MAINTENANCE

INTRODUCTION

Machines degrade as they age. Degradation causes failures and shutdowns. Buildings also age, however, static structures generally age much more slowly than does machinery.

Effective maintenance manages the aging process. Managing the aging process helps prevent failures that occur during service. These are the failures that are most likely to cause extensive damage.

Most losses occur during shutdown, startup and off-normal operating conditions. Effectively managed equipment experiences fewer unnecessary shutdowns, startups and off-normal conditions. Therefore, such equipment is less frequently exposed to the increased risk that is associated with these operating modes.

Building failures are rare, but they can be catastrophic. Buildings will, however, serve their purpose for a much longer time if they are effectively maintained.

All buildings and equipment must be maintained, however, a maintenance program that attempts to prevent all failures will be unjustifiably costly. On the other hand, “run-to-failure” assures unnecessarily frequent and severe failures, equipment outages and loss exposures. Neglected standby and emergency systems and equipment, including fire or explosion prevention and control systems, will not perform reliably. A cost-effective maintenance program controls loss probability and failure consequences by concentrating maintenance resources on the most risk-significant equipment.

POSITION

Maintain all facilities and their equipment in a way that cost-effectively controls the probability of failure-induced losses and their likely consequences. To accomplish this, develop and support a written maintenance policy for each facility. Appoint an experienced professional maintenance manager who will establish:

- A maintenance organization and management structure that will implement and support an effective maintenance program and a maintenance team that will consistently “do the job right the first time, on time.”
- An ongoing risk analysis and risk ranking function that will focus and support the maintenance program.
- Risk-based maintenance priorities that ensure sufficient resources are applied to items which PRC.1.13.0 has identified as “critical.” Critical equipment maintenance and testing require

clear management support and commitment because these activities often require or may cause production interruptions.

- An efficient work order system that delivers complete, fully planned job packages, tracks all maintenance resources, and feeds the maintenance information system and machine history files.
- Written impairment-handling procedures, similar to the RSVP Impairment Handling program (see PRC.1.1.0), for notifying other persons, departments and management when safety-related components and systems are out of service. The reports must detail the steps that are being taken to promptly restore such components and systems to normal operation and the interim safety precautions that have been applied.
- Detailed written procedures to explain how maintenance is to be done, how maintenance quality will be controlled, and which safety programs, such as hot work permits (see PRC.1.9.0), system isolation and lockout/tagout will apply.
- Precautions, including inspection department or management signoffs, to ensure that equipment on which work has been performed is restored to its normal conditions before it is returned to service.
- A maintenance information system that details equipment and component maintenance scope and frequency, records maintenance procedure results and provides feedback on maintenance program and procedure effectiveness. (See PRC.1.3.0.B for more information.)
- A maintenance engineering function that uses the information system and other resources to:
  - Continually improve the maintenance program.
  - Design modifications that eliminate repetitive failures.
  - Provide maintenance input to new facility and equipment selection decisions.
- Maintenance planning, work-measurement, scheduling, auditing and cost-control functions.
- Maintenance training programs, including maintenance program awareness and appreciation for nonmaintenance employees (see PRC.1.4.0).
- Controls and surveillance procedures that ensure contractors adhere to all facility loss prevention programs.
- Controls and signoffs in the work order system that ensure management of change procedures are followed.
- Maintenance material support and other logistical support systems as needed.

A well-designed facility requires less maintenance than a poorly designed one, and well-designed equipment is easier to maintain. Therefore, before building a new facility or modifying an existing one:

- Use life-cycle cost analysis to help balance initial cost and reduced lifetime maintenance.
- Select construction methods, materials and equipment that require a minimum amount of maintenance and are conservatively designed for the intended use.
- Arrange equipment with enough spacing for maintenance access and, when applicable, to make cascading failure events unlikely.

When purchasing and installing equipment, consider:

- The frequency and scope of required maintenance.
- The ease with which maintenance can be performed, and
- The equipment’s accessibility for inspection and repair.

Also, specify equipment that will withstand its intended operating environment.

See PRC.1.5.0 for more information about maintenance concerns that are related to new facilities and equipment.

DISCUSSION

Background

Buildings deteriorate and equipment wears. All facilities have maintenance programs that address these issues, however, some of these programs merely react to failures and breakdowns. Wholly reactive maintenance incurs excess direct maintenance costs. These include straight and overtime labor, contract services, overhead and benefits, and maintenance materials. Reactive maintenance also incurs vastly inflated indirect maintenance-related costs, such as those that are associated with:

- Unnecessary startups, shutdowns and equipment failures in service, and their associated higher probability of fire, explosion and injury;
- Excess downtime;
- Missed schedules;
- Lost good will and business opportunities;
- Unnecessary production of seconds, scrap and defective goods;
- Customer complaints and product liability exposures; and
- Possibly avoidable cleanup, waste disposal and environmental damage costs and regulatory fines.

To reduce these costs and exposures and to make maintenance a positive force in the facility's overall loss prevention and control efforts, maintenance must be proactive. The maintenance function and organization needs to be a fully integrated partner with the operating departments in the accomplishment of the facility mission. Maintenance needs unequivocal senior management support.

