The Guide to Asset Efficiency Optimization for Improved Profitability

“The most valuable assets of a 20th-century company were its production equipment. The most valuable asset of a 21st-century institution, whether business or non-business, will be its knowledgeable workers and their productivity.”

Peter Drucker
Management Challenges for the 21st Century
A conceptual representation of an industrial maintenance process.

Correct / Improve / Optimize
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Achieving asset efficiency is a significant challenge
Optimizing the efficiency of equipment has a significant impact on profits – and shareholder value. It affects productivity and quality. In some cases, it may even determine a company’s ability to compete, or survive. Corporations that focus on overall equipment efficiency find that they can add capacity without large capital investments.

Very often, management is aware of the significant benefits that can be achieved from a well run asset management program. However, in some organizations, actually achieving asset efficiency can present a major challenge. Few companies have the resources or expertise to implement the rapidly developing new technologies, processes, and cultural changes that are so important to achieving timely, long-term success. Many begin the process but are hindered by an incomplete strategy or insufficient planning or benchmarking. The result is inefficient utilization of capital and maintenance resources, and ultimately, failure to achieve efficiency objectives.

SKF can help you optimize asset efficiency to increase profitability
Typically, machine and component manufacturers stand at the forefront in developing and implementing new technologies. SKF for example, has traditionally invested significantly in research and development, and is committed to the application of new technologies and materials to enhance the design and quality of our products.

Today, reliance on supplier expertise is often recognized as one of the most practical and cost-effective means to enhance internal competencies. SKF enables customers to benefit from nearly a century of experience in developing solutions for optimizing machine and process performance. Through the business area called SKF Reliability Systems, SKF offers unique and highly effective methods to help corporations improve asset efficiency and manage maintenance costs more effectively.

The Asset Efficiency Optimization concept
SKF’s Asset Efficiency Optimization (AEO) concept picks up where plant asset management programs typically stop. AEO enables a plant to increase production while maintaining or even decreasing costs. It is a system of organizing and applying assets – from personnel to machinery – bringing knowledge and technology together to achieve the greatest return on investment. By applying the power of SKF’s technology and service solutions, you can benefit from a program which assists in achieving your organization’s overall business objectives. These include reduced costs, greater productivity, better utilization of resources, and as a result, increased bottom line profitability.
Beyond the Bearing

Improving machine and process performance

The bearing is the heart of the machine
From huge rolling machines to the smallest motors, if there’s a potential problem with the equipment, the bearing “knows.” As the key interface between moving parts, the bearing is literally the diagnostic heart of the machine: misalignment, unbalance, looseness, and friction are all telegraphed through the bearing. Understanding the information coming from this diagnostic pulse, and then applying the latest and best technologies to correct or avert a problem, is critical to raising machine productivity and lowering operating cost.

SKF expertise extends far beyond bearings
As a world leader and innovator in bearing technology since 1907, SKF has developed a unique understanding of not only how a bearing performs in an application but an intimate knowledge of machine components, systems and related processes – allowing us to create and provide realistic solutions for optimum machine and process reliability and productivity.

The evolution of SKF machine knowledge over nearly a century has enabled the company to become a leading supplier of condition monitoring and maintenance diagnostic systems, hardware and software. These tools, and the knowledge of how to best use them, enable us to monitor operations and identify problems.

Our experience includes virtually every industry
Close working partnerships with customers worldwide have provided SKF with an extensive knowledge of applications in virtually every industry. As a result, we have learned to apply the most relevant of today’s emerging technologies to industry-specific applications.

You can benefit from SKF’s advanced capabilities in manufacturing and research
SKF is taking the underlying competencies that have been behind our product success, and putting them ‘in front’ of our customers. We view our manufacturing and research capabilities as ‘portable’ expertise that can be transferred to other manufacturing operations – enabling you to benefit from our success.

SKF offers comprehensive solutions
SKF’s near-century tradition of excellence in bearings and machine reliability has evolved in response to industry need. Through SKF Reliability Systems we now provide a single source for a complete productivity solution. Our goal is to help reduce total machine related costs, enhance productivity and strengthen profitability.
To many, increasing productivity means building more factories. Yet, one of the biggest opportunities today for creating profits, positive cash flow and, ultimately, shareholder value is through improved factory efficiency. In fact, capitalizing on improved efficiency – as measured by Overall Equipment Efficiency (OEE) – may reveal the bottom line equivalent of a new factory “hidden” within many companies today.

Achieving optimum reliability is essential to maximizing OEE – and maintenance plays a critical role in meeting reliability targets. Reaching these targets, however, requires a shift from traditional maintenance activity, which is reactive and functional, to a proactive process that is fully integrated into overall plant activity.

SKF Reliability Systems is uniquely qualified to construct a comprehensive, customized change plan for the maintenance organization that is ready to be transformed from a cost center to a profit opportunity. Our seasoned asset management “pragmatists” work in true partnership with our clients, sharing risks as well as benefits in the quest to achieve optimum OEE. SKF works with clients to develop effective maintenance and asset management strategies and helps companies transition to even higher levels of efficiency. From streamlined analysis services to factory floor automation tools, SKF Reliability Systems has the breadth and depth to help its clients make practical, lasting changes with significant financial benefits.

In today’s economic environment, shareholders are taking a closer look at how companies manage asset efficiency. Wherever you stand, whatever your goals, SKF Reliability Systems can help you enhance productivity and value. The results could have a very positive effect on your company’s financial spreadsheet.

Our experience in the area of Asset Efficiency Optimization is not just limited to the successes we have helped our customers achieve. As the leading bearing supplier with 80 factories worldwide, we have learned how to optimize asset efficiencies to have an impact on our own bottom line – regardless of market conditions. The bearing industry is an extremely competitive market driven by the classic commodity supply model where the cost of production is one of the main determinants of company profitability. The profitability and financial stability of SKF demonstrates that employing the Asset Efficiency Optimization process is a viable route to increased shareholder value.
Reliability Focused Maintenance

Shifting maintenance practices from reactive to proactive

Developing a reliability-focused maintenance program is an ongoing process that begins with determining where your reliability and maintenance practices lie in the range of reactive to proactive maintenance, and then adjusting them to improve efficiency.

While in theory, this process is complete when you achieve optimum efficiency, in reality the process is never finished. A successful program is dynamic in nature, incorporating and retaining the most efficient mix of reactive, preventive, predictive, and proactive maintenance, as well as measures enabling operator driven reliability.

The goal, of course, is to optimize plant efficiency by shifting as much as possible from traditional, corrective activities to a fully integrated, proactive approach to reliability.

There are a wide range of scenarios to be considered, depending upon where your maintenance program is in the range, and what your business goals are.

The chart below illustrates the range of maintenance practices. A business-supported dynamic blend of all of these will generate the best results.

Maximum Efficiency

- **Operator Driven Reliability (ODR)**
  Front line operators are empowered to “own” their machinery. They identify, describe and communicate machine information to the plantwide team to keep machinery up and running.

- **Proactive Reliability Maintenance (PRM)**
  Predictive maintenance is applied to help identify the root causes of machine and process problems; machines operate with virtually no unplanned shutdowns; Mean Time Between Failure (MTBF) on machines and components is significantly increased.

- **Predictive Maintenance (PdM)**
  Machine condition is assessed using condition monitoring technologies; shutdowns are scheduled based upon machine problems which are identified using sophisticated vibration and condition monitoring equipment; unplanned shutdowns are significantly reduced.

- **Preventive Maintenance (PM)**
  Unplanned and planned shutdowns are scheduled to overhaul equipment at pre-determined intervals; maintenance efforts are not based upon an assessment of the machine’s condition while it operates.

- **Reactive/Corrective**
  Fix it when it breaks approach; unplanned shutdowns occur when the machine breaks.

Minimum Efficiency

Our goal is to help your facility manage the evolution of your maintenance program. A sustainable platform for efficiency improvement is easily achieved by addressing key issues which may involve a dynamic mix of programs.

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In the 1960’s, it was common practice to wait for equipment to fail, and then repair it – known today as “firefighting.” Generally speaking, management regarded maintenance as a necessary cost of doing business.

Over the decades, this standard way of working – and thinking – began to change. During the 1970’s most plants had some kind of preventive maintenance program. By the 1980’s, the best run facilities were employing predictive maintenance strategies and, by the 1990’s, diagnostic tools and software were providing maintenance personnel with machine condition information that would have been unthinkable a generation earlier.

Today, it is clear that maximizing the efficiency of a plant and its equipment requires a shift from traditional – or repair focused – maintenance activity, which is both reactive and functional, into a proactive maintenance (or reliability and risk focused) process that is fully integrated into overall plant activity.

The evolution of predictive to proactive and the integration of industrial decision support systems can often complete the transformation of maintenance from a cost center to a profit center.
Maintenance Maturity
Moving through four phases to achieve world class efficiency optimization

In an ideal world, every plant could make use of all the best new technologies for enhancing machine reliability. In reality, this is not possible.

