# Operations & Maintenance 101
## Maintenance Strategies and Work Practices to Reduce Costs

In this course:

1 Overview

2 Basic Maintenance Strategies

- Reactive Maintenance
- Preventive Maintenance
- Predictive Maintenance
- Proactive Maintenance

3 The Right Mix

4 Updating Maintenance Practices

5 Reducing Cost by Changing Work Practices

- Instrument Maintenance: Calibration
- Valve Maintenance
- Rotating Equipment Maintenance

6 Managing Changes in Work Process

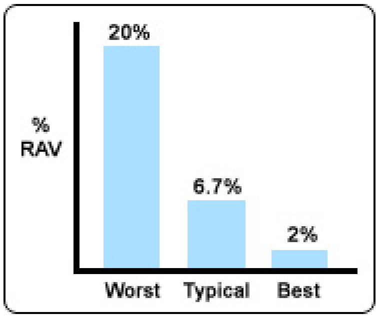
## Overview


Industry consolidation and worldwide competition are putting today's plants under intense financial pressure. Operations and maintenance budgets are among the first to be cut. Fewer personnel working for fewer hours are expected to operate and maintain more equipment at low cost. At the same time, they are also expected to deliver higher throughput, higher availability, and higher profits with aging assets.

This trend is showing no signs of change. Therefore, plants must increase the productivity of their existing operations and maintenance teams, while continuing to look for ways to reduce costs even more.

One frequent benchmark of maintenance productivity is annual maintenance cost as a percentage of replacement asset value (RAV). For example, a plant spending $5,000,000 annually to maintain assets that could be replaced for $100,000,000 has a 5% RAV.

The graph below shows typical as well as worst- and best-in-class % RAV.




For a plant with $250,000,000 in assets to maintain, moving from typical to best-in-class status could mean over $10,000,000 in annual savings.

So what can you do?

It is important to remember that minimum maintenance cost is not necessarily the most desirable outcome. The value of incremental production may be good enough to justify running the equipment past optimum maintenance point. The key is knowing plant equipment condition so the run vs maintain tradeoff can be best made.

The real goal is to use your maintenance budget and personnel more efficiently—so you can spend less and maintain or even improve plant performance.

In this course, you learn how to use the right mix of maintenance strategies and modify maintenance work practices to cut unnecessary costs. The second course in this sequence covers how you can use online monitoring and predictive diagnostics to further improve maintenance and cut costs.

**Hint**

As you go through the topics in this course, watch for answers to these questions:

- How can you adjust the mix of reactive, preventive, predictive, and proactive maintenance strategies so that workers can focus on doing the right things at the right time?
- What are the causes of excess operations and maintenance costs?
- What changes should you make to work practices so that you can find the time and resources to make improvements?

## Basic Maintenance Strategies

Often high maintenance costs can be reduced by adjusting the mix of the following maintenance strategies:

- **Reactive maintenance**
- **Preventive maintenance**
- **Predictive maintenance**
- **Proactive maintenance**

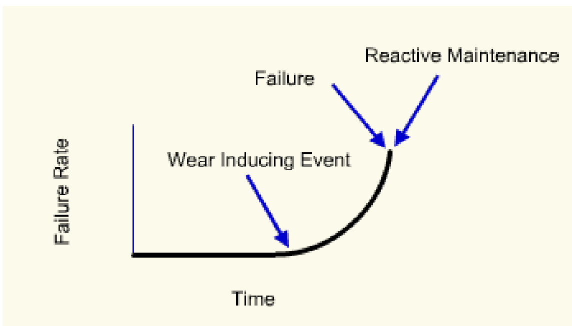
By using the right mix of these strategies, workers can focus on doing the right things at the right time.

Let's take a closer look at each of these four strategies, their cost impact, and how to find the right mix.

## Basic Maintenance Strategies >> Reactive Maintenance

The most basic approach to maintenance is **reactive**—also known as **run to failure**. Here, the asset is used until it fails. It is then repaired or replaced.

This strategy is acceptable and may be preferred for equipment with low costs and low consequences of failure. For example, if a kitchen light bulb burns out, the cost is low: a new bulb; and the consequence is low: diminished light. If the cost or the consequences of failure are high, run to failure is generally unacceptable.




