# Aviation Maintenance Management

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Second Edition

McGraw Hill

New York Chicago San Francisco Lisbon London Madrid
Mexico City Milan New Delhi San Juan Seoul
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Part

# I

# Fundamentals of Maintenance

*"... maintenance is a science since its execution relies, sooner or later, on most or all of the sciences. It is an art because seemingly identical problems regularly demand and receive varying approaches and actions and because some managers, foremen, and mechanics display greater aptitude for it than others show or even attain. It is above all a philosophy because it is a discipline that can be applied intensively, modestly, or not at all, depending upon a wide range of variables that frequently transcend more immediate and obvious solutions."*

LINDLEY R. HIGGINS
*Maintenance Engineering Handbook;*
*McGraw-Hill, NY, 1990.*

*These opening chapters contain basic information related to the aviation maintenance field and should be considered background for the maintenance management effort. Chapter 1 begins with a discussion of the fundamental reasons why we have to do maintenance in the first place. After all, our skills and techniques have improved immensely over the 100-year history of flight, but we haven't quite reached total perfection. And, considering the number of components on a modern aircraft, we realize early on that maintenance is a complex, ongoing process. For that reason, we need to approach it systematically.*

*We need a well-thought-out program to address the diverse activities we will encounter in this endeavor, so in Chap. 2 we will study the industry procedures for developing an initial maintenance program. We will discuss the various maintenance check packages (the 48-hour and transit check, the monthly "A" check, the yearly "C" check, etc.)*

*used to implement the maintenance tasks. We then address the ongoing process of adjusting that program during the lifetime of the equipment. In Chap. 3, we establish the goals and objectives for an airline maintenance program that will serve the real-life operation.*

*Chapter 4 discusses the extensive certification requirements levied on the aviation industry from the original design of the vehicle to the establishment of commercial operators and the people who run them. The documentation for the aircraft, its operation, and its maintenance, is discussed in Chap. 5 and includes the documents produced by the equipment manufacturers, by the regulatory authorities, and by the airline itself.*

*Chapter 6 will identify those activities required by the FAA to accomplish maintenance as well as those additional requirements deemed necessary by operators to coordinate and implement an effective maintenance and engineering program. Chapter 7 defines a maintenance and engineering (M&E) organization for a typical midsized airline. Variations for larger and smaller airlines will also be discussed. Part I, then, can serve as background to the remainder of the book and can, if desired, be used as the basis for a first or introductory course on the subject of aviation maintenance management.*

Chapter

# 1

# Why We Have to Do Maintenance

## Introduction

Why do we have to do maintenance? It is simple: "The maintenance of an aircraft provides assurance of flight safety, reliability, and airworthiness." The aircraft maintenance department is responsible for accomplishing all maintenance tasks as per the aircraft manufacturer and the company's requirements. The goal is a safe, reliable, and airworthy aircraft.

The aircraft maintenance department provides maintenance and preventive maintenance to ensure reliability, which translates into aircraft availability. These functions do not preclude a random failure or degradation of any part or system, but routine maintenance and checks will keep these from happening and keep the aircraft in good flying condition.

## Thermodynamics Revisited

Nearly all engineering students have to take a course in thermodynamics in their undergraduate years. To some students, aerodynamicists and power plant engineers for example, thermodynamics is a major requirement for graduation. Others, such as electrical engineers for instance, take the course as a necessary requirement for graduation. Of course, thermodynamics and numerous other courses are "required" for all engineers because these courses apply to the various theories of science and engineering that must be understood to effectively apply the "college learning" to the real world. After all, that is what engineering is all about—bridging the gap between theory and reality.

There is one concept in thermodynamics that often puzzles students. That concept is labeled *entropy*. The academic experts in the thermodynamics field got together one day (as one thermo professor explained) to create a classical thermodynamic equation describing all the energy of a system—any system. When they finished, they had an equation of more than several terms; and all but one of these terms were easily explainable. They identified the terms for heat energy, potential energy, kinetic energy, etc., but one term remained. They were puzzled about the meaning of this term. They knew they had done the work correctly; the term had to represent energy. So, after considerable pondering by these experts, the mysterious term was dubbed “unavailable energy”—energy that is unavailable for use. This explanation satisfied the basic law of thermodynamics that energy can neither be created nor destroyed; it can only be transformed. And it helped to validate their equation.

Let us shed a little more light on this. Energy is applied to create a system by manipulating, processing, and organizing various elements of the universe. More energy is applied to make the system do its prescribed job. And whenever the system is operated, the sum total of its output energy is less than the total energy input. While some of this can be attributed to heat loss through friction and other similar, traceable actions, there is still an imbalance of energy. Defining entropy as the “unavailable energy” of a system rectifies that imbalance.

The late Dr. Isaac Asimov, biophysicist and prolific writer of science fact and science fiction,[1] had the unique ability to explain the most difficult science to the layperson in simple, understandable terms. Dr. Asimov says that if you want to understand the concept of entropy in practical terms, think of it as the difference between the theoretically perfect system you have on the drawing board and the actual, physical system you have in hand. In other words, we can design perfect systems on paper, but we cannot build perfect systems in the real world. The difference between that which we design and that which we can build constitutes the natural entropy of the system.

## A Saw Blade Has Width

This concept of entropy, or unavailable energy, can be illustrated by a simple example. Mathematically, it is possible to take a half of a number repeatedly forever. That is, half of one is 1/2; half of that is 1/4, half of that is 1/8, and so on to infinity. Although the resulting number is smaller and smaller each time you divide, you can continue the process as long as you can stand to do so, and you will never reach the end.