Why? Because many techniques and technologies are appropriate only for plants that have reached a specific stage of maintenance maturity, and that have the necessary culture and processes in place.

Other practices, ideal for facilities in the early stages of maturity, offer little additional value to plants that are in the advanced phases of asset optimization.

The graphic above illustrates the drivers, rewards and behaviors experienced by a plant as it moves through the four phases of maintenance maturity: firefighting, maintaining, promoting and innovating.

The first step toward the goal of improved asset efficiency optimization is to accurately identify your plant's current situation and then construct and implement a program to achieve the optimum level of maintenance maturity.
The Financial Impact of AEO
Adding shareholder value through Asset Efficiency Optimization

Improved asset efficiency and reliability can have a direct impact on a company Statement of Income in three distinct areas:

(a) Cost of Goods Sold
(b) Cost of Capital
(c) Sales increase through improved Operating Equipment Effectiveness (OEE)

(a) Increase in Income
Because the expense of maintenance is accounted for as a part of the cost of goods sold, it is often a tempting target for reduction. However, if the impact of asset reliability and risk are not properly recognized, history has shown that short term savings will need to be repaid multiple times in the following years to regain the ability to produce.

The Wall Street Journal reported that for several hundred companies that engaged in cost cutting through layoffs or downsizing over a period of about five years:

• Only 33 % showed profit improvement
• Only 50 % showed productivity improvement
• 88 % experienced a serious decline in morale

(b) Reduction in Capital
Effective application of maintenance strategy and practices has been shown to reduce the need for capital by improving the reliability of existing assets and extending asset life. This reduces the amount of capital tied up in assets overall including spare equipment and parts inventories and has a significant influence on Economic Value Added (EVA). It also can have a very significant benefit of allowing the postponement of investment of new capital due to improved utilization of existing assets.

(c) Asset reliability improves every aspect of OEE.

(a) O&M costs are calculated in the cost of goods sold. Improvements impact the operating profit component of EVA.

(b) Improved asset reliability reduces amount of capital needed.
Overall Equipment Effectiveness (OEE)

(c) Increase in Sales
Another direct contribution to profitability can come from producing more with the same assets or producing at the same level with fewer assets. The most direct way to calculate this level of asset reliability is through the measurement of Overall Equipment Effectiveness (OEE). Improvements in OEE are an indication of an increase in asset reliability. A more reliable asset will make more products available for sale by:

- Being available to produce reliably when needed
- Producing at a higher run rate or for longer periods of time
- Producing more products within the required standards for quality and consistency.

However, to simply “improve” the efficiency of an asset is an open-ended target and will at some point bring a diminishing return. The term “Asset Efficiency Optimization” means what it says: to achieve an optimized level of asset efficiency. The decision about which level is correct for your firm should be driven by the overall business strategy of your company. Linking this strategy to an appropriate maintenance strategy and supporting it with a suitable blend of maintenance processes and practices can create profit opportunities that would otherwise be overlooked.
Critical Factors for Success

Achieving Asset Efficiency Optimization requires balance

The experience gained by SKF Reliability Systems in real world conditions in a wide range of industries shows that achieving competitive productivity and increased profitability through machine asset management depends on a balance of key factors:

- **Corporate culture** – It is important to have a culture that is willing to embrace change. With regard to improving reliability, the required changes may involve the shifting of responsibilities among plant personnel. This means a company must be willing to invest the time and energy to re-train employees and bring them emotionally and intellectually into the culture.

- **Technology** – Successful companies use technology as a tool to facilitate improvements in products and productivity. In addition, they commit the financial, educational, and personnel resources necessary to make the best use of new and emerging technology initiatives.

- **Processes** – To be most effective and to achieve long-lasting results, technology must be supported by updated and enhanced processes. In the case of machine asset management, incorporating new technology into the data collection, knowledge management, and decision making processes is critical to achieving success.

Logically, each process connects to or has a relationship to others, so the health of one area affects the overall system.

Our experience has shown that most companies have one or more maintenance programs in place. It is actually a rare situation where these are integrated into the overall plant activity, and thought of as a strategic component of the enterprise.

Viewing reliability maintenance from the asset management standpoint means that all improvements are important, and can be made at any and all levels of the plant. Whatever your current machine asset management strategy, SKF Reliability Systems has the knowledge to help you identify the areas that can be improved to help you meet your company’s business objectives.

The chart on the opposite page summarizes the capabilities of SKF Reliability Systems – from initial assessment to full Asset Efficiency Optimization. Page numbers accompanying each heading indicate where you will find additional information about these subjects in this brochure.
Summary of Capabilities

The Asset Efficiency Optimization (AEO) process

See pages 12–13.

SKF service capabilities are available in a variety of forms to meet the most unique requirements. All of the capabilities shown in this section are offered to support the AEO process described on the next page.

Summary of Capabilities

### Assessment

- Client Needs Analysis
- Machine Reliability Assessment
- Maintenance Strategy Review
- Operating Unit Assessment

### Maintenance Strategy

- Reliability-Centered Maintenance (RCM)
- Streamlined Reliability-Center Maintenance (SRCM®)
- Risk-Based Maintenance (RBM)
- Criticality analysis
- Quick Start Reliability

### Maintenance Engineering

- Planned, predictive and proactive maintenance procedures
- Process Documentation
- CMMS structure and implementation
- Spare Parts Alignment Rationalization and Optimization (SPARO)

### Asset Knowledge

- Predictive maintenance (PdM)
- Proactive Reliability Maintenance (PRM)
- Condition monitoring systems:
  - Vibration analysis
  - Lubrication Analysis
  - Thermography
  - Operating Deflection Shape Analysis
- Operator Driven Reliability
- Machine diagnostics
- Knowledge management
- Decision Support System

### Machine Maintenance

- Precision alignment
- Precision balancing
- Lubrication management
- Bearing failure analysis
- Bearing installation, maintenance and repair
- Maintenance tools

### Logistics and Supply Process

- Trouble-free supply
- e-supply
- e-commerce
- Spare Parts Alignment Rationalization and Optimization (SPARO)

### Machine Improvements

- Machine upgrade, rebuild and re-design
- Design engineering
- Technology upgrade
  - Components
  - Systems
- Refurbishment and repairs
- Post-maintenance testing

### Training

- Machine Reliability
  - Condition monitoring
  - Vibration analysis
  - Application specific training
- Lubrication management
- Bearing application
- Bearing maintenance
- Asset management
  Refer to page 31

### Assets
The AEO Process

A process for translating asset knowledge into bottom-line value

A key aspect of any world-class asset management program is a proactive, efficient work management process, designed to ensure the effective performance of maintenance on critical assets. To achieve maximum return on investment and maintain the greatest degree of productivity, it is pivotal that organizations have a process that effectively translates asset information to knowledge, and ultimately gain value from that knowledge.

To help organizations achieve these goals, SKF offers Asset Efficiency Optimization (AEO), a management process designed to achieve maximum efficiency and effectiveness from work management activities focused on business goals for the facility.

The AEO process encompasses four key elements: Strategy, Identification, Control and Execution. Within each of these elements, the coordination and participation of three essential factors within the organization – process, culture, and technology – is paramount to the overall success of the AEO process.

Maintenance Strategy involves the evaluation of work activities in relationship to a facility’s business objectives, a procedure that creates the documented basis for the maintenance program.

Work Identification is where “work” is identified from the evaluation of a comprehensive flow of data in conjunction with an integrated decision-making process. Key to the success of Identification is a comprehensive CMMS (Computerized Maintenance Management System).

Work Control involves establishing procedures for planning and scheduling the work identified by the CMMS. Tasks are organized based on several parameters, including time and condition; job plans or procedures; man-hours required; data feedback; special requirements; and many other factors.

Work Execution is where identified, planned and scheduled work is performed. Once work is completed, feedback from the field plays a key role in measuring the overall effectiveness of the AEO process and making refinements for even greater efficiency in the future.

The AEO process transforms conceptual asset management to tangible competitive edge. SKF can help plan a course of action to align your reliability and risk focused maintenance strategy with your organization’s business objectives. Our team will help correct known problems, and will then work with you to assess and identify additional opportunities for improvement in the areas of production, safety and environment.
Asset Efficiency Optimization – Work Flow Process

Maintenance Strategy

- Reliability Issues (Design)
- Pre-Defined Priorities

Work Identification

- PRM/ODR Collection and Analysis
- Information Integration and Decision Making
- Work Order Generation

Work Control

- Standard Job Plans and Procedures
- Planning
- Rolling Schedule
- Spare Parts Alignment

Work Execution

- Work Execution
- Post Maintenance Testing
- Update Living Program

Maximum return is achieved when all parts of the process are implemented; however, customers can focus on first one area then another in progressive stages.

