvement program must incorporate additional training and support for mechanics and unit operators. Lastly, it is possible to reduce overall costs associated with seal failures, while fully complying with increasingly stringent environmental regulations and significantly improving safety.

INTRODUCTION

A need was recognized at a major oil refinery to improve the reliability of mechanical seals in pumps. The pump mechanical seal mean time between failures (MTBF) was less than 24 months, and the warehouse inventory of spare seals and seal parts was excessive.

A partnership agreement was reached with a major mechanical seal manufacturer and a program was initiated to improve seal reliability, reduce emissions, improve safety, and reduce costs. The resulting program will be presented as follows:

- Program inception and definition
- Organization and preparation
- Program implementation
- Discussion of results

As a result of the program, significant improvements have been realized in seal reliability and maintenance costs.

BACKGROUND

The refinery involved in this program was originally constructed in the mid-1950s and has been regularly expanded over the past 35 years. The current refinery has grown to more than 10 times the original capacity. As a result, a wide variety of pump types and configurations are used. The current population consists of approximately 800 horizontal and 400 vertical centrifugal pumps. These pumps are processing hydrocarbon streams ranging from asphalt to propane, along with various water streams, sour water, acids, and caustics. The pumps range in size from five hp to 1250 hp with an average of approximately 80 hp. With the exception of fire water and cooling water pumps, all pumps utilize mechanical seals. At the onset of the program, the majority of the pumps utilized noncartridge seal designs that were originally provided by the pump manufacturer. As a result there was a large number of seals and seal parts in warehouse stock, relative to the number of pumps in service. Preparations were underway to comply with upcoming environmental emissions limitations. Additionally, a new wave of construction and expansion was beginning which would increase the population of sealed pumps by over 10 percent. It was obvious that opportunities existed to improve the reliability of existing mechanical seals, and to more effectively incorporate environmental seals and seals for new pumps into an overall program of mechanical seal improvements.

PROGRAM INCEPTION AND DEFINITION

A program coordinator was selected and an effort was begun to define the program. This task involved the creation of a document which specified the mission, goals and scope of the program as follows:

Mission Statement

Continuously improve the reliability of the mechanical seals used in pumps in order to improve safety, reduce equipment downtime, protect the environment, and reduce maintenance costs. Optimize warehouse stocking of mechanical seals to provide the greatest availability and stocking efficiency with the lowest cost.

Goals

- Increase the pump seal MTBF to 36 months.
- Reduce maintenance costs associated with mechanical seal failures by 10 percent.
- Reduce the number of stock items and value of warehouse stock of seals and seal parts by 10 percent.
- Meet or exceed all environmental regulations regarding emissions from pump seals.

Scope

- Environmental: Pumps that handle volatile organic compounds (VOCs) or are deemed to be significant safety or environmental hazards will be converted to dual seal arrangements.
- Reliability: Seals which have been determined to have had unacceptable past reliability or have inherent design flaws and limitations will be converted to improved designs.
- Standardization: Seal designs will be standardized such that each seal is able to be used in the greatest number of pumps possible.
- Cartridges: Where it is determined to be practical, seals will be stocked in the form of cartridges. Complete cartridges will be repaired by the manufacturer and pressure tested prior to shipment.
- Procedures: Improved procedures for seal selection, repair, installation, and failure analysis will be utilized to improve the reliability of seal designs.
- Support Systems: Detailed analysis of seal support systems will be conducted to insure that the systems are designed and operated so as to improve seal reliability with current and future seal designs.
- Training: Extensive training will be conducted for all unit operators and mechanics to ensure that all parties understand how installation and operation procedures effects seal reliability.

ORGANIZATION AND PREPARATION

Partnership

A decision was made that the success of a seal improvement program would require extensive preparation and resources. Three principle seal suppliers were asked to provide a survey of existing seals. This involved researching equipment files for original installation seals and histories for past seal conversions. The seal suppliers were then invited to submit proposals for a partnership with the refinery. After the proposals were evaluated, one supplier was selected to be designated as preferred vendor for seal cartridges purchased as a result of the seal program. The selection of a preferred vendor was based on the following criteria:

- Cost—The initial purchase cost of conversion cartridges and the costs associated with parts and repairs.
- Technology—The level of technology offered by the vendor.
- Experience—The refinery specific experience with the products and support provided by the vendor.