**Adverse consequences of run to failure include:**

- Compromised safety or environmental compliance
- Collateral damage where failure increases the cost of repair
- Loss of product quality
- Loss of process availability
- Reduced throughput
- Increased waste and rework cost

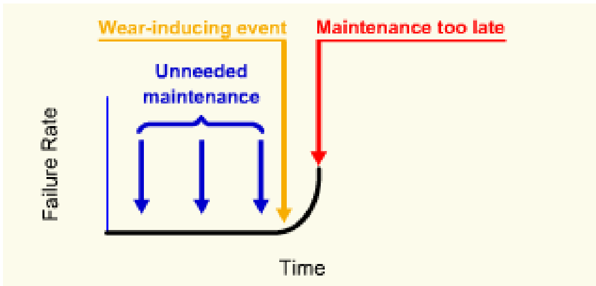
If equipment failure makes any of these consequences likely, run to failure is not recommended. In a **typical** plant **50%** of maintenance is reactive. In an **ideal** plant **10-25%** of maintenance would still be reactive or run to failure.

## Basic Maintenance Strategies >> Preventive Maintenance

**Preventive Maintenance (PM)** is typically used on equipment that has a **high cost of failure**. For this purpose, "failure" means more than when equipment ceases to function—it also covers situations where the equipment is unable to perform its intended function at needed quality, cost, and throughput.

To avoid high cost of failure, preventive maintenance often includes **periodic lubrication, adjustment, replacement of parts, and cleaning**. It is often based on the assumption that wear is a slow and continuous process that accelerates over time. Preventive maintenance is intended to stop the acceleration of wear, and return it to a low level.

Unfortunately, most wear is episodic in nature. That is, there is little or no wear until some outside stress ranging from lubricant contamination to exceeding equipment constraints triggers the rapid onset of wear. Maintenance in the absence of an outside stress is frequently not required. Failure to maintain equipment immediately after a stress can result in dramatic wear and rapid shortening of equipment life. The net result is that much preventive maintenance is either not required, or too late to be effective.




Preventive maintenance is time-based instead of condition-based. It often takes place before there is a problem or after the damage has grown.

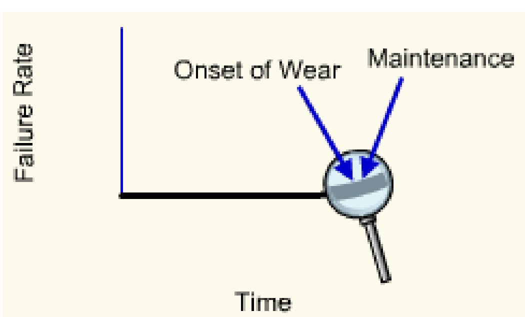
**Adverse consequences of preventive maintenance include:**

- Over-maintenance, where unnecessary or ineffective maintenance is performed—generally the cost of unnecessary maintenance and failures induced by incorrectly performed maintenance
- Under-maintenance, where failure conditions exist and are not corrected—leading to the consequences described earlier for reactive or run to fail strategies

## Basic Maintenance Strategies >> Predictive Maintenance

**Predictive maintenance** improves on preventive maintenance by using actual equipment performance to determine when maintenance should occur.

With this strategy, **periodic or continuous monitoring detects the onset of wear or degradation**, and the information is then used to predict potential problems and the best time for maintenance. Predictive maintenance is typically used where failure cost is high.




Monitoring for predictive maintenance is available for rotating equipment, electrical equipment, process equipment, transmitters and valves, and other equipment types.

## Basic Maintenance Strategies >> Proactive Maintenance

The next level of maintenance is called **proactive maintenance**. Proactive maintenance is fundamentally different from the other approaches.

Proactive maintenance seeks to improve performance, in addition to maintaining asset availability. It uses monitoring and diagnostics to determine both equipment health and performance. Maintenance is performed on healthy equipment if a performance improvement can save or make money.