PM = Preventive Maintenance (time based)
PRM = Proactive Reliability Maintenance (predictive and corrective)
ODR = Operator Driven Reliability (observations)
RTF = Run to Failure (reactive maintenance)
RCFA = Root Cause Failure Analysis
Assessment

Identifying the problems – when, where and how they matter

The most common reason for the failure of an asset management change initiative is the failure to establish if there really is a problem – and when, why and how it matters. Planning a shift to an integrated reliability and risk-based asset management strategy starts with a deep understanding of where you have been, where you truly are today and where you really need to go.

The purpose of an assessment is to gain this understanding and then to use it to put together a detailed, structured improvement plan that includes realistic, achievable, and necessary actions. To achieve and measure success, there must be clear and objective documentation of what the AEO process is intended to accomplish.

Every assessment is unique

We make sure that we clearly understand a client’s needs before recommending the type, depth and complexity of the assessment.

Assessments vary from a three-hour facilitated Client Needs Analysis to situations where we deploy multiple subject matter experts at the client’s site for periods of four to five days.

The Client Needs Analysis can be completed in just a few hours and asks 10 assessment questions for each of the four main facets of the AEO process: maintenance strategy, work identification, work control, and work execution. These 40 questions are designed to investigate, quantify, and visualize the situation at your facility. Results are displayed in a graphical “spider chart” format which provides a visual footprint of a particular plant’s assessment in accordance with international standards/models of business excellence.
Each assessment is conducted via a standardized and proven process that uses our detailed AEO model as a baseline from which to work. At a practical level, assessments can use purely quantitative (discrete/numerical approach), purely qualitative (descriptive/questioning/interview approach) or a composite approach.

**Skilled assessment teams**
Our assessment teams are made up of specialists selected for their knowledge and understanding of your specific industry, type of plant, and the equipment it uses. Their job is to interview plant personnel to collect information that will be used to pinpoint problem areas, and serve as a benchmark for improvements. They will also provide recommendations for streamlining processes and implementing the most cost effective practices.

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**The Quick Start Reliability Program**

SKF typically offers the Quick Start Reliability program to facilities that are organized in a classically reactive structure or hierarchy, and so often have absent or sub-optimized maintenance/reliability engineering capabilities. The program can provide a basic first step in the evolution towards using the complete AEO process. The Quick Start Reliability program is:

- Targeted to those clients that are in the lower maturity phase (firefighting) in the maturity pyramid.
- Designed to establish a maintenance process where none exists or is sub-standard.
- Focused on the first 90 days of the overall change management plan for maintenance.
- Geared to quickly put a performance management culture or process in place.
- An 8-step process that identifies a plant’s best “early wins” and implements a program to achieve them.
- Built around performing the right work at the right time in the right way – on equipment that is business critical.
- The best course of action when a plant has neither the time nor the funding to conduct a comprehensive maintenance strategy review.
Maximizing the efficiency of a plant and its machine assets requires a shift from discrete maintenance activities to a strategic process that is embraced company-wide.

Properly structured and implemented, a well thought-out maintenance strategy transforms maintenance from a cost to a profit center.

A comprehensive maintenance strategy is likely to employ a number of techniques working to support each other. Choosing the right technology tool, or combination of tools, requires a sound understanding of the plant and the relative data that may or may not be available.

SKF Reliability Systems has assembled a formidable body of expertise in the field of maintenance engineering and employs seasoned asset management pragmatists who are skilled at developing and executing strategies based on their knowledge and a real world understanding of all current maintenance techniques.

In addition to more than 15 years in the business of reliability maintenance, SKF Reliability Systems also has acquired several firms recognized in the field of maintenance engineering to complement our capabilities with in-depth first-hand knowledge and understanding of reliability issues.

With this knowledge and experience, we are able to identify what is truly needed for each client and then create a maintenance strategy which most effectively combines the right technologies to meet those needs.

The following is a brief discussion of the most commonly applied maintenance techniques:

**RCM – Reliability-Centered Maintenance**
This is often recommended for equipment where criticality is high and confidence in existing maintenance is low. The role of RCM in most cases is to provide a defensible base for specific equipment where there is limited knowledge and history. While RCM can be quite effective for reliability improvements in specific areas, in general it is inappropriate for the rest of the plant. This aspect of RCM has led to the development of other similar maintenance techniques which are more appropriate on a plant-wide basis.

**SRCM® – Streamlined Reliability-Centered Maintenance**
This enhanced version of RCM focuses on the dominant failure modes of equipment and the significant effects of those failures such as production losses, personnel safety, environmental releases, etc. A key benefit of an SRCM program is developing the understanding of plant personnel on the value of a modern-based maintenance strategy. As such, SRCM is particularly appropriate where a major change in the maintenance culture within the enterprise needs to be made, which also makes it a good option for new builds.

**RBM – Risk-Based Maintenance**
This is a financially based analysis technique which focuses on establishing the relative worth of maintenance. It was originally developed as a means of reviewing existing maintenance programs, and in this mode it works well as a continuous improvement tool. RBM defines opportunities for incremental improvement through the elimination of tasks of low value and the introduction of tasks which address high commercial risk areas. As such, RBM is also valuable in transferring knowledge from existing installations to provide a baseline for new builds.
Typical Maintenance Strategy Model

1. Business Goals
2. Select System
3. Boundaries
4. System Function
5. Non-Important Function
6. Important Function
7. System Components
8. FMEA (Criticality Analysis)
9. Failure Modes and Effects Analysis
10. Component Critical?
11. Define Appropriate PM Tasks
12. Performance Non-Critical Evaluation
13. Execute Living Program
14. Continuous improvement process

- Failure Causes
- Define Simple Tasks
- Recommended RTF
- Change PM Program
- Implement Decisions
- Existing PM Program
- Compare

* Planned Maintenance
** Run to Failure
SKF Proactive Reliability Maintenance (PRM) addresses failures and implements the processes necessary to prevent recurrence. At the foundation of the process is a systematic method to benchmark asset productivity and implement corrective actions that will reduce total life cycle costs. In short, it enables an organization to take complete control over what is happening on the plant floor.

While traditional Predictive Maintenance (PdM) processes form a sustained maintenance loop, the PRM process forms a continuous improvement loop.

The SKF Proactive Reliability Maintenance process is based on four key steps:

1. **Predictive Maintenance**
   Predictive Maintenance (PdM) is a process aimed at detecting a machine condition that will eventually lead to failure and then estimating the amount of time before failure occurs. To do this, sophisticated condition monitoring technology is used to gather data such as machine vibration, thermography, lubricant condition, motor current analysis, process parameters, etc.

   While most PdM programs stop at detecting a problem and making a residual life prediction, SKF uses this information as the basis to diagnose the problem with the objective to determine which proactive tasks are necessary to achieve an extension of machine life.
2. Diagnostics and Root Cause Failure Analysis (RCFA)
SKF Reliability Engineers use applied knowledge and its accumulated experience to diagnose collected data. This may lead to the recommendation for actions such as precision alignment, precision balancing, alterations in lubrication management, redesign of machine or critical components, etc.

To complement the knowledge derived from the diagnosis of data, detailed machine and component diagnostics are conducted on site, or at a centralized SKF Reliability Systems center. Damaged or failed components undergo a thorough Root Cause Failure Analysis (RCFA). This information is used to prevent a recurrence of the problem or, if required, to assist our OEM partners in a redesign of the machine.

3. Key Performance Indicators
Key Performance Indicators (KPIs) are performance improvement targets established jointly between plant management and SKF. They can cover a range of factors, such as unplanned mechanical downtime, quantity of product manufactured, plant efficiency, maintenance costs, and bearing performance. KPIs are also used to determine the number of personnel needed to maintain asset performance, and what qualifications those individuals need in terms of specific skills (e.g. lubrication, mounting, alignment). Where possible, once a KPI is achieved, a new target is set to facilitate continuous improvement.

4. Operational Review
Achievement of Key Performance Indicators is monitored through a periodic review of the total PRM program. Results are documented and presented at performance review meetings between plant management and SKF Reliability Systems. These meetings also help to assure that the process is continually refined to achieve the best asset performance and PRM process activity cost.

An effective decision support system further enhances the PRM process, allowing for information and data that is captured throughout PRM to be fully utilized in decision-making processes. The decision support system facilitates efficient organization and presentation of data, interprets data based on user-defined parameters, and then provides recommended actions for maintenance and operations.

A well-implemented and managed Proactive Reliability Maintenance process is the most effective method of managing risk, increasing reliability and ensuring the best possible return on plant assets. Depending on your needs, SKF can design, implement and manage the process for your entire plant or specific sectors, and supply all necessary hardware, software and technical resources. For those who wish to run the process on their own, we can provide consulting services and the technologies necessary to initiate and manage the process.
The relationship between operations and maintenance is an under-exploited opportunity in most companies today. The reasons for this are usually organizational, cultural or historic. Even in firms where a healthy relationship exists, the interaction process between the two departments can be improved. Trend-setting firms have realized this and are embracing a strategy called Operator Driven Reliability (ODR). ODR is built upon the following main concepts:

**Operators are critical to asset reliability**
Being in close proximity to the machines – 24 hours a day, 7 days a week – operators are often the first to notice even the smallest changes in machine condition. What they do with this information can mean the difference between machine failure and failure avoidance. ODR provides a process to turn early detection of developing problems into prompt corrective actions.