In exchange for preferred vendor status, the seal manufacturer agreed to supply a fulltime, onsite applications engineer to assist with the program.

Because a significant proportion of the seal population would continue to utilize seals from the other two principle seal vendors, efforts were made to encourage their continued efforts to support their seals. Additionally, because of the unique technology offered by these other vendors, a proportion of the conversion seals would continue to be purchased from other than the preferred vendor.

Reliability Key Indicators

In order to accurately identify changes in reliability or other key statistics, it was necessary to define the key reliability indicators and establish a minimum of one year of history for each indicator. The refinery computer database provided extensive reporting capabilities. The following key indicators were selected and reports were generated to provide the required history:

- Number of Seal Failures—the number of work orders closed during the month that were generated because of a leaking seal. Each work order was checked to verify that the seal had actually failed, but the root cause of the failure was not considered.

• Number of Environmental Seal Failures—the number of seal failure work orders that originated as a result of unacceptable emissions detected by the refinery environmental group.

• Mean Time Between Failures (MTBF)—the number of active pumps in the population divided by the number of seal failures during the month. The units work out as follows:

Pumps / (Failures/Month) = Pump Months / Failures

• Total Cost of Seal Failures—defined at the total of all labor and materials costs billed to work orders generated as the result of mechanical seal failures.

Database

Prior to implementing the program, a complete plant survey was conducted and the following information was obtained for each piece of equipment: pump manufacturer and model, operating parameters, current seal type, and current seal support system piping arrangement (API Piping Plan). Emphasis was placed on obtaining complete and accurate operating conditions for all possible operating points. This was imperative to ensure that new seals were designed to handle maximum operating conditions that may have caused premature failures in the past.

A database was set up to consolidate the vast amount of information required to implement the improvement program. It served as a single source for all the information pertinent to the program. After the information gathered in the plant survey was entered into the database, each service was reviewed and new seals and support systems were recommended and recorded. Therefore, all the applications engineering was completed prior to commencing the program, which allowed the program to be implemented swiftly.

The database was also effective in the following areas: identifying areas where consolidation efforts would be most beneficial, tracking reliability statistics, assessing seal vendor lead times, and highlighting pumps that were slated for conversion. It was also used to record any pump or seal system modifications that were performed or required to complete a conversion.

Seal Selection Guidelines

Using the database to review the various products found within the plant, it was possible to divide the applications into two main categories, hydrocarbons and nonhydrocarbons. These categories were then subdivided as follows in order to encompass the majority of the seal applications.

Hydrocarbons

• High temperature hydrocarbons

• Low temperature flashing hydrocarbons (vapor pressure greater than 14.7 psia at the pumping temperature) or hazardous compounds

• Low temperature nonflashing hydrocarbons (vapor pressure less than 14.7 psia at the pumping temperature)

Nonhydrocarbons

• Amines and caustics (crystallizing products)

• Acids

• Sour water

• Water

Each of the above categories was separated into two pressure ranges and different temperature ranges based on individual physical properties. As illustrated in Figure 1, preferred seal designs were established for each pressure and temperature range. These seal selections were based on the past experience of both the seal vendor and the refinery as well as established engineering principles. Based on documentation provided by the seal vendor, a cut off point of 300 psi was established for utilizing standard bellows seals. Bellows seals used above 300 psi were engineered to handle the higher pressure.

