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Report to the Chairman, Subcommittee on Federal Services, Post Office, and Civil Service, Committee on Governmental Affairs, U.S. Senate

August 1990

F-15 FUEL CELLS

Air Force Needs Better Data for Informed Decisions

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National Security and
International Affairs Division

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August 16, 1990

The Honorable David H. Pryor
Chairman, Subcommittee on Federal Services,
Post Office, and Civil Service
Committee on Governmental Affairs
United States Senate

Dear Mr. Chairman:

This report, prepared at your request, addresses F-15 aircraft fuel cell management issues on premature failures, life cycle costs of different materials, the advantage of an extended warranty, and repair and replacement policies. The report concludes that the Air Force does not have the necessary data on F-15 fuel cells to make informed decisions on any of these management issues.

We are sending copies of this report to interested congressional committees; the Secretaries of Defense and the Air Force; and the Director, Office of Management and Budget.

Please contact me at (202) 275-4268 if you or your staff have any questions concerning this report. Other major contributors to this report are listed in appendix I.

Sincerely yours,

Nancy R. Kingsbury

Nancy R. Kingsbury
Director
Air Force Issues

Executive Summary

Purpose

In 1987 the Air Force changed from polyurethane fuel cells to nitrile fuel cells for its KC-135 aircraft. Before October 1989, when the Air Force awarded a competitive contract for nitrile cells, the fuel cells for the Air Force's F-15 aircraft were made exclusively of polyurethane. The Air Force expects to spend more than $24 million on fuel cells for its F-15 aircraft in the next 4 years.

The Chairman, Subcommittee on Federal Services, Post Office, and Civil Service, Senate Committee on Governmental Affairs, asked GAO to review the Air Force's experience with F-15 and KC-135 fuel cells. Specifically, the Chairman asked that GAO determine (1) whether F-15 polyurethane fuel cells are failing prematurely, (2) whether one fuel cell material offers a substantial life cycle cost advantage over the other, (3) whether the Air Force should mandate a 12-year warranty for new F-15 fuel cells, (4) why nitrile was chosen as the fuel cell material for the KC-135, and (5) whether longevity requirements of fuel cells differ between the F-15 and the KC-135.

Background

A fuel cell is a flexible bag designed to hold fuel that can be contoured to the shape of an aircraft's fuselage or wing cavity. Two materials are used in fuel cell construction, nitrile (a rubber material) and polyurethane (a polyester material). The F-15 fighter aircraft has four to six fuel cells, depending on the aircraft model. The KC-135 tanker aircraft has 16 fuel cells.

The cells for the F-15E, the latest version of the aircraft, range in capacity from 40 to 655 gallons and cost from about $2,350 to about $9,750. The KC-135 cells range in capacity from 561 to 2,345 gallons and cost from about $4,380 to about $10,045. The cells for both aircraft carry a 1-year manufacturer's warranty that covers only materials and workmanship.

The Warner Robins and the Oklahoma City Air Logistics Centers are responsible for maintaining the F-15 and KC-135 aircraft, respectively. They perform major maintenance and upgrades to the aircraft. Air bases are responsible for minor repair and maintenance of assigned aircraft.

Warner Robins requires that each F-15 undergo programmed maintenance, including removal, examination, and replacement of fuel cells, every 6 years. Warner Robins has determined that F-15 fuel cells have a useful life of 9 years and has based its repair and replacement policies

on that time. F-15 bases are authorized to repair and replace fuel cells as needed.

Results in Brief

The Air Force does not have the necessary data on F-15 fuel cells to determine whether (1) the cells are failing prematurely, (2) one fuel cell material offers life cycle cost advantages over the other, and (3) an extended warranty would be advantageous to the government. Moreover, the Air Force does not have the historical data needed to establish repair and replacement policies based on the actual life of the F-15 fuel cells.

The Air Force is automating maintenance records at Warner Robins and F-15 air bases. Although the records are designed to detail more data about fuel cells, the Air Force needs to ensure that data are fully and accurately reported.