**Shared ownership of assets**
Most companies are being asked to produce more with fewer personnel. ODR creates a culture of shared ownership that leads to a greater contribution and a higher level of job satisfaction for operations personnel. Operations is responsible for process reliability. Maintenance is responsible for asset reliability. Together they can generate improvements in process availability.
Facilitates total productive maintenance
The most competitive companies in any industry have long ago accepted the concept of Total Productive Maintenance (TPM). ODR augments the TPM process and extends the cultural benefit by enhancing liaison between maintenance and operations. In companies where TPM does not exist, an Operator Driven Reliability program can be the stimulus for adopting it.

Automates data collection
Manual data collection by an operator is often inefficient and prone to error. The increase of dependable handheld computers in the industrial workplace makes it possible to automate most data collection tasks. Clear benefits in efficiency, accuracy and job satisfaction are the result.

Builds teamwork
Recent advancements in the IT world do not solve the problem alone: silos of information still exist in most organizations. By linking the two worlds of operations and maintenance, ODR increases cross-functional awareness with direct benefits to both.

Fulfills Maintenance Strategy Work Plans
One of the key outputs of the maintenance strategy process is a recommended work plan and task list for each asset and process. Building an Operator Driven Reliability program around these requirements has the benefit of linking daily activities directly to the overall strategy.

The MARLIN® system for Operator Driven Reliability
Recognizing this developing trend towards ODR in the mid-1990s, SKF developed a technology solution that fully supports the concept: The MARLIN system consists of a customized rugged handheld computer and specifically developed application software, allowing operators to easily collect three main types of data:

- Process Data (pressures, flow rates, temperatures, etc.)
- Machine Inspection Data (visual observations of machine condition)
- Machine Condition (level of vibration and temperature)

As operators make their rounds and collect data, the MARLIN system makes specific recommendations when certain machine conditions are detected. The recommendations are pre-determined by the maintenance staff and allow the operator to take immediate corrective action.

Collecting and trending each type of data in an accurate, repeatable and objective manner has its own direct benefit. And linking operational data to the mechanical condition monitoring data collected by maintenance personnel yields a more complete picture of asset and process condition.

Developing a decision from the merged data brings the ultimate benefit. The SKF @ptitude® Industrial Decision Support system automates this process and captures the knowledge derived from it for future use.

ODR implementation
SKF has also developed a complete implementation process to facilitate rapid and successful deployment of the technology. The ODR implementation addresses the many cultural and process changes that are needed to succeed. Let our experience and success in this field help your company benefit from using Operator Driven Reliability.
Managing and Applying Knowledge

An enterprise-wide approach yields optimum results

As organizations compete in the global arena and seek ways to reduce costs while increasing efficiencies, the ability to gather, store and instantly access essential knowledge is increasingly urgent for maintaining and improving plant productivity.

SKF Reliability Systems has recognized the importance of cultivating and retaining knowledge and competencies to ensure the ongoing stability, effectiveness and continuous improvement of your program. Today's technology makes it possible to amass and provide immediate access to essential internal and external knowledge from an array of sources, enabling your team to effectively and efficiently apply it to address your plant's unique reliability and productivity issues.

The Factory of the Future is here

e-business has revolutionized the way today's plants operate. Plant assets (people and machines) are now governed and directed by information networks such as planning systems and are linked to an even smaller number of suppliers (Figure 1). As e-business continues to evolve, the majority of transactions – those which are typical and repetitive in nature, and require no human interaction – will occur automatically. As workers focus only on the exceptions, and suppliers take on the role of managing customer inventories, transaction costs are significantly reduced.

Similarly, today’s advanced decision support systems provide a significant operational and financial benefit to plants that implement them. As predictable events occur at regular intervals between the assets and productivity systems in an enterprise – such as a motor failing every six months – the system automatically addresses the occurrence. This typically consists of a series of actions ranging from identifying the problem to providing the specific steps to take to correct it.
As exceptions occur, they are analyzed, corrected, resolved and incorporated into the Decision Support System (DSS) information base. A series of rules are defined based upon information and knowledge derived from subject matter experts and knowledgeable workers who have provided input to the system. As such, a process for identifying and addressing such problems is established for future occurrences.

Each new occurrence provides an opportunity to add to the decision support information base so that predictable events are automatically addressed if or when they recur. Therefore, the knowledge in the information base is continually updated, then shared to implement consistent resolutions to common problems within a single enterprise or at multiple sites throughout the country or around globe.

Users of decision support systems dramatically improve asset efficiency and integrity while maintaining and enhancing results over the long term. The impact on time, cost savings and enhanced productivity are significant.
Advanced Decision Support

Knowledge is power

The @ptitude® Industrial Decision Support system from SKF is an advanced, multi-faceted asset management solution which automates the industrial reliability maintenance decision making process. The system makes it possible for users to efficiently and effectively utilize the data made available through plant systems, providing a dynamic resource for machine and process diagnosis, analysis, reporting and corrective actions.

The @ptitude system integrates SKF’s range of competencies with data from other systems such as condition monitoring systems, distributed control systems, computerized maintenance management systems (CMMS), and internet/intranet websites, with your own organization’s internal knowledge. It incorporates the best of the world’s most widely used failure analysis methodologies with SKF’s extensive practical knowledge of components and machinery, and fuses this knowledge with live data analyzed through the @ptitude system software.

The system is built upon Asset Knowledge Science (Figure 1), which goes beyond traditional failure analysis models like Failure Modes and Effects Analysis (FMEA), Fault Tree Analysis (FTA), Reliability Centered Maintenance (RCM) and others to embody a fundamental understanding of the predominant failure modes of machinery, the measurements required to effectively monitor equipment health, and the consequences of failure. The essence of this capability is knowledge of an asset’s components, how they are assembled and how the asset is designed to perform, allowing for fault detection and resolution prior to failure.

Figure 1

Asset Knowledge Science “Tree”
Reliability expertise at your fingertips
The @ptitude® Industrial Decision Support system includes an expert environment where a diagnostic system manages the decisions for rotating machines. Based on a rule set made of asset systems and key features, the @ptitude system triggers notifications to plant personnel and recommends appropriate action. Should a part need replacement or if a failure analysis is required, the system advises on appropriate procedures and optimization, even linking actions with the plant’s specific asset management strategy. This helps to ensure accuracy and consistency in performing such tasks anywhere in the plant or around the world.

Asset management databank combines asset history and worker knowledge
To facilitate the incorporation of local or enterprise-specific knowledge, processes and procedures, the @ptitude system also includes the ability to add physical information about plant assets including lists of faults and symptoms, activity history and document management folders. The information is organized and readily accessible according to its criticality – specifically relative to production, safety or environment.

Accurate, consistent and reliable decision making
The @ptitude® Industrial Decision Support system includes an online web-enabled knowledge portal known as @ptitudeXchange that allows instant access to reliability maintenance knowledge 24/7. Through @ptitudeXchange, customers gain access and share in the wealth of knowledge and experience of SKF, and SKF’s alliance partners as well. Website content includes papers, application notes, best practices, benchmarking information and more. @ptitudeXchange complements the knowledge of your reliability professionals and provides immediate access to knowledge which can be instantly applied to support or enhance your team’s reliability efforts.

By integrating data from multiple sources into one easy-to-use software application, the @ptitude system applies a structured approach to facilitate consistent and reliable decision making – enabling personnel to act quickly based on meaningful data and a predetermined set of procedures and priorities. The system replaces labor-intensive data collection and analysis with automatic analysis, fault resolution and even work order notification.

www.aptitudeXchange.com
Machine Maintenance

Comprehensive service programs for rotating machinery

The bearing is at the heart of all rotating equipment
As the key interface between moving parts, the condition of the bearing often reflects how well a machine is running. Problems such as misalignment, unbalance, looseness and friction are all telegraphed through the bearing.

With its expertise in bearings, SKF has the unique capability to develop the most comprehensive service programs for rotating equipment. We’ll help you to combine an asset-aware maintenance strategy, structured competence and capabilities – including the best mix of internal resources and external specialists – to drive machine maintenance in the most cost effective ways.

- **Precision alignment**
  Misalignment is one of the major causes of machine component failure. SKF has the competencies to conduct precision alignment of machines. Comprehensive engineering services – combined with the application of products that quickly and correctly accomplish critical alignment and machinery mounting – can contribute significantly to the reduction of machine failure.

- **Precision balancing**
  Unbalanced components in machinery cause an increase in load on bearings and on the entire machine structure – all evidenced by high vibration levels. Precision balancing will reduce vibration, lower maintenance costs and optimize machine running time. SKF Reliability Engineers, using state-of-the-art instrumentation, will accurately diagnose machine conditions and, if needed, provide on-site precision balancing services.