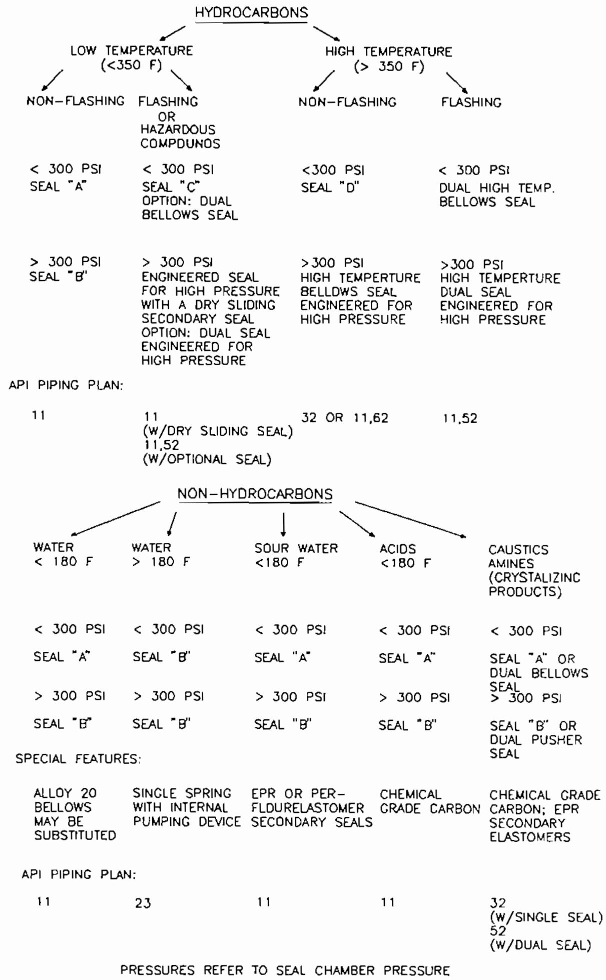

Figure 1. Seal Selection Guidelines.

After analyzing the preferred seals selected in Figure 1, four standard cartridge seal designs as described in Table 1 were identified. The standard low temperature bellows seal (identified as seal "A," Figure 2) was the preferred seal in all low temperature applications below 300 psi with one exception. Based on past experience within the plant, a single spring pusher seal was selected for use in water applications above 180°F. The standard bellows seal design utilized a rotating Hastelloy C bellows seal with a premium grade carbon seal ring insert, flouroelastomer O-ring secondary seals, reaction bonded silicon carbide stationary seal face, and 316 stainless steel gland and sleeve. Selecting Hastelloy as the standard bellows material allowed this seal to be applied to a variety of services, thus optimizing seal stock consolidation. If a group of pumps with similar seal chamber dimensions was discovered and none of the applications required the additional corrosion resistance of Hastelloy, a more cost effective material such as Alloy 20 was substituted. Other material changes, as noted in Figure 1, were made to adapt the standard design to the various services.

Table 1. Standard Seal Designs.

Seal "A": Standard Low Temperature Belows Seal
- Low Temperature Rotating Bellows Seal
- O-Ring Secondary Seals (Flouroelastomer)
- Hastelloy C Bellows
- Premium Grade Carbon Vs. Reaction Bonded Silicon Carbide Seal Face Combination
- 316 SS Gland and Sleeve

Seal "B": Standard Low Temperature Pusher Seal
- Multiple Spring Seal With a Rotating Flexible Element
- O-Ring Secondary Seals (Flouroelastomer)
- Premium Grade Carbon Vs. Reaction Bonded Silicon Carbide Seal Face Combination
- 316 SS Gland, Sleeve, and Other Metal Parts

Seal "C": Standard Environmental Seal
- Dual Seal Arrangement
- Hastelloy C Bellows Primary (Inner Seal)
- Dry Sliding Secondary Seal (Outer Seal)
- O-Ring Secondary Seals (Flouoelastomer)
- Premium Grade Carbon Vs. Reaction Bonded Silicon Carbide Seal Face Combination
- 316 SS Gland and Sleeve

Seal "D": Standard High Temperature Bellows Seal
- High Temperature Rotating Bellows Seal
- AM 350 Bellows Material Standard (Inconel 718 Used When Required)
- Flexible Graphite Secondary SEals
- Premium Grade Carbon Vs. Reaction Bonded Silicon Carbide Seal Face Combination
- 316 SS Gland and Sleeve
- Floating Carbon Bushing in the Gland When Using a Steam Quench