Proactive maintenance prevents premature building and equipment deterioration and failure, and thus avoids unnecessary replacement costs, reduces maintenance costs and prevents or reduces losses. A good maintenance program:

- Anticipates failures.
- Assesses the risk associated with each possible failure.
- Prevents or mitigates failures that present intolerable risk.
- Effectively expedites repairs and helps identify alternate means of production when failures occur.
- Provides the tools for self-diagnosis and correction where the program is ineffective.
- Tracks building and equipment remaining life and applies life extension techniques when they are needed.

Maintenance must not focus merely on the urgent. Applying the entire maintenance resource to today's problems can do no better than to perpetuate the status quo. Instead, maintenance must focus on the important. Properly applied maintenance resources will make an operation more reliable and will therefore contribute directly to the ongoing preservation of the business entity.

Effective maintenance reduces the serious failure probability by managing the aging process. An effective maintenance program begins with operational tasks such as equipment cleaning and lubrication. It continues with both on-line and off-line monitoring and testing techniques that detect deterioration before failures can occur. An effective maintenance program preemptively shuts down equipment before it fails and then preserves, repairs or replaces "wear parts," such as bearings, and also any other worn or corroded parts before their failure in service can cause major component damage. This proactive approach is the essence of effective maintenance. Such a program requires management commitment and a substantial supporting infrastructure.

Some equipment failures are likely to cause a dangerous condition directly; other equipment failures are likely to initiate cascading failure events that could lead to catastrophic loss. This "high-risk" equipment needs to be identified so that maintenance can apply the resources that are needed to prevent equipment failure. Specifically, "critical" components, systems or procedures, if they are out of service or not followed, could cause or allow a catastrophic loss. Catastrophic losses include fire, explosion, loss of hazardous material containment and extended unscheduled shutdown. If critical components or systems are out of service, the process or operation must be shut down in order to remain safe. A risk-based decision process will also determine how frequently critical components and systems should be tested to ensure that they will function as designed when needed.

Many equipment failures will cause costly production outages. Each possible failure must be considered, its risk-significance determined, and a risk-informed priority attached to the measures that would prevent the failure or control its consequences.

Risk is a two-dimensional measure of failure occurrence probability and consequence. Risk significance is a measure of risk level. Qualitative measures, such as very low, low, medium, high and very high can be used to estimate the probability and consequence for each machine, component or failure mode being considered. Placing each item being considered in a plot like the one shown in Figure 1 provides a measure of the item risk significance. Items toward the upper right are the most risk significant. Figure 1 is a risk plot for tubes in a large water tube boiler. The shaded regions in the plot represent areas of approximately equal risk. The plot clearly risk-ranks the various kinds of tubes in the boiler.

What must be recognized, however, is that sometimes a minor maintenance expenditure can reduce failure probability or consequence severity. For example, a cost-benefit analysis might justify some minor maintenance action to avoid the nuisance of frequent failures or high severity events.

Quantitative risk analysis methods are also available. In quantitative analysis, risk is generally calculated by multiplying failure probability by the cost of failure consequence. Quantitative methods vary in complexity. Relatively simple spreadsheet-based analysis can use probability and consequence estimates that are obtained from experts. Statistical probabilities are valid only when the all the equipment to which they are applied is equivalent in terms of type, materials, loading, environment and other factors. Whether two or more pieces of equipment are “sufficiently” equivalent causes controversy even among experts.