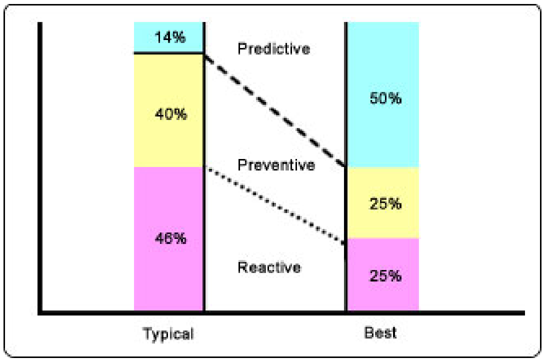
**Rigorous use of proactive maintenance can make maintenance highly profitable.**

## The Right Mix

A typical plant uses a combination of all four approaches. The approach used for a particular piece of equipment is determined by the following factors:

- **Criticality of equipment/process**
- **Safety and environmental issues**
- **Cost/Profit**

Plants in general over-depend on preventive maintenance, and under-utilize predictive and proactive maintenance. The result is higher reactive maintenance and an increased overall cost.




Typical maintenance practices have not changed in many years. The mix is heavily reactive. Best-practices plants improve productivity and reduce costs by emphasizing a predictive maintenance strategy.

Despite the benefits of predictive maintenance, typical practices have not changed in over 15 years. New tools and capabilities make best practices more achievable today.

Data shows that 86% of maintenance is reactive (too late) or preventive (unnecessary). Unnecessary maintenance wastes money and maintenance that is too late leads to failures.

Predictive maintenance is generally 10-15% of the maintenance activities in a typical plant. Ideally, this figure should be close to 50%. Predictive maintenance is under-used because it is perceived as too expensive. This is because the range of tools available is not understood, or plant maintenance personnel are "too busy" to implement predictive techniques.

These perceptions are incorrect. Many field instruments, for example, have diagnostics built in. Predictive maintenance can be conducted on them at a minimal cost. In addition, advances in technology are reducing the cost of monitoring required for predictive maintenance in equipment such as rotating equipment.

Finally, smarter diagnostic software is reducing the human analysis needed to diagnose equipment health in equipment such as valves and process equipment. These factors combine to make predictive maintenance surprisingly cost effective.

**Note**

To learn more about maintenance strategies and choosing what is right for you, please review the course Maintenance 101 "Understanding maintenance strategies" in the Business School of PlantWeb University.

## Updating Maintenance Practices

Changes in work practices are critical to reducing maintenance cost.

Maintenance practices were typically developed long ago when most plant equipment was "dumb"—that is, unable to provide or communicate information other than the basic measured variable or control signal. This limitation led to preventive maintenance, since actual equipment performance or condition was poorly known. Most of the maintenance procedures, data entry, record keeping, and work order management was manual. Most of the equipment was over-maintained to reduce unscheduled downtime. Maintenance intervals were determined by the failure frequency of the highest failure units.

These practices have tended to remain even after advances have made them unnecessary, locking in excess maintenance activity and cost. To reduce cost, budgets and staff are cut, but without changes in work processes. The result is a growing backlog of activities and an increase in urgent work. These practices need to be updated to reflect new technology and capabilities.

## Reducing Cost by Changing Work Practices

Work practice changes are critical to reduce maintenance and operations cost. Often, however, the prospect of changing work practices convinces us that change is too difficult to be worthwhile.

The key to success in changing work practices is, therefore, to start with small, easy to accomplish changes that have big benefit. Some examples that illustrate the point are:

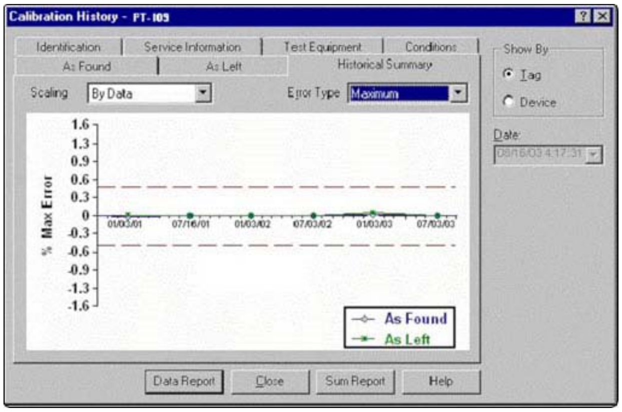
- **Changing instrument maintenance practices such as calibration**
- **Changing valve maintenance practices**
- **Changing rotating equipment maintenance practices such as cleaning**

You will now study each of these examples in detail.

## Reducing Cost by Changing Work Practices >> Instrument Maintenance: Calibration

One of the easiest ways to reduce maintenance cost is to calibrate devices less frequently.