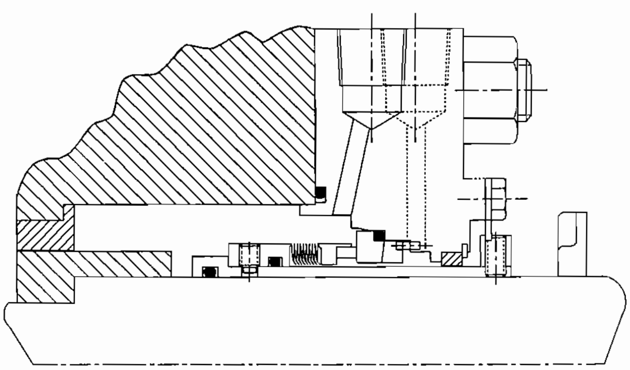

Figure 2. Standard Low Temperature Bellows Seal — Seal "A."

Due to the ease of adapting the design to high pressure and economic considerations, a standard pusher type seal (identified as seal "B," Figure 3) was selected to be installed in several of the applications above 300 psi. The standard design was a multiple spring seal with a rotating flexible element, flouroelastomer O-ring secondary seals, premium grade carbon rotating seal ring, reaction bonded silicon carbide stationary seal face, and 316 stainless steel gland, sleeve, and other metal parts.

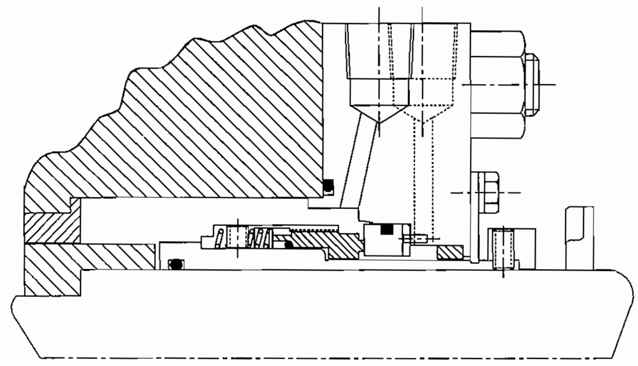

Figure 3. Standard Low Temperature Pusher Seal — Seal "B."

As shown in Figure 1, the preferred seal design for low temperature flashing products or services involving hazardous compounds, was a dual seal arrangement with a bellows inner seal and a dry sliding outer seal (seal "C," Figure 4). For service pressures below 300 psi, the inner seal in this arrangement was similar to seal "A" in material selection. Above 300 psi, the standard inner seal was replaced with a bellows seal engineered for higher pressure. A dual bellows seal with a liquid barrier system was the standard option for certain applications where additional cooling of the seal faces was required or when retrofitting a noncartridge dual seal that already had a liquid barrier system. Whenever practical, multiport injection was incorporated into the seal glands of both the standard environmental seal and the optional dual seal.

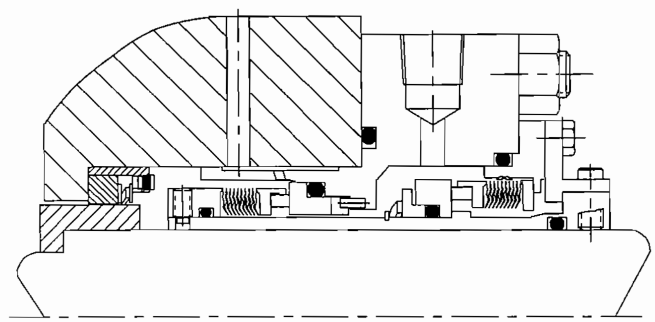

Figure 4. Standard Environmental Seal — Seal "C."