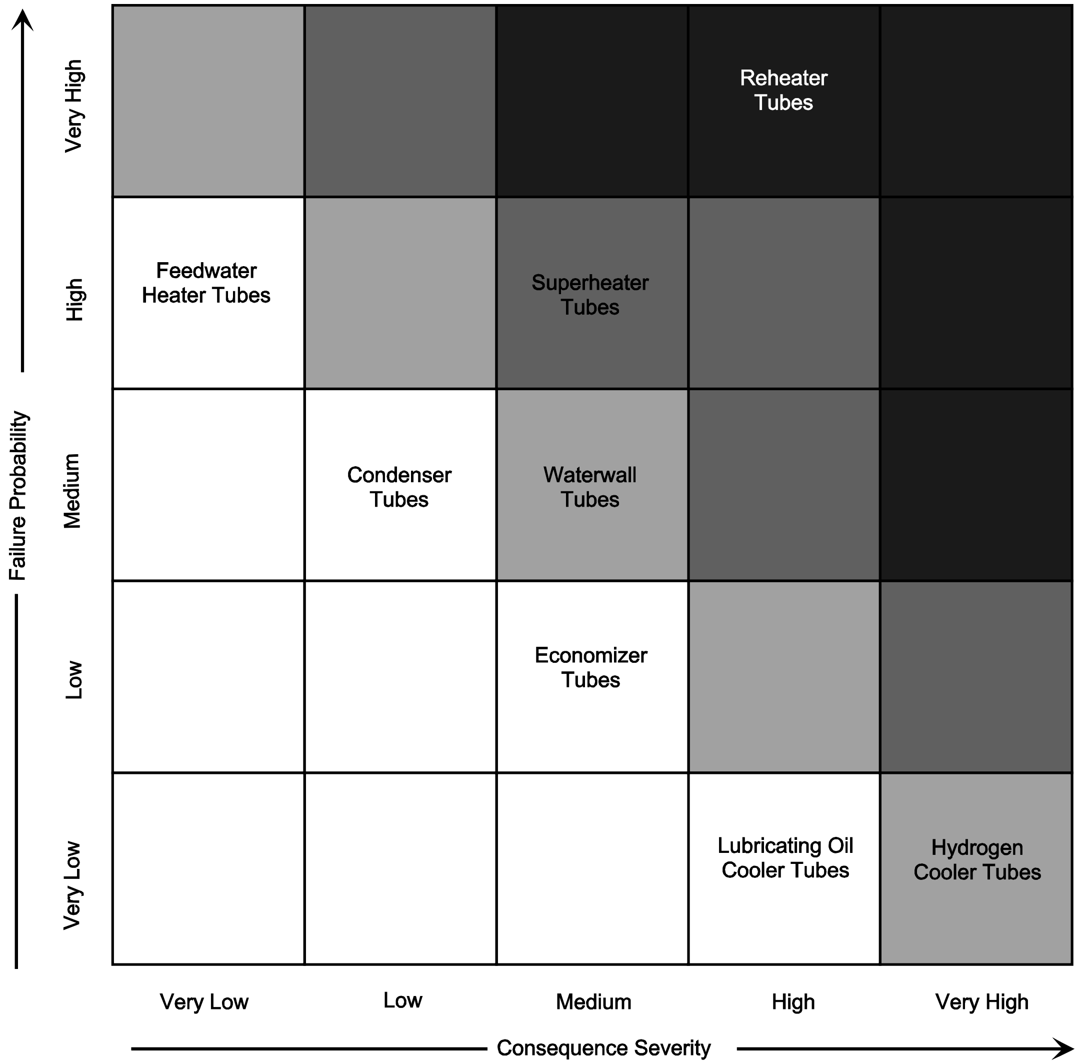


Figure 1. Qualitative Risk Plot For A Boiler (example).

More sophisticated techniques are also available. These techniques might use probabilities that are based upon component engineering models and consequence estimates that are based upon probabilistic analysis of actual predicted failure events. Many of these methods can estimate the probable facility net present value change that a proposed maintenance strategy is likely to produce. This capability is desirable because probable net present value can bridge the communications gap that is often found between engineering-oriented maintenance analysts and financially-oriented management decision makers.

Risk analysis focuses resources where they will be most effective and helps to avoid the tendency to maintain the most easily maintained items rather than the most important ones. Using calculated or estimated risk values or risk-significance measures will also ensure low probability/high consequence events like building collapse receive appropriate maintenance attention and resources.

History

Historically, maintenance was viewed as a necessary evil. Machines were simple, labor was cheap, and failure was perceived to be either unavoidable or of little consequence. The only maintenance that was normally performed was routine or operational maintenance, such as cleaning, lubricating moving parts, tightening loose bolts and joints, and watching and listening for signs of trouble. Additional maintenance took place only when wear progressed to the degree that performance was intolerably poor or when an actual breakdown occurred. In effect, the machine controlled outage timing and duration. Incredibly, this philosophy is still applied to whole facilities. It is variously referred to as “run to failure,” “breakdown maintenance” or “reactive maintenance.”

The earliest attempts at scheduled shutdowns involved programmed, or time-based, maintenance systems. The planned maintenance system (PMS) established by the U.S. Navy is probably the best-known example. Under such a system, all maintenance, whether operational tasks or complete overhaul, is scheduled based on elapsed time or on a specific number of operating hours or cycles. The interval between performances of a task is based upon experience, and, in theory at least, all activity can be planned. These systems worked well with equipment of slight complexity, particularly when components were standardized. Two problems emerged, however.

The first problem was how to set the maintenance intervals. When the intervals are too large, failures occur before the maintenance that is supposed to prevent them can happen, and breakdown maintenance results. When the intervals are too small, resources are wasted, and the shutdown of equipment to replace good parts quickly results in the perception that the program is nothing more than “going through the motions.” Sooner or later, the persons responsible for the tasks will do nothing but “go through the motions,” or worse, will feel free to document work that is not actually performed, and breakdown maintenance will again result.

The other problem involved system variation. While establishment of appropriate intervals for equipment in a single service (e.g., ship’s propulsion) with at least some standardization (e.g., Military Standard parts) is manageable, it is quite difficult with less standardized procurement and virtually impossible with a wide variety of applications and operating environments.

Those time-based systems were a step toward the goal of proactive maintenance. Now, better inspection techniques and on-line machine condition measuring tools allow a more focused and cost-effective approach. Rather than basing all maintenance decisions on time or number of operating cycles, these techniques and tools allow such decisions to be based on measured deterioration. Vibration amplitude in rotating machines, differential temperature in heat exchangers, and insulation resistance in electrical windings all indirectly measure equipment conditions. These measures often permit corrective action before failure. (See PRC.1.3.0.A.) However, this approach requires management support for taking the necessary maintenance action based upon measured conditions, regardless of the elapsed time.

An effective maintenance program properly applies all three approaches. “Condition-based” or “predictive” maintenance can be used in risk-significant equipment that has failure modes that are reliably measurable on-line or at least externally. “Time-based” or “programmed” maintenance can be used in risk-significant equipment in which failure probability can reasonably be expected to increase with time and particularly without maintenance. “Run to failure” or “breakdown” maintenance can be used when the failure consequences are low enough to be deemed acceptable to management, particularly when the expected failure mode is a random event.

Random failure modes that do not have acceptable consequences are the biggest challenge to maintenance decision makers. Equipment with such failure modes may require frequent “preventive” inspections and possibly redundant equipment for satisfactory risk control. Also, turbines, motors and other complex machines have components with all three — measurable, time-based and random — failure modes. These machines require condition monitoring commensurate with their importance and a pre-determined maximum overhaul interval.