Look at your maintenance records. Devices that show very little drift between calibrations are candidates for longer intervals between device calibrations. This simple change can save money on most of the transmitters in the plant. Nothing needs to be purchased; just do what you do less often.




Excess work can be eliminated by moving this instrument from a 6-month calibration schedule to a 12-month schedule.

Calibration cost can be further reduced by using intelligent calibrators and PC-based calibration management software to reduce the time and effort required.

With such tools, calibration schemes can be automatically entered into the calibrator from the PC software package. Calibration routes can be maintained in the PC as well.

Calibration of a device consists of attaching the calibrator, attaching the process variable source (for example, a pressure pump), and applying the process variable as the test scheme progresses. At the end of the calibration exercise, the smart calibrator will capture "as-found" and "as-left" information. In this way calibration is done faster, and with fewer errors.

Data lookup and data entry can consume up to half of an instrument technician's work time. Automating the input of calibration routes and schemes, and automating the upload of device calibration information to the calibration manager, can eliminate most of the data look-up and entry time.

Calibration management software can automate calibration routes and calibration schemes. It can also automate the transfer of calibration data to the instrument record system. This combination of functions can save time, reduce cost, and improve calibration and record accuracy.

**PlantWeb Advantage**

The **AMS Suite: Intelligent Device Manager** calibration manager will automatically upload the information from the smart calibrator into the PC database and update the device audit trail record.

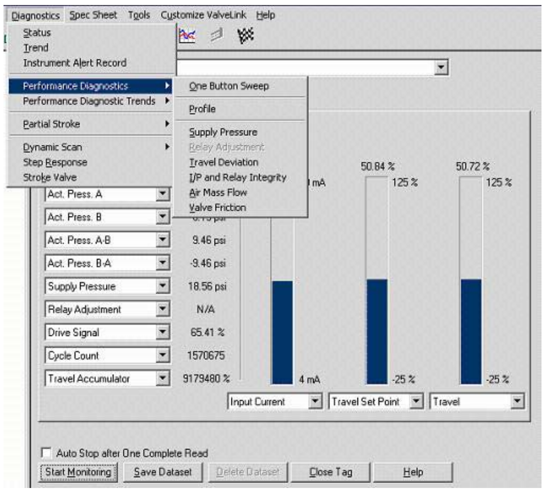
## Reducing Cost by Changing Work Practices >> Valve Maintenance

With information from a digital valve controller or other diagnostic tools, you can check a valve's condition before pulling it out of service for repair or rebuilding—and cancel or postpone service if it's not needed yet.

Typically, valves are pulled for rebuild on a scheduled basis—based on the wear of the valves in more severe services. These valves are sometimes tested in the maintenance shop, but are frequently simply rebuilt regardless of actual valve condition.

However, multiple studies have shown that a majority of valves scheduled for rebuild don't actually need it. Many valves can be brought back to good performance by simple adjustment. Some need no maintenance at all.

Valve performance testing can be conducted for the valve in the field using portable PC based test tools, or from the maintenance shop using online tools.




Common tests include a full signature test that checks valve response over the full valve stroke and measures seating pressure for full valve closure. These tests also monitor actuator pressure and valve movement. The One Button Sweep performs all these checks in a single diagnostic test.

This work process change will yield significant cost savings.

## Reducing Cost by Changing Work Practices >> Rotating Equipment Maintenance


A large percentage of rotating equipment maintenance cost is induced by installation or maintenance.

One of the easiest ways to reduce rotating equipment maintenance cost is to properly clean rotating equipment before service. Topping off the lubricating oil reserve can cause downstream problems if contamination is introduced with the lube oil. The work process of proper cleaning is the key to eliminating these types of problems.

Changing the work process to provide the time and proper directions for cleaning can eliminate most contamination and significantly extend rotating equipment life.

## Managing Changes in Work Process

Work process changes need not be disruptive. They can start small and selectively, one "pain point" at a time, and expand as maintenance personnel become more comfortable with them.

The following practices can help you manage changes in work processes:

- **Training personnel on the new work processes**
- **Posting new processes where they will be seen by the maintenance staff**
- **Stressing the work process changes until they become automatic**
- **Rewarding those that adopt the changes quickly and effectively**

Often a simple "good job, keep it up" is enough to reinforce a change and save you money.

[End of course]