The final standard seal arrangement (identified as seal "D," Figure 5) was designed for nonflashing high temperature hydrocarbon services. The design was composed of a rotating high temperature bellows seal, flexible graphite secondary seals, premium grade carbon seal ring insert, reaction bonded silicon carbide stationary seal face, and 316 stainless steel gland and sleeve. A close clearance floating carbon bushing assembly was installed in the seal gland when a steam quench was used. Since the majority of the high temperature services in the plant employ a clean cool flush from an outside source (API Plan 32), it was decided that the additional expense of exotic metallurgy was unnecessary, and AM350 was chosen as the standard bellows material. However, Inconel 718 was substituted when a clean flush was not available and additional corrosion resistance was required.

Piping

The seal support piping arrangement (API Piping Plan) is imperative to the successful operation and reliability of any seal

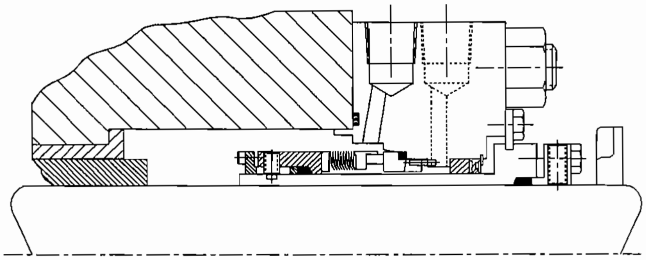

Figure 5. Standard High Temperature Bellows Seal — Seal "D."

design. As indicated in Figure 1, standard piping arrangements were selected for each service and type of seal. When each pump was removed from service, a complete review of the seal support system was conducted. The review included checking the size of any inline orifices, verifying that flowrates were sufficient to remove heat generated at the seal faces, and checking inline filters for clogging.

In the majority of the services where the standard low temperature single seals ("A" or "B") were installed, a recirculation line from the pump discharge (API Plan 11) either already existed or was incorporated. Where adequate differential pressure did not exist between discharge and the seal chamber, as in many vertical pumps, an API Plan 13 (circulation from the seal chamber back to the pump suction) was applied.

In flashing applications where product vaporization within the seal chamber was a concern, a discharge recirculation line in conjunction with a close clearance bushing in the throat of the pump was utilized. This arrangement effectively maintains the seal chamber pressure above the vapor pressure of the product (at the pumping temperature) and provides sufficient lubrication for the seal faces.

Most flashing or environmental applications also incorporated a dry sliding outer seal. This seal acts as a full back up seal in the event of a failure and also allows normal vapor leakage from the primary seal to be contained and routed to the plant wide flare system. Therefore, near zero emissions to atmosphere were achieved without the added expense of installing or maintaining a liquid barrier fluid system. A standard piping arrangement for the dry sliding seal was developed, which routed the vapors to the flare system and allowed the condition of the primary seal to be monitored.

A dual seal with an API Plan 52 barrier fluid system was the standard option for environmental services. API Plan 52 calls for a nonpressurized barrier fluid circulated in a closed system loop between two mechanical seals. When dual seals were installed or out of service for repair, the support system was closely analyzed. A standard seal pot configuration was developed indicating the proper location of the reservoir, acceptable piping to and from the seal gland, and proper flare line access and instrumentation.

The standard piping arrangement for water greater that 180°F was API Plan 23 (circulation of the product by means of a pumping device from the seal chamber, through a heat exchanger, and back to the seal chamber in a closed loop system). A close clearance throat bushing was installed to isolate the cool seal chamber fluid from the hotter product in the impeller area. The position of the cooler and the configuration of the piping was reviewed and optimized with each seal failure or new installation.

The standard piping configuration for high temperature hydrocarbon services in the plant was an API Plan 32 (injection of a cool clean fluid at a higher pressure into the seal chamber). Throat bushing clearances were examined and tightened when necessary to control flush flowrates. If the failure history indicated seal flush flow was frequently interrupted, an API Plan 62 (steam quench on the atmosphere side of the seal) was also applied.

Caustics, amines, and other crystallizing products generally incorporated an outside flush (API Plan 32) to control the seal chamber environment and prevent crystallization build up at the seal faces. When a flush was not feasible for operational reasons, a dual seal with a nonpressurized barrier fluid system was installed. In this arrangement, normal product leakage crossing the primary seal faces is dissolved in the barrier fluid, thus eliminating failures due to product crystallization.