Life Extension

An additional consideration has arisen in many industries that use large machines, most notably the electric utilities. Because of the manufacturing surge during the last World War and the period that followed it, many major machines are simultaneously approaching the end of their design lives. The large efficiency increases that for years were available in the “next generation” of equipment and that financed replacements for old equipment either no longer exist or are unaffordable, motivating owners to continue operating aging equipment rather than replacing it. “Life extension” refers to techniques that, by some combination of inspection, repair, and operating restrictions, allow use of equipment beyond its original design life. It has four steps:

  - Design the extension — Determine what to inspect, re-engineer or derate, perform appropriate calculations and establish test criteria.
  - Inspect and test — Examine the identified critical components or areas by appropriate means, which might include intrusive techniques such as destructively testing samples.
  - Assess feasibility — Use the design information, inspection data and any other pertinent facts to decide whether the equipment, when refurbished by available techniques, will perform as expected. Also, determine whether the proposed rework will indeed extend the life of the machine as a whole. Finally, calculate whether the investment in the modification is likely to produce an adequate return.
- Perform the necessary work — Reblade the rotor, replace the super-heater pendants or do whatever has been established as the right thing to do for the limiting component(s).

Maintenance Priorities

A good maintenance program does not allow production-oriented maintenance to supersede safety-related maintenance. A proactive maintenance environment includes regularly scheduled opportunities for safety instrumentation maintenance.

The maintenance program must set priorities by identifying critical components and systems (see PRC.1.13.0) and promptly establishing procedures to oversee their integrity. Ventilation systems for flammable liquid handling, combustion safety controls on fuel-fired equipment, overpressure protection on boilers and pressure vessels, overspeed protection on turbines, and the master shutdown system for a chemical process unit are examples of critical systems. In each case, the maintenance program must give special attention to testing and maintaining these critical systems and their components.

To set priorities and develop schedules for other equipment, evaluate each process or equipment component to determine its failure risk, then rank the equipment according to its risk significance. Use the risk ranking to help prioritize maintenance work. Consider these factors, however:

- “Predictive” activities, like taking vibration readings, are only valuable if they are regularly conducted on time. Their priority should be handled accordingly.
- “Backlog” items are almost always known deficiencies that will eventually cause more and possibly serious problems if they are not corrected. Therefore, jobs need to automatically rise in priority as they age.
- Some maintenance actions are taken to lower the overall cost of maintenance.

Assign a high priority to the inspection, service, and repair of instrumentation that is installed to prevent losses or of systems and equipment that handle emergencies. Although this assignment is often made initially, such maintenance may be subsequently neglected because safety instrumentation and fire protection equipment have a low “visibility factor.” This means that such equipment is not often called upon to operate unless adverse circumstances exist.

Maintenance priorities are often influenced by external factors such as seasonal changes (see PRC.1.3.0.C) or legal requirements. These influences must be included in the overall maintenance evaluation.

Spares

Spare parts should be available so that critical components or systems that fail will be returned to service as quickly as possible. For other equipment, spare parts management depends upon the failure risk and upon the cost, availability, and lead time for the parts.

For large pieces of machinery, such as compressors and turbines, or for equipment made of exotic materials, the spare parts needed may be very costly. Companies that have identical pieces of equipment sometimes try to reduce these costs by pooling their major spare parts. Manufacturers of machinery may at times maintain spare parts for customers. While these spare parts managing methods are not as secure as on-site storage, they can provide an effective alternative solution if contractual provisions are properly drafted.

Chemical analysis should be used to ensure that important replacement parts are made of the proper materials. Similarly, nondestructive testing methods such as dye penetrant testing, ultrasonic examination or radiography should be used to ensure that these parts do not contain defects. The quality of maintenance operations such as welding can also be verified by inspection.

Management Of Change

There are occasionally reasons to substitute parts that differ from the original parts in design, material of manufacture, or source. For a trivial example from every-day life, think about how many things once made from welded, riveted or bolted metal parts were more recently die cast metals and are now plastics. There is nothing wrong with a similar pursuit of more economical and perhaps more closely engineered parts in the industrial setting, as long as the changes are properly managed. History is full of failures and disasters caused by improperly managed material and other changes. See the management of change discussion in PRC.1.0.2.

Groups of items like valves, motors or switches, which appear to be alike, may in fact contain some that have unique performance and maintainability features. Review of the maintenance information system often reveals instances where more costly items have a lower life-cycle cost than the “same” items from the lowest bidder.

The philosophy that “if it ain’t broke, don’t fix it” receives occasional unwarranted support from managers who have taken smoothly running machinery down for maintenance only to have a failure soon after its return to service. More often, the statement is disproved by the discovery of incipient failures during properly scheduled overhauls. Furthermore, in an enlightened, risk-based maintenance management environment, an inspection that reveals no adverse condition is valuable. A “clean” inspection measurably increases confidence in the rest of the maintenance program, reduces failure probability uncertainty, and provides a data point that, when factored into the risk analysis program, can result in significant long term savings. The key is a highly skilled, aggressively proactive maintenance organization that does the right jobs and does them right the first time, and which is an accepted partner with the operating departments in accomplishing the facility mission.

