









A well-structured compressor maintenance program will thus bring about several important benefits, including, of course, improved safety, reliability, efficiency, run-time, housekeeping and environmental/regulatory compliance. The final product cost will be materially decreased by this program. When increased production adds substantially to the profits of a plant, the minor expense of a well-structured maintenance program is insignificant. Dependability is a vital factor in any operation. The degree of dependability attained is in direct proportion to the effectiveness of the preventive maintenance program.

## 4. Maintenance Program

### 4.1. Maintenance Improvement

Problems associated with machine up-time and quality output involve many functional areas. Many people are from plant manager to engineers and operators, make decisions and take actions that indirectly or directly affect equipment performance. Manufacturing, production, maintenance personnel, engineering, and purchasing as well as outside stores and vendors use their own internal methods, systems, processes, policies, procedures, and practices to manage their departments of the business enterprise. These organizational systems to interact with one or another, depend on one or another, and constrain one or another in a variety of ways. These constraints can have destroyer consequences on equipment reliability.

### 4.2. Evaluating Inspection Data

Recording inspection data serves several purposes:

- 1) To establish the exact condition of all wearing parts.
- 2) To establish the wear rate of parts, which, if promptly replaced, will not deteriorate to such a degree that associated parts will be damaged and will also require replacement.
- 3) To determine which parts require reconditioning and which parts can be reconditioned to like-new condition.

### 4.3. Maintenance Costs

Perhaps the most frequent problem maintenance departments face is the rising cost and probable diminishing resources. While being constantly confronted with budget questions and the pressure to reduce costs, maintenance managers are still expected to raise the level of service in the plant. Maintenance often falls victim to budget cuts because management mistakenly believes maintenance can be deferred. It is thus important to effectively allocate and spend money. The observation data and records can diffidently be used to show what must be done to optimize the reliability of the compressor and to determine logical shutdown intervals.

## 5. Failure Modes of Reciprocating Compressor:

The failure of air compressor may be results of many factors such as Electrical and Mechanical. In electrical failure includes system control problems, overheating and single

phasing. In mechanical failure includes cylinder leakage, inoperative suction and discharge valves, damage piston rings, damage crankshaft, cylinder fail to move, damage connecting rods and unbalance of crankshaft. Some time air compressor fail due to improper operation, improper application, and improper cleaning purpose. Table 3 represents the failure modes of air reciprocating compressor due to different causes and effects of these failure on compressor.

**Table 3:** Failure modes, cause and effect[2,3]

Failure types	Cause of failure	Effect of failure
1. Cylinder fail to move	valves fail to open	Loss of gas output
2. Cylinder leakage	Mechanical wear, Damage seal	Reduces compressor efficiency
3. Damage piston rings	Low compressor oil, Wear out	Permanent compressor failure
4. Inoperative suction and discharge valve	Valve leakage, Discharge valve open to fail	Reduces compressor efficiency
5. Damage cylinder packing rings	Moisture entering cylinder	Permanent valve damage, Reduces compressor efficiency
6. Damage crankshaft, connecting rod	Mechanical bending, Loss of lubricants	Noisy compressor, Shutdown of compressor
7. Unbalance crankshaft	Misalignment, Mechanical bending	Noisy compressor,
8. Failure of piston rod	Wear, Excessive duty cycle	Compressor failure

## 6. Maintenance Procedures

Although monitoring of reciprocating compressors is not as simple and definitive as monitoring other rotating equipment, there are some things that can be and should be monitored. The first step in the program is to decide what is to be monitored. An effective predictive maintenance program should include the following:

### 6.1. Daily Operating Reports and Logs

These are used to observe operating parameters, temperature, flows, pressure etc. These are overlooked and recorded as part of the operator's duties but not referred to until after a problem develops. Continual monitoring can show trends of developing problems.

### 6.2. Maintenance Records and Wear Measurements

These are taken as part of the overall maintenance program covered previously. These records are the most important of all parts of the program. Inspection records will allow spotting of trends and prediction of possible parts failure. These records use as the foundation of planning for shutdown and replacement of worn and failing components.