PROGRAM IMPLEMENTATION

The seal improvement program consisted of several separate, but related efforts as follows.

Seal Failure Analysis

All seal failures were investigated to determine the root cause of failure and recommendations were made as to possible changes in installation, operation, or support system configuration which would improve reliability. At this time, the seal design was evaluated to determine if changes were needed. The program coordinator would then decide if any design changes would be initiated, up to and including cartridge conversion. The decision to convert a pump to a cartridge was based on the following criteria:

- Existing Design—the existing design had inherent design limitations which could be expected to have a significant deleterious effect on safety, reliability, or environmental impact.
- History—the seal had experienced unacceptable past reliability despite efforts to improve the installation, operation, or support system.
- Pump Criticality—the pump was critical to the operation such that any unplanned downtime represented an unacceptable risk to the continuity of unit operation.
- Potential for Standardization—conversion to a cartridge would provide a significant advantage in terms of spare parts consolidation and warehouse stock elimination.

Problem Seals

At the end of each quarter, a list was generated of the pumps with the worst record of seal reliability. This list was determined from the total number of seal failures experienced during the previous 12 months. At the beginning of the program, the list included any pumps that had experienced three or more seal failures during the past year. After the first year, it was necessary to expand the list to include any pumps with two or more failures. At least two of the pumps on this list were addressed each month.

Environmental Seals

The computer database allowed reports to be generated of pumps with products that were likely to be environmental concerns. Additional pumps were identified from emissions monitoring reports generated by the refinery environmental group. During each month, at least two of these environmental pumps were evaluated to determine the best course of action to ensure compliance with emissions limits. If it was determined that a dual seal arrangement was needed, the appropriate seal was designed and ordered.

Support Systems

Any seal that was examined for possible improvements necessitated evaluation of the associated seal support systems.

In many instances, the support system, rather than the seal design, was found to be the cause of unacceptable performance. Changes were made in the support system piping as deemed appropriate.

Training

Training was conducted for all unit operators and mechanics. The training included group training sessions and one-on-one training for individuals involved in seal conversions.

Operators

All unit operators are provided with regular training on various topics related to mechanical equipment. This training included a section on mechanical seals that taught the basics of seal design and operation. Emphasis was placed on developing an understanding of how operational changes effect mechanical seal reliability. In addition to group training seminars, operators were given one-on-one training on the particular seals that were being installed in their areas. Each time a seal was converted from one design to another or a seal support system operating parameter was changed, the operators in that area were provided with additional training specific to the operation of that seal or system.

Mechanics

All mechanics are provided with regular, detailed training on pump repair procedures that includes mechanical seal repair and installation. Additional topics were added to this training to teach the mechanics about the operation of seals and seal support systems. The mechanics were also taught the basics of seal failure analysis and encouraged to try and correct the root cause of any seal failure. As the program coordinator and applications engineer worked with individual mechanics on seal conversions and failure analyses, an effort was made to provide the mechanics with additional training specific to that job.

Warehouse Stock Reduction

As mentioned earlier, the amount of warehouse seal stock and seal parts was high relative to the number of pumps in service. Only limited efforts had been made during the preceding 35 years to consolidate stock and eliminate obsolete stock. As conversion cartridges were designed, the existing seal parts were evaluated to determine what could be eliminated following the conversion of all the affected pumps to the new design. Even though the seals being eliminated were generally less expensive noncartridge designs, the net value of warehouse stock was reduced, because a greater number of pumps were utilizing a common seal.

Program Evaluation

It was recognized from the beginning that the program would need to be evaluated on a regular basis. Quarterly review meetings were conducted with involved parties from the refinery and the seal vendor. At the review meetings, the rate of progress was evaluated and the goals were adjusted and expanded.

Documentation

Information in the computer database was maintained to keep track of the conversions as they were installed. Documentation was also provided in the form of a conversion book which listed all pumps for which conversion seals had been purchased. This book was available as a resource to mechanical repair supervisors, so that they were able to complete conversions even in off-hours when the program coordinator and applications engineer were unavailable. The book included seal drawings and instructions regarding any pump or support system modifications needed in order to install a new cartridge.