MAINTENANCE INSPECTIONS

Inspections and tests are a necessary part of maintenance. Use them to determine the degree and rate of equipment deterioration. A good inspection program, aided by computer and maintenance engineering analysis, can predict the probable time of failure of a piece of equipment so that the equipment can be replaced or repaired prior to that time. Inspections and tests that reveal no deterioration may help avoid unnecessary maintenance.

Inspections are most effective when they are conducted by qualified, preferably certified, persons in accordance with a written procedure or protocol that has been proven to provide consistent and repeatable results. Nationally recognized certification programs are available for many types of inspections.

Inspection techniques are being developed continuously. Some newer techniques include:

- Ferrography and wear particle analysis — analyze the contaminants in a lubricating oil system. These tests are sensitive to changes caused by abnormal wear. If the composition of the various parts of the machine are known, the source of wear products can be identified and maintenance scheduled before a failure occurs.
- Vibration monitoring and analysis — detect gross problems such as imbalance, misalignment and looseness. When coupled with modern computer analysis, vibration analysis becomes an extremely effective tool for diagnosing and predicting machine ailments including some rotating element cracks.
- Acoustic emissions analysis — can detect incipient flaws and small leaks by detecting sound in a structure. Acoustic emissions analysis can often be performed on equipment while it is in service.
- Infrared inspection — allows the user to “see” the heat being radiated by an object. This technique is excellent for detecting incipient faults in electrical equipment, refractory and insulation. The same equipment can be used to locate heat imbalance in equipment such as engines, leaking valves in compressors, leaking steam traps, and a host of other adverse conditions. Under certain conditions, it can even locate leaks in roofs.

Because of the sophistication of some test methods, it may be advantageous to develop an inspection department. The inspection techniques that are used depend upon the type of equipment and materials that are being inspected, the condition of the equipment at the time of inspection, and, where applicable (generally for equipment such as cranes, elevators, boilers and pressure vessels), requirements of the governmental authority (jurisdiction). Operating equipment often requires different inspection methods than idle equipment requires.

Some inspection techniques, such as eddy current analysis, radiography or acoustic emission, may best be done through a contract service in all facilities except those with the very largest inspection departments.

Inspection results provide feedback to the maintenance system. Assign the inspection frequency based upon:

- The importance of equipment and its failure risk.
- Previous inspection results and failure history.
- Service conditions.
- Time in service.
- Legal requirements.
- Insurance company recommendations.

- Recommendations of standards bodies and manufacturers.

The inspection force may also provide quality control monitoring for work in progress. This includes audits to verify that plant and vendor personnel are adhering to written procedures, safety programs, corporate standards, jurisdictional requirements, and good engineering practice. One frequently-overlooked aspect of quality control is tool control. Strictly limit access to open machinery casings and maintain accountability of all tools and parts, so that nothing is inadvertently left in the machine.

Finally, maintenance of almost any piece of equipment requires abnormal configurations of some sort. Examples include gagged safety valves for hydrostatic tests, blanked flanges and missing valves for piping system isolation or flushes, and extra filters in steam and lubricating oil systems. Ensure normal conditions are restored before equipment is returned to service.

MAINTENANCE INFORMATION SYSTEMS

A maintenance information system is a necessary part of a good maintenance program. Such a system makes the maintenance program more effective and reduces its cost in the long run. A suitable system allows the maintenance manager to gather data to support maintenance decisions. It includes equipment failure data that may be fed back to designers or manufacturers, used for process hazard evaluation (see PRC.1.13.0), or sent to the purchasing department to support changes to specifications or to support the selection or avoidance of particular vendors or equipment types. The maintenance information system is also a valuable resource for the planning department to use when preparing job packages for future maintenance work.

The maintenance information system provides:

- An easily retrievable historical record for each major piece of equipment or group of similar equipment. This record should include the original specification information, manufacturer, a history of operation time and conditions, and a record of inspection results and of all maintenance performed.
- Equipment inspection and service schedules that specify the inspection and service scope and standards. The schedule should indicate which safety precautions apply and which permits are required during each activity (for example, see PRC.1.9.0). When fire protection equipment or systems are involved, proper backup procedures should be required (see PRC.1.1.0).
- A persistent follow-up or tracking system to ensure that proper inspection and maintenance service are being performed according to schedule.
- An equipment repair and maintenance task priority assignment system that automatically increases the priority of deferred jobs.
- Specifications for special replacement parts and materials for individual pieces of equipment so that proper parts and materials are used during maintenance procedures. A list of qualified suppliers for these items should be maintained. Management of change procedures should be followed before any substitutions are authorized. See PRC.1.0.2.
- An inventory of spare parts and an inventory control system. The control system should include written procedures for proper storage of large, complex or sensitive parts such as turbine rotors, electric motors or coils, or electronic modules.
- Programs to analyze the effectiveness and cost of inspection and maintenance procedures.
- Written notification to management and other affected departments so they will be promptly alerted when critical or safety-related components and systems are out of service for maintenance or any other reason.

In most organizations, the maintenance information system uses computers to assist in program management. With the present state of the technology, there is no reason that even small organizations cannot benefit from the relatively low-cost computer equipment and maintenance management software available.