- **Lubrication management**
  A concentrated effort to evaluate and improve lubrication issues in your plant will improve returns on plant assets and lower consumption and supply costs. SKF can provide a complete management process that will focus on improving lubrication conditions in the plant, and lower the associated supply and logistic costs.
Bearing failure analysis
The process of bearing analysis offers an important mechanism for identifying and addressing machine performance issues. SKF provides a Failure Analysis service with the most comprehensive analysis report in the industry. Each report includes a complete written account of why the failure occurred, plus recommendations for corrective actions needed to eliminate repetitive failures.

Technology advice and machine upgrades
Upgrading machines and processes with the latest technologies can play a significant role in improving profitability. SKF engineers are experts at evaluating applications and initiating improvements to extend machine life.

Bearing installation
Alignment of the machine, precision balancing and a vibration baseline analysis at start up can be included as part of the mounting process.
To remain competitive, plants must keep pace with new machine technologies

Increased production targets for your existing machines and competition with global companies equipped with newer machines make it hard to keep pace using your existing assets. SKF Reliability Systems can help – without the need to invest in completely new equipment.

Our engineers apply the latest design solutions, which are built on a solid foundation of reliability engineering. Their recommendations can include one, or a combination of actions:

Upgrade, rebuild and re-design

A pragmatic review of current operating conditions and machine history combined with information derived from a thorough Root Cause Failure Analysis (RCFA) can lead to a recommendation for an upgrade of key components or a re-design of entire sub-assemblies. These actions can extend asset life or result in an improvement of production capability – or a combination of both – generating significant value at the bottom line. Projects might include:

- Post-maintenance testing
- Optimization of paper machine press and dryer section for speed increase
- Conversions of continuous casters or chocks for the metals industry
- Upgrade of machine tool spindle design for high run rates
- Modernization of printing press cylinder systems for improved quality
- Re-engineering of lubrication and sealing systems for new operating conditions

Design engineering

SKF can also provide an extensive range of design services, including:

- Design review using finite element modeling
- CAD/CAM design and consulting
- Prototype design and production
- Structural modeling with modal analysis/operating deflection shape
**Refurbishment of bearings and assemblies**

Another way of maximizing your existing asset investments is through refurbishment and repair. Professional refurbishment procedures are used for large or specialized bearings that have been in operation or stored for some time. These can often be returned to an “as new” condition for a fraction of the cost of a new bearing.

A skilled technician inspects each bearing, then issues a comprehensive Bearing Failure Analysis Report. In addition to providing detailed information about the bearing, this report also contains a wealth of information about the operating environment and how it might be improved to maximize service life.

- Large size bearings and their housings
- Industry-specific repair and services
- Continuous caster bearings and assemblies
- Backup and work roll bearings for metal rolling mills
- Housings, rolls, and complete units such as printing cylinders and water-cooled housings for continuous casters
Supply Process

Partnership and technology for reduced costs, greater efficiency

Reducing costs associated with purchasing, supply and inventory management is an integral part of increasing profitability.

SKF Reliability Systems works in close partnership with our SKF Authorized Distributor Network – or your currently contracted supplier – to reduce transaction costs, release capital tied up in spares inventories, and assure that spares are available and delivered when needed. SKF can also assist you in taking full advantage of electronic purchasing systems.

Trouble-free supply

SKF maintains the world's widest network of authorized distributors who can provide you with supply arrangements for bearings and other industrial components through a single buying channel.

Through trouble-free supply, the management of inventory and supply is handled by the SKF distributor network. Our distributors will determine with you, the precise requirements for each machine so that dedicated inventories are available to meet demand. This eliminates the need to invest in inventory, or manage the supply process, and contributes to reduced costs.

Electronic supply

SKF has developed electronic supply processes to facilitate efficient, reliable and cost effective inventory management.

SKF Authorized Distributors are connected to a central warehouse and logistics support center, so you can link directly to this system for quick and easy access to the latest inventory and shipping information.

Many distributors are also joining two web based industrial marketplaces: Endorsia.com® and PTplace.com.® Endorsed by leading manufacturers, these all-in-one service networks are dynamic electronic marketplaces for branded industrial goods and services. Distributors, manufacturers and MRO users benefit from an efficient, streamlined system for buying and selling.

Websites: www.ptplace.com (USA) and www.endorsia.com
SKF Reliability Systems offers machine reliability and asset management training – from the shop floor to the highest levels of management. Courses focus on the skills and knowledge your team needs to work toward achieving maximum reliability and productivity. Our trainers are experts with years of experience in industry, many of whom also teach at universities or trade organizations.

Machine Reliability
- Condition monitoring
- Maintenance management
- Mechanical maintenance skills
- Lubrication management
- Bearing maintenance and service

Asset Management
- Proactive Reliability Maintenance skills
- Assessment techniques
- Equipment criticality analysis
- Maintenance strategy
- Reliability and Risk Based Maintenance
- Key Performance Indicators
- CMMS population and optimization
- Operator Driven Reliability
- Predictive Maintenance program setup and management
- Planning and scheduling
- Continuous improvement process “living” program management
- Spare Parts Optimization

Classes are held around the globe, or may be customized and taught on-site to meet your plant’s specific needs. Many courses are offered via e-learning and tutor-led interactive web tutorials. Or, your team can learn at their own pace or enhance their existing knowledge as time permits with a subscription to @ptitudeXchange, SKF’s reliability knowledge website.

Contact your local SKF office for availability and scheduling in your area.
The Integrated Maintenance Solutions (IMS) agreement offers industry a new alternative to current maintenance practices or full outsourcing.

With an IMS agreement, SKF Reliability Systems will manage every key component of a machine asset management strategy, providing a total system for achieving Asset Efficiency Optimization.

An IMS contract brings together all areas of expertise offered by SKF, establishing a continuous process of maintenance monitoring, analysis and improvement. It provides a planned skills transfer program for maintenance and operations personnel, and technology upgrades where required. The services and support best suited to optimize asset efficiency and integrity (safety and environment) are all included under one fixed fee performance based agreement.

Each agreement is customized to specific business needs. You can choose which areas you want included, based on internal resources and current supplier contracts.

With an IMS contract, SKF plays a significant part in increasing the reliability and integrity of your plant. We share some of the risk as well as the savings, while you receive agreed upon financial returns and technology upgrades without capital investment.

(See Case History on pages 54–55.)
Maintain and Modify

All data collected is used to achieve optimum machine performance and to establish effective maintenance practices.

Training

The skills of plant personnel must be developed to make the most effective use of new technologies and evolve asset management culture.
An integrated platform
SKF’s range of products and services – from condition monitoring and decision support systems to bearings and seals – are all designed to provide the solutions that will ultimately lead to increased bottom line profitability for SKF customers. Our focus on technology and seamless interface with plantwide systems supports four key areas in an effective maintenance process.

- **Decision support:** The ability to facilitate consistent, accurate and effective decisions on plant equipment and processes is a crucial component of a world class program. SKF has made a commitment to assisting customers in the retention, storage and utilization of crucial information with its decision support software.

- **Condition monitoring:** As a leading supplier of condition monitoring products, SKF offers a complete range – from hand-held data collectors/analyzers to online surveillance and machinery protection systems. These products offer a seamless interface to condition monitoring analysis software, CMMS, ERP, and other plantwide systems.

![Diagram](https://example.com/diagram.png)
■ **Tools and lubricants:** Safe and proper machine maintenance is critical when the goal is to optimize equipment running time. The development of SKF tools and lubricants is based upon our own experience in field work and includes the latest technologies.

■ **Component innovations:** New component innovations are needed to achieve productivity goals that were never intended by original equipment manufacturers. SKF continues to develop bearing products designed to run faster, longer, cooler and maintenance-free in many difficult applications.
Management of a predictive maintenance program can be a challenging task due to the amount of data acquired and the time required to reduce it into meaningful information. In some facilities, the personnel who collect machine data are also required to perform the analysis. This leaves little time to focus on corrective actions and work order follow-up. It then becomes impractical to evolve from PdM into a full Proactive Reliability Maintenance program.

SKF has developed a solution for this dilemma called e-maintenance, which uses web-enabled technology and integrates SKF Machine Analyst data management and analysis software; the @ptitude® Industrial Decision Support system; and the Microlog® portable vibration data collector. The entire process is managed by a group of experienced SKF reliability engineers. The result is a complete analysis process built upon proven techniques that support your existing infrastructure. And your PdM program begins to evolve into a true PRM program.

For companies that do not have a PdM program or have had trouble in maintaining one due to lost expertise or investment limitations, the SKF e-maintenance process can be used to run your PdM program at one facility. Or, it can also be used to standardize on PdM processes across multiple facilities. SKF can manage the entire e-maintenance program for you or put together the infrastructure as a turnkey system for your company to run itself.