DISCUSSION OF RESULTS

During the first 32 months of the seal program, a total of 191 pumps were converted to cartridge seals. Of those, 28 were converted from single seals to dual seals with dry sliding secondary seals and 25 were converted from single seals to dual seals with liquid barrier systems. The cartridge seals that were purchased up through August 1994 will be installed in an additional 171 pumps. Another 11 pumps are scheduled to be converted from single seals to noncartridges dual seals with liquid barrier systems. Noncartridge seal designs were only used in cases where the pump design did not allow for the installation of a cartridge.

The most dramatic and immediate result of the seal improvement program was the increase in pump seal MTBF. The increase in MTBF can be seen in Figure 6. From the start of the program in December 1991 to September 1994 the pump seal MTBF increased from 23.4 months to 36.1 months, an increase of 54 percent. The upward trend in MTBF leveled off from May through August of 1993. This was caused by a group of seal failures that occurred during the startup of four new units. However, after the new units achieved a more stable operation, the earlier upward trend of MTBF was resumed and the goal of 36 months was achieved.

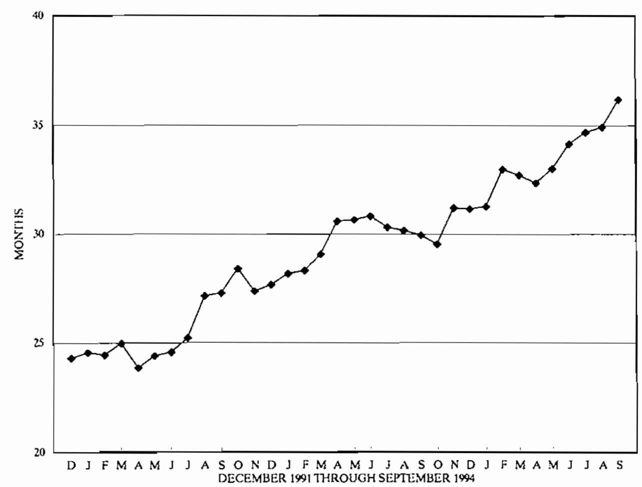

Figure 6. Pump Seal Mean Time Between Failures.

Pump seal MTBF was calculated separately for pumps which were converted from noncartridge to cartridge designs. Prior to conversion, these pumps experienced a MTBF of 11.1 months. After conversion, the MTBF of these pumps increase to 22.5 months, an increase of 102 percent. The final MTBF of these pumps was still below the plantwide average of 36 months. It should be noted that many of these pumps were in extremely harsh services and had been targeted for conversion because of extremely poor reliability.

The overall cost associated with mechanical seal failures did not improve in such a dramatic fashion. The changes in seal failure cost may be seen in Figure 7. An 18 percent reduction in cost had been achieved as of April 1993. However, as noted above, the startup of four new units from May through August result in an atypical group of seal failures. The cost of these failures resulted in a temporary increase in seal failure costs. As a result, the reduction in cost from December 1991 to September

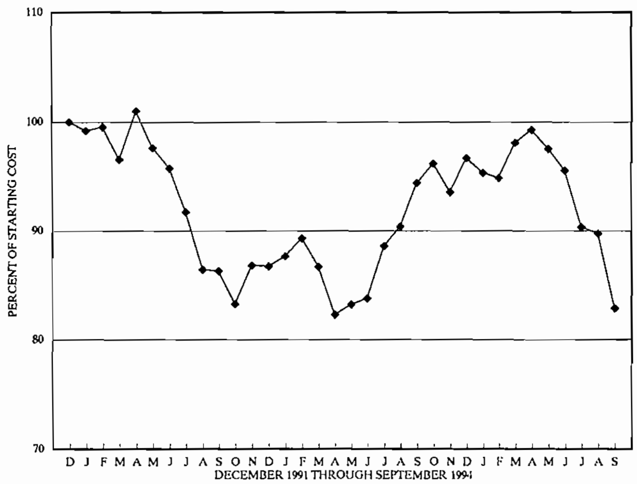

Figure 7. Total Cost of Mechanical Seal Failures.