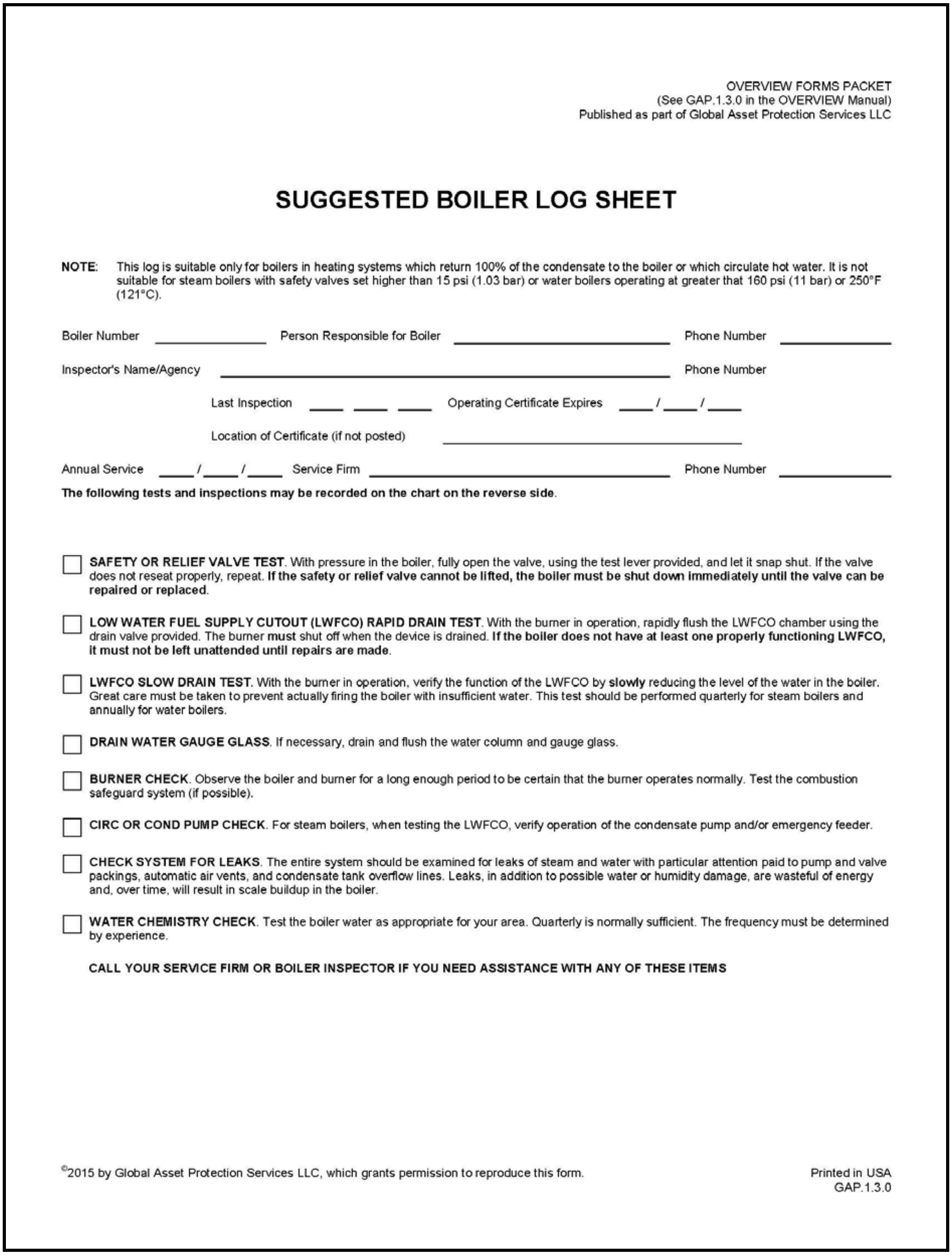
Operating Logs

Operating logs are not generally a part of the maintenance information system; however, they may provide valuable information to it. To be effective, any log program requires the following attributes:

- The information must be gathered regularly. Even less desirable information, regularly collected, may be better than the right information, gathered haphazardly. For example, consider a pump that is being pulled out of alignment by process temperature changes. While daily vibration readings might be the most efficient way to disclose this condition, it is also true that reliable hourly bearing temperature readings may bring the problem to the attention of an astute reviewer faster than vibration readings which are taken “as the opportunity presents.”

- The information that is selected for collection should be complete enough for intelligent interpretation. For example, turbine bearing temperatures are more valuable if the load on the turbine at the time of the reading is also recorded.
- The information is periodically reviewed by a maintenance engineer. Too often, loss investigations reveal meticulously gathered data showing a steady, unexplained rise in vibration level or a steady, unexplained drop in performance — that no one noticed until the crash.

Operating logs for any but the most rudimentary equipment must be custom designed. Logs are so important that preparation or review by an independent specialist is recommended. As examples, sample log sheets for small, low-pressure heating boilers and small, compression-type, fluorocarbon air conditioning machines are shown in Figures 1 and 2.



OVERVIEW FORMS PACKET
(See GAP.1.3.0 in the OVERVIEW Manual)
Published as part of Global Asset Protection Services LLC

SUGGESTED BOILER LOG SHEET

NOTE: This log is suitable only for boilers in heating systems which return 100% of the condensate to the boiler or which circulate hot water. It is not suitable for steam boilers with safety valves set higher than 15 psi (1.03 bar) or water boilers operating at greater that 160 psi (11 bar) or 250°F (121°C).

Boiler Number ____________ Person Responsible for Boiler ______________________ Phone Number ____________

Inspector's Name/Agency ____ Phone Number

Last Inspection ____ ____ ____ Operating Certificate Expires ____/____/____

Location of Certificate (if not posted) ______________________________

Annual Service ____/____/____ Service Firm ______________________________ Phone Number ____________

The following tests and inspections may be recorded on the chart on the reverse side.