Benefits of an Internet-enabled e-maintenance solution from SKF:

- Remote monitoring 24/7
  Data collected via portable or on-line surveillance devices at remote locations can be uploaded to the SKF Diagnostics Center for analysis and reporting.

- Centralized data repository
  Historical data from all locations is easily accessed by all responsible personnel. Reports are generated centrally and distributed to local workstations electronically.

- Better informed field technicians
  Maintenance and operations have access to more complete and timely data.

- Efficiency and consistency
  Data is managed more efficiently, and in a consistent manner throughout an organization.

- Minimized investment
  A centralized location eliminates the need for redundant analysis centers, saving on hardware, software and manpower.

- Savings through outsourcing
  Users may choose to use the SKF Diagnostics Center; supported by SKF reliability experts and a dedicated web server.
An example of e-maintenance at work

(1) From a central SKF Diagnostics Center, a data collection route is sent electronically to the laptop computer of a technician in a remote location.

(2) The information is downloaded to a Microlog portable data collector. (3) Once collected, machine vibration or process data is (4) uploaded into the remote PC and then (5) sent electronically back to the SKF Diagnostics Center where it is displayed, analyzed and stored in SKF Machine Analyst software.

(6) Using the @ptitude system, an SKF analyst generates reports or work order requests which are sent to the customer along with the supportive data. This information is also posted to a web server for future reference by the customer. The SKF Diagnostics Center provides the data repository.
AEO Technology Products

Condition monitoring for Proactive Reliability Maintenance (PRM)

Accurately interpreting what data means is more effective when the hardware and software used can also analyze, then seamlessly blend it with other systems. As the world’s largest supplier of condition monitoring products, SKF offers everything from simple hand-held devices to plant-wide protection systems.

Portable vibration analysis for predictive maintenance programs
The Microlog® family of vibration analyzers and data collectors incorporate a comprehensive range of features ideal for walk around condition monitoring. Selected products include on-board smart diagnostic wizards, single or two channel capability, color screens and intrinsic safety for industries with hazardous/gaseous environments. All Micrologs are supported by the SKF Machine Analyst Data Management and Analysis software and seamlessly integrate with the @ptitude® Industrial Decision Support system.

Portable systems for Operator Driven Reliability
The MARLIN® system automates the machine inspection process and builds a technology and communications bridge between the operations and maintenance functions. MARLIN collects, stores, analyzes and reports on vibration, process and inspection data, providing information needed to take proactive measures to improve machine and process reliability. The MARLIN family includes a range of rugged PDAs that operate with Microsoft® Pocket PC, is supported by SKF Machine Analyst Suite and integrates with the @ptitude system.

Surveillance systems for 24/7 on-line machinery monitoring
Continuous monitoring systems alert operations personnel to important changes in machine condition before they result in unexpected downtime. They also enable vibration analysts to spend less time collecting data and more time identifying the root causes of machine problems. SKF’s surveillance family includes the Multilog® and MasCon lines – each designed for specific applications and supported by data management and analysis software including SKF Machine Analyst and ProCon. Both integrate with the @ptitude system.

Critical machine protection and diagnosis
The SKF range of API compliant machinery protection systems can be easily extended to include condition and performance monitoring capabilities. They monitor both mechanical condition and process variables. Versatile and open, the systems operates in standalone modes or as parts of a comprehensive network linked to plant-wide information systems, and can be integrated with the @ptitude system.
Accelerometers, Eddy Probe Systems and accessories
SKF offers a broad range of high quality industrial sensors, accelerometers, velocity transducers, eddy probes and mounting accessories to suit a range of applications from general purpose to those in the harshest environments. SKF’s experience in every aspect of on-line condition monitoring and machine protection systems means that we have the expertise to identify and apply the appropriate product for the best result.

Integrated software platform
SKF Machine Analyst software manages, manipulates and analyzes machine condition data, and forms the core platform in SKF’s family of reliability software applications called SKF Machine Suite. The software may be customized for maximum efficiency and ease of use. Open architecture enables easy access to data within the Oracle® relational database as well as easy integration with the SKF @ptitude® system and other plant-wide systems.

Human machine interface software
The SKF Machine Analyst/HMI enables an effective and timely response to changes in machine condition by showing a graphical representation of the machine. Data from the on-line system is displayed “live,” enabling an operator or analyst to identify not only the symptoms of an alarm condition but the potential cause.

Specialty Applications – Wind turbine monitoring
The SKF WindCon system helps to extend maintenance intervals by continually monitoring the operational parameters and the key mechanical components of a wind turbine. This allows potential maintenance needs to be identified early and incorporated in scheduled maintenance stops. As a consequence, the time between maintenance intervals increases and costly emergency stops can be significantly reduced. Together these benefits result in less downtime, which increases the performance and cost efficiency of the turbine.

The products shown here are only samples from the range SKF has to offer. For information about other products, or more information about the ones shown, contact your local SKF representative or go to www.skf.com/reliability.
AEO Technology Products

Reliability tools for mechanical machine maintenance

Safe and damage-free machine maintenance is critical when the goal is to optimize running time. The development of SKF tools and lubricants is based on our own experience in field work, and includes the latest technologies for effective bearing maintenance and extended productivity.

**SKF shaft alignment tools**
Shaft misalignment in rotating equipment can cause frequent breakdowns. It generates additional loads and vibration which can cause premature damage to bearings, seals and couplings. And, it can significantly increase energy consumption. Shaft alignment tools from SKF use the latest laser technology to provide a more accurate way of detecting and correcting shaft misalignment. The display unit provides ‘live’ values of the nature and degree of misalignment, allowing easy and quick correction of shaft misalignment.

**Vibracon® SM element**
Vibracon is a universal, adjustable steel chock that eliminates the need for rigid steel chocks, shims or epoxy resin chocks. For generators, compressors, turbine and pump sets, Vibracon chocks eliminate a number of problems common to traditional methods such as parallel and angular soft foot and it is not necessary to machine the base frame or foundation. And there are no on-site problems related to arranging or installing shims. When used in combination with laser alignment equipment, alignment time can be reduced by 50 percent.

**SKF BeltAlign: belt alignment tool**
Pulley misalignment can result in frequent breakdowns, additional noise and vibration, and higher energy consumption. Therefore, accurate pulley alignment is an essential element in reducing maintenance costs. While traditional methods align the face of the pulley, BeltAlign provides fine-tuning of alignment where it counts most: in the grooves of the pulley.

**Personal Digital Assistants (PDAs) for vibration monitoring**
SKF’s most powerful palm-sized vibration meters are made to fit the expansion slot of a standard PDA. The unit collects acceleration, velocity, displacement, High Frequency Detection (HFD) and enveloped acceleration – then automatically evaluates results. It stores overall vibration signals, FFT spectrum and time waveform data for later recall. The PDA easily fits into a shirt pocket and is the perfect starter for beginners or a spot-check tool for technicians.
Vibration PenPlus
The Vibration PenPlus is a pocket-sized vibration monitoring tool which measures overall vibration caused by rotational and structural problems like imbalance, misalignment, and looseness. It can also take enveloped acceleration measurements of vibration in higher frequencies, such as those caused by rolling element bearings or gear mesh problems. The LCD simultaneously displays both overall and enveloped acceleration measurement values, providing useful fault detection data.

SYSTEM 24® automatic lubricator
The System 24 automatic lubricator delivers greases or oil continuously for up to 12 months. The System Multipoint keeps up to eight lubrication points simultaneously and automatically lubricated. Simply use SKF's DialSet re-lubrication calculation program for the correct grease dispense rate. The interactive LubeSelect available on the @ptitudeXchange website helps you to identify the appropriate lubricant for your application.

SensorMount®
SensorMount is designed to prevent errors when mounting large-size bearings by measuring the bearing inner ring expansion during drive-up on a tapered shaft seating. The system includes a bearing with sensor and a hand-held indicator. The signal from the sensor is picked up by the indicator, which displays a value representing the internal clearance reduction (mm) divided by the bore diameter (m).

Induction heaters
Forcing a bearing into place can damage bearings and compromise employee safety. By heating the bearing before mounting, larger bearings can easily be mounted onto a shaft. SKF induction heaters quickly heat bearings to the optimum mounting temperature, enabling a fast, easy and accurate installation. SKF offers induction heaters for a wide variety of bearings and other components including gears, pulleys, shrink rings, couplings, belt wheels, pistons and sleeves.

The products shown here are only samples from the range SKF has to offer. For information about other products, or more information about the ones shown, contact your local SKF representative or go to www.skf.com/reliability.
AEO Technology Products

SKF technology inside the machine

The world’s largest manufacturer of high quality rolling bearings, SKF is also a leading innovator of new bearing technologies. Beyond our line of standard bearing products, SKF has developed new, technologically advanced bearings designed to solve problems related to extreme operating conditions and specialized machine applications.