1994 was only 17 percent. This still exceeded the original goal of 10 percent.

The value of warehouse stock of seals and seal parts was reduced by 11 percent as a result of the consolidation and standardization achieved during the seal program. More dramatic than the reduction in the value of stock was a 34 percent reduction in the number of stock items. This result is all the more noteworthy considering that 25 percent of the cartridge conversions were designed to convert pumps from single seals to dual seals.

A primary goal of the seal program was the reduction of VOC emissions from pump seals. As of August 1994, 53 pumps had been converted from single seals to dual seals. Seals have been purchased to convert an additional 51 pumps from single to dual configurations. Many other pumps have been converted to low emissions single seals or have been modified in some other manner in order to reduce emissions. During 1993, there were 31 seal failures attributable to environmental emissions in excess of allowable limits. As of this writing, there have been only two environmental seal failures during the past ten months. Based on the available emissions readings on 7 of the pumps converted from single to dual seals, average emissions were reduced from over 1200 ppm to less than 250 ppm.

CONCLUSIONS

Cartridges

The use of cartridge seals is justified because of the inherent advantage over noncartridge seals in terms of reliability, ease of installation, and stocking efficiency. The initial cost of purchasing cartridge seals can seem relatively high. However, a well designed cartridge, assembled by the manufacturer and pressure tested prior to installation, eliminates several of the primary causes of premature seal failure. Specifically, the possibility of such problems as missing parts, incorrect seal compression, cut elastomers, or misaligned antirotation pins is virtually eliminated. If the cartridge is designed to meet the application but also designed to be used in the greatest number of pumps possible, there is no need for a major increase in the value of warehouse stock as a result of converting to cartridges. This is especially true as the plantwide seal reliability improves, reducing the necessity to stock a large number of cartridges of each design. This assumes, of course, that the cartridges are being provided by a vendor with an excellent program of quality control.

Training

Training is the key to almost any program aimed at improving quality. Even experienced operators and mechanics can benefit from refresher training on the proper installation and operation of seals and seal support systems. If any program of seal improvement is to succeed, it must have the support of the mechanics who install the seals and the operators that are in charge of running the equipment. One-on-one training with individual operators and mechanics also helps to build a rapport that fosters open communication of problems or questions as they arise.

Safety

The increase in seal MTBF represents the elimination of approximately 220 seal failures per year. Because of the sorts of products typically handled in an oil refinery, this represents a major reduction in the likelihood of catastrophic releases of product, fires, or personnel exposure to toxic materials. Although this improvement in safety is difficult to quantify in terms of cost saving, it is nevertheless significant. Any responsible employer should make every effort possible to continuously improve the safety of their employees. A major improvement in mechanical seal reliability can provide an important contribution to the overall plant safety efforts.

Emissions Reduction

In many instances, it is possible to reduce mechanical seal emissions to acceptable levels without the use of dual seals. Single seals, when properly applied, generally maintain emissions within allowable limits with possible spikes in emissions during operational upsets. Environmental monitoring of these seals during upset conditions would normally lead to seal replacement. However, by utilizing dry sliding secondary seal technology currently available, near zero emissions to atmosphere are achieved without extravagant expenditures. Dry sliding seals most economically comply with emissions regulations by eliminating the initial cost and associated maintenance cost of a liquid barrier system. In instances where a liquid barrier system is needed, the additional expense can be offset by improved reliability as a result of the heat transfer capabilities of the barrier fluid. In fact, as mentioned above, it is possible to incorporate an effective emissions reduction program in a program of improved reliability and actually reduce overall costs.

Reliability

A delicate balance is needed to weigh the advantages of improved reliability with other goals such as stock consolidation. Consolidation and standardization should not be pursued at the expense of reliability, nor should reliability be pursued to the exclusion of sound economic analysis. Priorities should always be set to provide the greatest long-term return for the company rather than to pursue unrealistic goals or short-term advantages.