☐ **SAFETY OR RELIEF VALVE TEST**. With pressure in the boiler, fully open the valve, using the test lever provided, and let it snap shut. If the valve does not reseat properly, repeat. **If the safety or relief valve cannot be lifted, the boiler must be shut down immediately until the valve can be repaired or replaced.**

☐ **LOW WATER FUEL SUPPLY CUTOUT (LWFCO) RAPID DRAIN TEST**. With the burner in operation, rapidly flush the LWFCO chamber using the drain valve provided. The burner **must** shut off when the device is drained. **If the boiler does not have at least one properly functioning LWFCO, it must not be left unattended until repairs are made.**

☐ **LWFCO SLOW DRAIN TEST**. With the burner in operation, verify the function of the LWFCO by **slowly** reducing the level of the water in the boiler. Great care must be taken to prevent actually firing the boiler with insufficient water. This test should be performed quarterly for steam boilers and annually for water boilers.

☐ **DRAIN WATER GAUGE GLASS**. If necessary, drain and flush the water column and gauge glass.

☐ **BURNER CHECK**. Observe the boiler and burner for a long enough period to be certain that the burner operates normally. Test the combustion safeguard system (if possible).

☐ **CIRC OR COND PUMP CHECK**. For steam boilers, when testing the LWFCO, verify operation of the condensate pump and/or emergency feeder.

☐ **CHECK SYSTEM FOR LEAKS**. The entire system should be examined for leaks of steam and water with particular attention paid to pump and valve packings, automatic air vents, and condensate tank overflow lines. Leaks, in addition to possible water or humidity damage, are wasteful of energy and, over time, will result in scale buildup in the boiler.

☐ **WATER CHEMISTRY CHECK**. Test the boiler water as appropriate for your area. Quarterly is normally sufficient. The frequency must be determined by experience.

CALL YOUR SERVICE FIRM OR BOILER INSPECTOR IF YOU NEED ASSISTANCE WITH ANY OF THESE ITEMS

Printed in USA
GAP.1.3.0

Figure 1. Simple Boiler Log Sheet (front).

RECORD YOUR TEST AND INSPECT DATA HERE:

	SAFETY OR RELIEF VALVE TEST	LOW WATER FUEL SUPPLY CUTOUT RAPID DRAIN TEST					LWFCO SLOW DRAIN TEST	DRAIN WATER GAUGE GLASS	CHECK BURNER	CHECK CIRC OR COND PUMP	CHECK SYSTEM FOR LEAKS	CHECK OR VERIFY WATER CHEMISTRY
SEP												
OCT												
NOV												
DEC												
JAN												
FEB												
MAR												
APR												
MAY												
JUN												
JUL												
AUG												

Figure 1. Simple Boiler Log Sheet (back).

OVERVIEW FORMS PACKET
(See PRC.1.3.0 in the OVERVIEW Manual)
Published as part of AXA XL Risk Consulting

CENTRIFUGAL AIR CONDITIONING LOG SHEET

NOTE: This log is recommended for fluorocarbon (Freon, Genetron, etc.) air conditioning systems with hermetic centrifugal compressors. With minor modification, it is suitable for similar equipment separately driven by a motor, turbine or engine.

Unit Number ____________ Person Responsible for Unit ____________ Phone Number ____________

Inspector's Name/Agency ____________ Phone Number ____________

Startup Service ____/____/____ Winterizing (if applicable) ____/____/____

Service Firm ____________ Phone Number ____________

	COMPRESSOR							MOTOR			EVAPORATOR				CONDENSER				PURGE		AIR TEMP.		INITIALS
		Bearing Temp.		Oil							Refrigerant		Water		Refrigerant		Water						
Date/Time	Vane Position			Level	Reservoir Temp/Heater*	Cooler Outlet Temp.	Pressure	Volts	Amps	Vibration Level	Pressure/Level*	Temp.	In.et Temp.	Outlet Temp.	Pressure	Temp.	Inlet Temp.	Outlet Temp	Run Time	Water Level	Outdoor	Air Conditioned Space	Operator

On the back, list any additional information, including leakage or abnormal conditions observed, oil or refrigerant added, purged fluid drained, and any tests, repairs or adjustments performed. Record any automatic shutdowns, including their time and cause. "If the unit is not running, enter the refrigerant level in the evaporator and the status of the oil reservoir heater.

PRC.1.3.0

Figure 2. Log Sheet for a Centrifugal Air Conditioning System.

SEASONAL MAINTENANCE

COLD WEATHER MAINTENANCE

Cold weather and freezing temperatures normally occur each year in most of North America and much of the rest of the world. In some areas, however, cold weather is usually not considered a matter of concern. Temperatures in these areas seldom reach freezing, and, when they do, they remain there for a relatively short period of time, usually no more than a few hours.

Such lack of concern may not be justified. Loss experience illustrates that shifts in the jet stream can cause bitterly cold arctic air masses to press deeply into the warmer climes, sustaining freezing temperatures for periods of several days. At the same time, these unusual arctic air masses may cause temperatures in normally cold areas to drop far below freezing for periods of up to three weeks.