**CARB® for non-locating bearing arrangements**

The CARB® bearing from SKF, is a toroidal roller design exclusively for use as a non-locating bearing. In addition to accommodating shaft deflection, CARB bearings allow axial freedom not possible with traditional locating and non-locating bearing arrangements that use self-aligning bearings in both positions. The CARB bearing finds the best position to carry the load, no matter how the shaft moves.

**SKF Explorer spherical roller bearings provide endurance and performance**

After years of intensive efforts by an international team of SKF scientists and engineers, Explorer bearings have been reengineered at the micro and molecular levels for superior life and performance. Field tests confirm that Explorer bearings last longer in real-world conditions than any other brand of bearing, including previous generations of SKF bearings. Explorer designs have been introduced for spherical roller, angular contact ball, cylindrical roller, taper and spherical roller thrust bearing product lines.

**INSOCOAT® electrically insulated bearings**

INSOCOAT® bearings are insulated to protect against flashover damage in electric motors and generators. They are designed with an outer ring coated with a thin layer of aluminum oxide of uniform thickness, which is further treated to make it virtually impervious. The SKF plasma spray coating technique used on INSOCOAT bearings provides significantly better adhesion than is possible using other methods. At just 100 microns thick, the INSOCOAT bearing insulation layer can withstand 1 000 volts.
Sensorized Rotostat Seal
SKF has a strong capability in providing customized sealing solutions. A good example of this is the sensorized ROTOSTAT® seal design which integrates a speed sensor and PTFE seal in a custom designed metal frame to form a single, integrated assembly for use on the crankshaft of a passenger vehicle. SKF has extensive experience in providing all types of radial shaft seals, as well as a unique capability in bonding elastomeric and metal.

SKF Hybrid Ceramic bearings surpass extreme conditions
The silicon nitride ceramic balls used in hybrid bearings make them an excellent choice for applications that require high speed, high stiffness, high temperature, low noise, and intrinsic electrical insulation. The lower density of ceramic material enables higher speeds and more rapid acceleration. A low coefficient of friction enhances wear resistance, so bearings run cooler.

NoWear® bearings for increased lifetime in difficult conditions
NoWear® bearings are made of steel, but the rolling elements are coated with a new type of diamond-like-carbon which is only a few microns thick. This coating can be applied to most bearings and other components such as gears and bushings. Steel coated in this way has all the resilience of steel, plus the hardness and low friction coefficient of NoWear bearings. Ideal for demanding environments, NoWear helps to increase component lifetime, improve machine performance, and reduce risk of unplanned downtime.

SKF Magnetic bearings
The SKF line of magnetic bearings is non-contact and lubrication-free, providing cleaner, faster and more efficient performance. They operate at extremely high rotational speeds, unaffected by harsh environments, corrosive fluids, and even cryogenic temperatures. Recent advancements in electronics, software and motion control systems make them suitable for applications ranging from compressors to machine tools. SKF has developed magnetic bearing solutions for industries as diverse as petroleum, semiconductor fabrication, HVAC, machine tools and pulp and paper.

The products shown here are only samples from the range SKF has to offer. For information about other products, or more information about the ones shown, contact your local SKF representative or go to www.skf.com/reliability.
Real Conditions. Real Solutions.

For machine and plant productivity

On the following pages are examples of how SKF Reliability Systems has combined its knowledge, services and products to provide solutions to real-life application conditions. The applications described are only samples from the multitude of industries in which SKF is involved.

For information about how SKF can help increase profitability in your type of business, talk to your SKF representative or visit www.skf.com/reliability.
Real Conditions. Real Solutions.

Integrated solutions for complex data management

In modern process plants, growing demands upon the availability and reliability of critical rotating machinery have lead to requirements for more complex machine condition data in automated monitoring systems.

The machine’s monitoring function must be integrated with the plant’s control and safety functions. In addition, vital machinery health data must be available for manual or automated analysis over the plant LAN (Local Area Network) and over a corporate WAN (Wide Area Network) for enterprise-wide analysis. A successful example follows:

**Application:**
Gas-turbine-driven power generation.

**Condition:**
A series of remote power stations – some 500 km apart – each relied upon aeroderivative gas turbines as the prime mover for the generation plant. The availability of the turbines had been adversely affected by compressor section problems, which manifested themselves as specific sub-synchronous vibrations.

The existing vibration monitoring system was unable to react to these vibrations in order to provide adequate early warning for corrective action. A more complex approach was required, that would be reliable, usable and accessible over a WAN.

**Solution:**
An integrated system combining machinery protection, condition monitoring and transient analysis was installed at each site. The protection hardware was programmed to track and, through voting logic, automatically trip on the occurrence of the dangerous sub-synchronous vibrations. The condition monitoring system acquired complete FFT data continuously to gather a full scope of diagnostic information for analysis by dedicated trending, analysis and data management software. A vital factor was bandwidth limitations of the WAN for transfer and/or access of data from a remote location.

Additional options were expansion of the data into the plant control system by modern open protocol such as OPC, Object Linking and Embedding (OLE) for Process Control, and interfacing into a decision support system (@ptitude® from SKF).
SKF Reliability Systems implemented an advanced on-line monitoring system for a critical power generation plant distributed over a remote region. The system supports WAN operations, and provides machinery protection and continuous condition monitoring – capturing and archiving critical rotating machinery condition parameters, including steady state vibration data and run-up/coast-down transient events, for early warning of mechanical problems that could lead to costly machine failure.

Results:
The modern digital monitoring system has provided live information to machinery reliability experts at remote locations in a cost effective and timely manner. The protection system provides insurance against the known compressor problems, and the condition monitoring analysis software has given early warning of an engine bolt problem, avoiding multi-million dollar unplanned downtime.
Improving reliability does not necessarily mean adding maintenance tasks. Sometimes the opposite is true. The key to optimizing plant operations and assets, therefore, is to develop a strategic plan that increases value-adding activities and decreases non-value adding activities. This is the core of Reliability Centered Maintenance (RCM), which demonstrates that the best overall maintenance strategy improves reliability while meeting business goals.

With unique expertise in RCM, SKF partners with companies to develop a maintenance strategy that defines:

- the right equipment on which to spend preventive maintenance dollars
- performing the right maintenance tasks at the right time.

With RCM, recommendations are developed in concert with the business objectives of the organization. The results speak for themselves.

### Task Type Metrics for Two Systems Where Total Task Decreased After RCM Analysis

<table>
<thead>
<tr>
<th>Task Type</th>
<th>RCM Program</th>
<th>RCM Program</th>
<th>OLD Program</th>
<th>OLD Program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average #</td>
<td>Average %</td>
<td>Average #</td>
<td>Average %</td>
</tr>
<tr>
<td>Time Directed Intrusive</td>
<td>10</td>
<td>23</td>
<td>39</td>
<td>53</td>
</tr>
<tr>
<td>Time Directed Non-Int.</td>
<td>7</td>
<td>15</td>
<td>29</td>
<td>40</td>
</tr>
<tr>
<td>Condition Directed</td>
<td>13</td>
<td>29</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Failure Finding</td>
<td>19</td>
<td>33</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Totals</td>
<td>49</td>
<td>100</td>
<td>72</td>
<td>100</td>
</tr>
</tbody>
</table>

HPI installation decreases unplanned maintenance, saves $2.4 million per year

**Application:**
Inlet gas compressor/engine system at a major refinery

**Condition:**
In the field, gas compressor intercoolers were cleaned infrequently and poorly, as were engines within the igniter cooling system. In addition, there was no chemical treatment or operating parameters established for one of the cooling towers. In the inlet gas system, the current batch operation caused daily variations. Plus, the current flows and conditions failed to adequately remove H₂S.

**Solution:**
RCM was applied to all processes and utility units. SKF ran two studies concurrently. The studies took 24 months to complete. Implementation included:

- Reducing intrusive-type maintenance tasks
- Increasing condition-monitoring tasks
- Improving compressor/engine reliability
- Reducing lost production time

**Results:**
Savings are conservatively estimated at 5 cents per barrel of crude oil processed. This equates to sustainable savings of $2,430,000 per year.
Power utility decreases high priority corrective work by up to 40 %

**Application:**
Twenty-seven operating units at 15 power plants.

**Condition:**
After several years of cost-cutting measures, the utility was experiencing reliability and performance problems. There was a clear need to improve performance by decreasing equipment failure while ensuring properly focused maintenance resources.

**Solution:**
RCM was applied to all key systems. SKF studied the systems over a 30-month period. Implementation included:
- Development of documentation for the maintenance program
- Focusing planned maintenance on critical equipment and dominant failure mechanisms
- Emphasizing condition-based tasks
- Eliminating unnecessary routine and outage tasks
- Reducing maintenance costs
- Improving availability and reliability

**Results:**
- 30 % reduction in equivalent forced outage rate (EFOR)
- 7 % increase in peak period reliability
- 30–40 % reduction in high priority corrective work

Petrochemical plant – potential savings of up to $400,000 per year

**Application:**
Pilot program at one of the company’s five chemical processing plants.

**Condition:**
The company was seeking to increase profitability by reducing costs from equipment failures and shutdowns at the five plants.