### 6.3. Infrared Thermography

Infrared thermography of the valve covers temperatures . This very simple procedure is an important part of any

maintenance program and used to predict valve problems that can be taken care of before a major failure occurs. It should be a part of every maintenance plan.

#### 6.4. Lubricating Oil Monitoring

This procedure helps to detect the progressive deterioration of components such as bearings. It consists of monthly sampling of the compressor lubricating oil and performing spectrographic analysis that provides an accurate quantitative breakout of individual chemical elements contained in the oil elements as oil additives and contaminants. A comparison of the amount of trace elements in successive oil samples can indicate wear patterns of all wetted parts in the equipment and warn of impending failure. Full benefits of oil analysis can only be achieved by taking frequent samples and trending the data for each compressor. The basic data on each compressor allow the laboratory to build a unique database. Reports then include values from the current tests, the average for the particular compressor, and values from previous tests. A spike in the content of one element indicates a sudden change in the conditions inside the compressor. A comparison with the plant and laboratory averages provides a means of judging the significance of the change. Oil analysis can provide a wealth of information on which to base decisions. However, major payback is rarely possible without a consistent program of sampling in order that data can be trended. While oil sampling and analysis can provide an additional capability to existing preventive maintenance programs, it should not be depended upon to the exclusion of all other techniques. In other words, there are documented instances of bearing failures taking place in operating compressors that, for some reason, were not picked up by sampling the lubricating oil.

#### 6.5. Vibration Monitoring

This monitoring is particularly useful on those compressors that use anti-friction bearings that are the smaller sizes of reciprocating compressors. Because reciprocating compressors have relatively low rotative speeds, they produce low frequency vibrations and unfortunately require more than the traditional vibration velocity monitoring or frequency analysis. However, monitoring packages are available from experienced specialty firms.

#### 6.6. Acoustic Emissions or Ultrasonic Detection

As any gas (air, oxygen, nitrogen, etc.) passes through a leak orifice or leaking gaskets, etc., it generates a turbulent flow with detectable high frequency components. By scanning the test area with an ultrasonic detection device, a leak can be heard through the headset as a rushing sound or noted on the ballistic meter. The closer the instrument is to the leak, the louder the rushing sound and the higher the meter reading. Should ambient noise be a problem, a rubber focusing probe may be used to narrow the instrument's reception field and to shield it from conflicting ultrasounds. Performance and condition analysis of compressor cylinders will provide substantial savings to the user. Analysis will:

- \*Reduce power consumption by 10% or more
- Increase compressor throughput

- Reduce maintenance costs

#### 6.7. Oscilloscope Analyzers

These devices can be used to observe what is happening internally in the compressor cylinder, and, by comparing the actual pressure, volume, time indicator card, to the theoretical indicator card, the analysis determines if components are malfunctioning. It was noted that piston ring leaks can be detected by placing an ultrasonic microphone in the middle of the cylinder. Scuffing of piston rings or rider bands will show on the scope. A piston that is loose on its rod will show up at the end of the re-expansion and the end of the compression event. It is obvious that reciprocating compressor maintenance programs should include predictive and preventive maintenance elements. Notice, again, that predictive maintenance alone is not enough. It would be foolhardy to completely depend on lubricating oil analysis and vibration monitoring to determine maintenance schedules for compressors. We must take effective practices from both types of programs and merge them into an overall preventive maintenance program.

### 7. Conclusions

In this article an attempt has been made to diagnosis the problem associated with reciprocating air compressor, providing a solution by suggesting appropriate maintenance strategies. The maintenance program has been reviewed keeping in view of failure modes. The present article highlights the different failure modes of reciprocating compressor under varied operating conditions along with the appropriate maintenance strategies to diagnose and tackle the problems occurring very often. This article helps in detecting the premature and catastrophic failures leading to drastic productivity and system deterioration. This article work is all about of reciprocating compressor failure and prevention of its failure. Condition monitoring is predictive maintenance technique to identify the early failure. A proper maintenance program of reciprocating compressor increases the reliability, availability and decreases the downtime, maintenance cost of machine. Maintenance program also helps in increasing the productivity and effectiveness of reciprocating compressor.

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