Facilities located in all but tropical areas (latitude less than 23.5°) must carefully consider precautions to be taken before the cold-weather season each year. Unless proper precautions are taken, cold weather can cause problems. Building roof and structural systems may be loaded beyond their design by snow and ice accumulations. Sprinkler piping and fire mains may freeze, leaving major portions of a facility without fire protection. Pipes can burst and cause liquid damage. Boiler feed and condensate systems can freeze, rendering the major heat source inoperative and perhaps even causing it to be damaged by dry firing or freezing.

Prior to and during cold weather, take the following precautions:

- General
    - Plan ways and obtain equipment to remove snow from flat roofs or other structures which might collapse.
    - Make all doors, windows, skylights, ventilators, and other openings weather tight so they will not admit cold air that could cause water piping, radiators or sprinkler systems to freeze.
    - Install antifreeze, heat or steam tracing, or simple and effective means for draining all exposed service, process and fire protection lines and vessels such as air conditioning or compressor cooling jackets or heat exchangers which may contain water, condensate or solutions subject to freezing. Equipment in penthouses and other out-of-the-way areas needs particular attention.
    - Water can accumulate in service and instrument air and process-gas line low points. Such accumulations might not rupture the piping when they freeze, but they will block or reduce flow. Locate and eliminate, drain, or freeze-protect these low points.
    - Boiler, pressure vessel, and tank vent and safety or relief valve discharge lines often terminate outside of buildings or at least outside heated spaces. Pitch these lines so that they gravity drain to the warm area if possible, otherwise, provide antifreeze or auxiliary heating.
- Heating Systems
    - Examine all systems and correct any deficiencies to ensure the systems are in proper operating condition. Clean and service burners, boilers, and flues. Remove any obstructions from pipes, radiators, and unit heaters. Test heating equipment controls for proper operation.
    - Where possible, keep an adequate reserve supply of fuel on hand at all times. Investigate safe alternative energy sources.

- Maintain temperatures above 40°F (4°C) at all times in buildings equipped with wet pipe sprinkler systems, domestic water, or any other water-filled systems; in all dry pipe, pre-action, and deluge valve closets; and in all pump houses.
- Maintain clearances between heating system components and combustible floors, walls, partitions, platforms, and stock.

- Fire Protection Systems

NOTE: Some of the following maintenance procedures involve valve operation or other activities that will impair fire protection systems. Proper procedures should be followed in all such cases (see PRC.1.1.0).

  - Plans to clear snow promptly from access ways, control valves, hydrants, hose cabinets, and other essential equipment to permit effective operations during an emergency.
  - Convert wet pipe sprinkler systems in areas which are inadequately heated to dry pipe or pre-action systems.
  - Remove any condensation that collects in low points in the dry pipe or pre-action sprinkler piping. Also remove any excessive priming water.
  - Test solutions in all antifreeze sprinkler systems and add antifreeze as necessary.
  - Convert any “shut-in-winter” systems to either a dry pipe or a pre-action system.
  - Shut off, drain, and tag all wet standpipe systems that have piping located in areas subject to freezing.
  - Properly drain water motor gongs, piping, and fire department pumper connections.
  - Repair leaking gravity tanks.
  - Flush tank heating systems and place them in good working order.
  - Drain hydrants and fire pump hose headers. Leave outlet hose valves half open to prevent freeze damage.
  - Properly drain hose.
  - Check post indicator valves for leaky packings and repair them where necessary.
  - Ensure valve and meter pits are dry and frost proof.
  - Properly service automotive fire apparatus for winter.
- Freeze Protection System Maintenance
  - Inspect heat tracing equipment. Replace any cracked or deteriorated heating tape. Service traps in steam tracing systems.
  - Review all work packages in the backlog to ensure that any out-of-service protective equipment is promptly restored.
  - If any equipment is to be shut down during the cold season, plan in advance and provide any needed extra freeze protection.

WARM WEATHER MAINTENANCE

During more temperate periods of the year, there are a number of preventive maintenance steps that should be taken:

- General
  - Remove grass and brush from around such hazards as combustible gas or liquid storage tanks or metering stations, transformers, and switchgear.
  - Clean obstructions from roof drains.
  - Inspect and, where necessary, repair roof coverings and flashings.
  - Inspect and service lightning protection systems (see NFPA 780) and electrical grounds.

  - Inspect screens and fences and otherwise survey outdoor transformers and switchgear for indications of animal entry.
  - Inspect and service seasonal cooling water, air conditioning and refrigeration systems well in advance of anticipated use.
  - Clean and service boilers; arrange for certificate inspections where applicable.
- Fire Protection Systems

NOTE: Some of the following maintenance procedures require valve operation or other activities that will impair fire protection systems. Follow proper procedures in all such cases (see PRC.1.1.0).

  - Lubricate, close, and reopen all fire protection valves.
  - Flush out private hydrants and check them for proper drainage. Lubricate each operating mechanism.
  - Check dry pipe valve system piping for obstruction in accordance with NFPA 25. If the quantity of debris is excessive, flushing is required.
  - Examine internally at five-year intervals check valves, backflow preventers, meters, and pressure regulators, and clean as necessary. The health department having jurisdiction might also require tightness testing for backflow preventers and double check valve installations.
  - Cut high grass around all outside fire protection equipment.
  - Paint gravity and suction tank interiors and exteriors if inspections indicate this is needed. Inspect cathodic protection systems and repair them as needed. If tanks are filled from a raw water source, clean them to remove collected residue from the tank bottom riser.
  - Clean open reservoirs and suction cribs.