**Solution:**
RCM was applied during a five-month period. SKF analyzed seven processes within the pilot plant. Implementation included:
- Utilizing SRCM® software to unify data collection and analysis
- Training team on RCM and software
- Verifying equipment IDs and updating process and instrumentation diagrams
- Establishing a methodology to standardize the company’s maintenance practices from plant to plant

**Results:**
The pilot program demonstrated that each of the five plants could achieve estimated sustainable maintenance savings from $40,000 to $150,000 per year, for a potential company-wide maintenance savings of $400,000 per year.
Industrial fans are an integral part of most plant installations. Often, the very nature of their work creates process bottlenecks. Heat, dust, dirt, gasses and paint are daily environmental factors that can cause impeller imbalance and contribute to reliability problems.

Application: Primary dust control fan, cement plant

Condition:
Repeated fan failure was shutting down the process every six months. It took maintenance crews six hours to restore the fan back to operation and one hour to restart the process. Revenue losses were approximately $10,000 an hour, and the problem had been occurring for three years – ever since the new fan was installed. Plant engineers had tried to solve the problem by themselves, with the help of the fan OEM and three consultant groups, all with no success.

Solution:
An SKF Machine Reliability Assessment was carried out on the fan:
- A complete asset history was developed
- Maintenance technicians, engineers and operators were interviewed for opinions
- A detailed vibration analysis was performed
- The lubrication system and lubricant type were examined
- The bearing arrangement and L₁₀ design life were reviewed

SKF Reliability Systems then conducted an analysis of the fan base structure using a vibration analyzer and Operating Deflection Shape (ODS) Software. It was determined that the structure was deflecting considerably. This caused the fan pedestal to twist, and the bearings to become misaligned during operation. The result was higher than calculated bearing loads and excessive seal stresses.

SKF strengthened the base structure; changed the bearing setup from two spherical roller bearings to a CARB® bearing on the wheel side of the fan and an SKF Explorer spherical roller bearing on the sheave end; and permanently installed an SKF Machine Condition Transmitter system to alert the plant DCS to higher than normal vibrations. The lubricant type and delivery system were also upgraded.
It was also determined that periodic dust build-up occurred on the fan blades, causing an imbalance condition in the fan. With the introduction of the low cost SKF Machine Condition Transmitter vibration monitoring, the operators could detect the problem as it began to reoccur and take necessary proactive steps during a convenient shutdown period.

Fan life improved dramatically. The fan easily surpassed the old MTBF (mean time between failure) and ran for three more years until it was shut down during a major outage, when the bearings were replaced and analyzed as part of a design assessment. All showed normal wear with significant residual life remaining.

Results:
Approximately $420,000 in production gain and a sustainable maintenance cost reduction of $50,000.

Benefit/Cost = more than 20:1

Based on the success of this project, the customer opted for a complete Proactive Reliability Maintenance (PRM) contract for all plant fans.
In the hydrocarbon processing and chemical industries, centrifugal pumps are a key asset in the plant infrastructure. They are of vital importance to production processes, yet they operate in a harsh environment with demanding duty cycles that can easily lead to reliability problems. High maintenance competencies are required to maximize pump reliability.

Application: Centrifugal pump, Oil Refinery

Condition:
The operator of a large refinery, concerned about the effectiveness of the existing plant maintenance strategy and predictive maintenance program, was interested in improving the performance of pump assets in relation to actual pump maintenance and operating costs. SKF Reliability Systems was called in to assess the current strategy and make recommendations for improvement.

Solution:
SKF conducted a detailed plant-wide pump audit in conjunction with the customer’s mechanical seal supplier. The assessment examined all facets of pump performance, maintenance activities and component supply logistics, focusing on improvement opportunities that would have the most impact on maximizing asset efficiency.

A key component of the SKF recommendation included the refocusing of critical maintenance activities, including the implementation of a Proactive Reliability Maintenance (PRM) strategy aimed at eliminating repetitive component failures.
Another major improvement opportunity was to involve operations personnel as the first line of defense in the maintenance program. The use of the MARLIN® data collection process was suggested, along with training for plant operators in using the MARLIN to collect strategic process and condition information. An ongoing maintenance skills training program related to bearings and mechanical seals was suggested for all mechanics. SKF also recommended that we join the mechanical seal supplier in a reliability maintenance partnership with the goal of reducing bearings and mechanical seals consumption.

**Products and Services provided**
- Assessment
- Proactive Reliability Maintenance
- Operator Driven Reliability
- MARLIN and Microlog® data collectors
- SKF Database, analysis and reporting software
- Seal partnership
- Bearing supply

**Result:**
All recommendations were accepted and SKF assisted with the integration of Proactive Reliability Maintenance and Operator Driven Reliability into the customers’ maintenance practices. This included support of the necessary cultural changes so that the use of technology and necessary work process changes would be accepted.

<table>
<thead>
<tr>
<th>Key Performance Indicator</th>
<th>Base Year</th>
<th>1st Year</th>
<th>2nd Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Machinery Maintenance Cost</td>
<td>100 %</td>
<td>66 %</td>
<td>62 %</td>
</tr>
<tr>
<td>Centrifugal Pump Maintenance Cost</td>
<td>100 %</td>
<td>83 %</td>
<td>74 %</td>
</tr>
<tr>
<td>Pump MTBF years</td>
<td>3.01</td>
<td>3.75</td>
<td>4.18</td>
</tr>
<tr>
<td>Mechanical Seal MTBF, years</td>
<td>8.5</td>
<td>11.6</td>
<td>13.9</td>
</tr>
<tr>
<td>Mechanical Seal Costs</td>
<td>100 %</td>
<td>69 %</td>
<td>52 %</td>
</tr>
</tbody>
</table>
SKF Reliability Systems introduced the Integrated Maintenance Solution (IMS) concept to show how our range of technologies and know-how provides the strategic framework and implementation capabilities for processes, systems, practices and technology. This performance-based approach to a long term customer relationship allows SKF to apply its core competence so that a customer is free to focus on their true competence.

Application: Paper mill

Condition:
Improve plant-wide asset reliability, reduce bearing and lubricant consumption, reduce unplanned downtime and total maintenance costs.

Over 100 hours of unplanned downtime in one year was incentive enough to prompt the management of a large integrated paper mill to recognize the value behind the IMS promise.

Solution:
The mill agreed that SKF should first conduct a detailed mill-wide assessment. The result was the identification of a long list of opportunities to optimize asset effectiveness, reduce the unplanned mechanical downtime and increase overall productivity – and a five year performance-based contract including:

- Supply and installation of an on- and off-line condition monitoring system. Because the cost is spread over five years no capital funds were necessary to upgrade to the latest technology. This was very important, since it released funds to invest in urgently needed production equipment.
- A staff of reliability engineers and maintenance technicians to manage the condition monitoring and lubrication program and make the necessary improvements.
- Specialist diagnostic support from two SKF support centers.
- Application engineering support for mechanical and lubrication redesign, as needed.
- Support on precision alignment and balancing.
- Training of the customer’s maintenance staff.
- 100 % bearing supply per a declining annual fixed price level.
- Bearing stock management, in partnership with an SKF Authorized Distributor.

Included in the terms is a guarantee that SKF will pay back part of the contracted fee if agreed goals are not met along with performance incentive if they are.
Customer Competitive Advantages:
- Fixed costs on bearing and lubrication products
- Integration of lubrication and vibration programs
- Root Cause Failure Analysis for ALL bearing failures
- Continuous improvement studies in critical areas
- Technology upgrades provided as part of contract
- Ongoing training and skills tracking

Products and Services provided
- Mill-wide Reliability Assessment
- On and off-line Condition Monitoring
- Decision Support System
- Proactive Reliability Maintenance
- Precision alignment and balancing
- Bearing and Lubrication Supply

Result:
In one year, the contract generated tangible savings for the mill, which gave the customer pay-back on their investment in less than one year. Additional progress in meeting the Key Performance Indicators led to a contract extension in the middle of the original 5 year contract.

<table>
<thead>
<tr>
<th>Key Performance Indicator</th>
<th>Base Year</th>
<th>1st Year</th>
<th>2nd Year</th>
<th>3rd Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment in Alarm</td>
<td>10 %</td>
<td>7</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Root Cause Failure Analysis</td>
<td>–</td>
<td>375</td>
<td>300</td>
<td>160</td>
</tr>
<tr>
<td>Bearing &amp; Lubricant Consumption</td>
<td>100 %</td>
<td>110 %</td>
<td>82 %</td>
<td>71 %</td>
</tr>
<tr>
<td>Unscheduled Shutdown, hours</td>
<td>120</td>
<td>47</td>
<td>0.7</td>
<td>0</td>
</tr>
</tbody>
</table>
SKF Reliability Systems
Global service and product/technology centers

Key

- Country Headquarters
- Product/Technology Centers
- Global Headquarters