Now, take a piece of wood about 2 feet long (a 2 × 4 will do) and a crosscut saw. Cut the board in half (on the short dimension). Then take one of the pieces and cut that in half. You can continue this until you reach a point where you can no longer hold the board to saw it. But, even if you could find some way to hold it while you sawed, you would soon reach a point where the piece you have left to cut is thinner than the saw blade itself. When (if) you saw it one more time, there will be nothing left at all—nothing but the pile of sawdust on the floor. The number of cuts made will be far less than the infinite number of times that you divided the number by two in theory.

[1] Dr. Asimov wrote over 400 books during his lifetime.

The fact that the saw blade has width and that the act of sawing creates a kerf in the wood wider than the saw blade itself, constitutes the entropy of this system. And no matter how thin you make the saw blade, the fact that it has width will limit the number of cuts that can be made. Even a laser beam has width. This is a rather simple example, but you can see that the real world is not the same as the theoretical one that scientists and some engineers live in. Nothing is perfect.

## The Role of the Engineer

The design of systems or components is not only limited by the imperfections of the physical world (i.e., the "natural entropy" of the system), it is also limited by a number of other constraints which we could refer to as "man-made entropy." A design engineer may be limited from making the perfect design by the technology or the state of the art within any facet of the design effort. He or she may be limited by ability or technique; or, more often than not, the designer may be limited by economics; i.e., there just is not enough money to build that nearly perfect system that is on the drawing board or in the designer's mind. Although the designer is limited by many factors, in the tradition of good engineering practice, the designer is obliged to build the best system possible within the constraints given.

Another common situation in design occurs when the designer has produced what he or she believes is the optimum system when the boss, who is responsible for budget asks, "How much will it cost to build this?" The designer has meticulously calculated that these widgets can be mass produced for $1200 each. "Great," says the boss. "Now redesign it so we can build it for under a thousand dollars." That means redesign, usually with reduced tolerances, cheaper materials, and, unfortunately, more entropy. More entropy sometimes translates into more maintenance required. The design engineer's primary concern, then, is to minimize (not eliminate) the entropy of the system he or she is designing while staying within the required constraints.

## The Role of the Mechanic

The mechanic [aircraft maintenance technician (AMT), repairer, or maintainer], on the other hand, has a different problem. Let us, once again, refer to the field of thermodynamics. One important point to understand is that entropy not only exists in every system, but that the entropy of a system is always increasing. That means that the designed-in level of perfection (imperfection?) will not be permanent. Some components or systems will deteriorate from use, and some will deteriorate from lack of use (time or environment related). Misuse by an operator or user may also cause some premature deterioration or degradation of the system or even outright damage. This deterioration or degradation of the system represents an increase in the total entropy of the system. Therefore, while the engineer's job is to minimize the entropy of a system during design, the mechanic's job is to combat the natural, continual increase in the entropy of the system during its operational lifetime.

To summarize, it is the engineer's responsibility to design the system with as high degree of perfection (low entropy) as possible within reasonable limits. The mechanic's responsibility is to remove and replace parts, troubleshoot systems, isolate faults in systems by following the fault isolation manual (FIM, discussed in Chap. 5), and restore systems for their intended use.

## Two Types of Maintenance

Figure 1-1 is a graph showing the level of perfection of a typical system. One hundred percent perfection is at the very top of the *y*-axis. The *x*-axis depicts time. There are no numbers on the scales on either axis since actual values have no meaning in this theoretical discussion. The left end of the curve shows the level of perfection attained by the designers of our real world system. Note that the curve begins to turn downward with time. This is a representation of the natural increase in entropy of the system—the natural

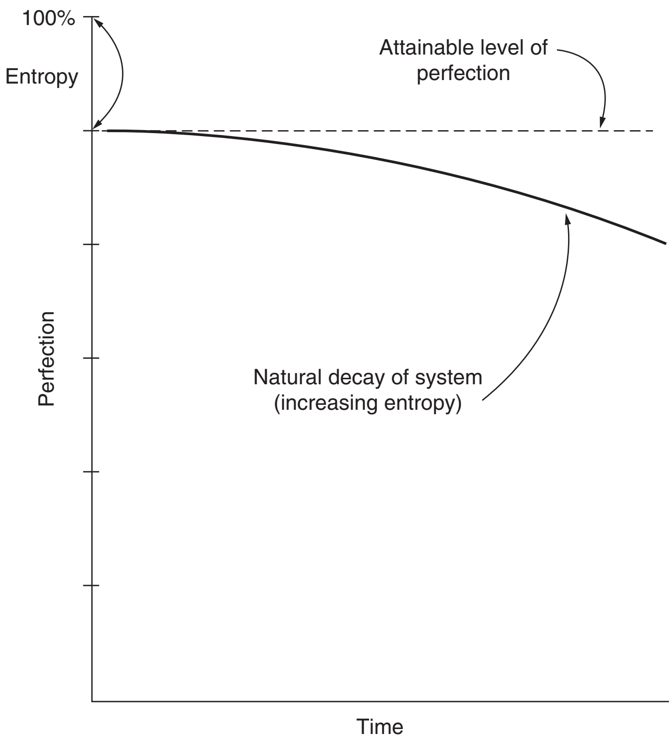


**Figure 1-1** The difference between theory and practice.