The Air Force has more extensive data on KC-135 fuel cells, which has enabled it to identify problems with polyurethane cells, make repair and replacement decisions, and choose nitrile as the fuel cell material. However, the experience gained with KC-135 fuel cells may not be directly applicable to F-15 fuel cells because the aircraft have different operational environments and missions.

Principal Findings

Replacement Data on F-15 Fuel Cells

Before October 1988 the Air Force did not record specific replacement data on F-15 fuel cells. In October 1988 Warner Robins required that records be maintained on when each fuel cell was installed so technicians could determine during programmed maintenance whether the cells met the criteria for removal and replacement. However, Warner Robins did not require that the records specify the reasons for replacing the cells.

Repair and Replacement Policies

A 9-year useful life for F-15 fuel cells was derived from a single experience in 1987 with problem cells at one base. This time frame is the basis for the fuel cell repair and replacement policies at Warner Robins.

When the Air Force established its 6-year programmed maintenance cycle for F-15s, it also established a 3-year replacement policy for fuel cells to achieve the useful life of 9 years. This ensures that fuel cells would be no older than 9 years when the F-15 aircraft would undergo its next programmed maintenance 6 years later. The repair policy directs that only fuel cells 2 years old or less are eligible for repair because it takes about 1 year to repair and return the cells to service. Therefore, if cells are to be 3 years old or less when reinstalled, they must be no more than 2 years old at time of removal for repair. According to the policies, all cells that have been in F-15 aircraft for more than 3 years and all damaged cells removed from aircraft that are over 2 years old are to be discarded, regardless of their condition.

Cells were removed at F-15 bases, and those that needed repairs beyond the bases' limited capabilities were discarded. Warner Robins now has a repair contractor that can perform major repairs on cells and return them to serviceable condition.

Life Cycle Costs

In 1985 an Air Force fact finding team concluded life cycle cost is one of the more important factors in selecting one fuel cell material over another but found existing data on fuel cells would not support life cycle cost studies. Although Warner Robins is accumulating some fuel cell data, it does not have data for life cycle cost analyses. The Air Force is automating maintenance records at Warner Robins and F-15 air bases, and officials believe such records can detail the data needed to perform life cycle cost analyses.

Fuel Cell Warranties

Even though a warranty is not required for replacement items such as fuel cells, it may be desirable if cost-effective for the government. F-15 fuel cell contracts have a 1-year warranty for materials and workmanship. One contractor had offered a 12-year extended warranty for its fuel cells at no cost to the government. Warner Robins officials said they had not evaluated the merits of the offer and that a warranty will be difficult to enforce because cells are often damaged and replaced during F-15 maintenance.

Historical Data on KC-135 Fuel Cells

In 1981 the Oklahoma City Air Logistics Center switched from nitrile to polyurethane fuel cells for the KC-135. However, the Center returned to nitrile in 1987 because of failures with the polyurethane cells. A material management official from the Center kept data on the types and

frequencies of failures, which facilitated the decision to revert to nitrile. The official also accumulated data on fuel cell age and the number of patches on each cell of each aircraft. These data allowed the Center to set repair and replacement policies based on the age and condition of the fuel cell.

Recommendation

GAO recommends that the Secretary of the Air Force ensure that data on F-15 fuel cells, such as useful life, failure rate distribution, and maintenance costs, are collected at Warner Robins and all F-15 bases as part of the automated maintenance records and that these data are (1) fully and accurately reported through the system, (2) used to assess the life cycle cost of the fuel cell materials and the merits of an extended warranty in future fuel cell procurement, and (3) used to validate and, if necessary, revise the conditions under which fuel cells should be repaired or discarded.

Agency Comments

As requested, GAO did not obtain official agency comments on a draft of this report. However, the views of Department of Defense and Air Force officials were obtained during the course of GAO's work and have been incorporated where appropriate.

Contents

Introduction

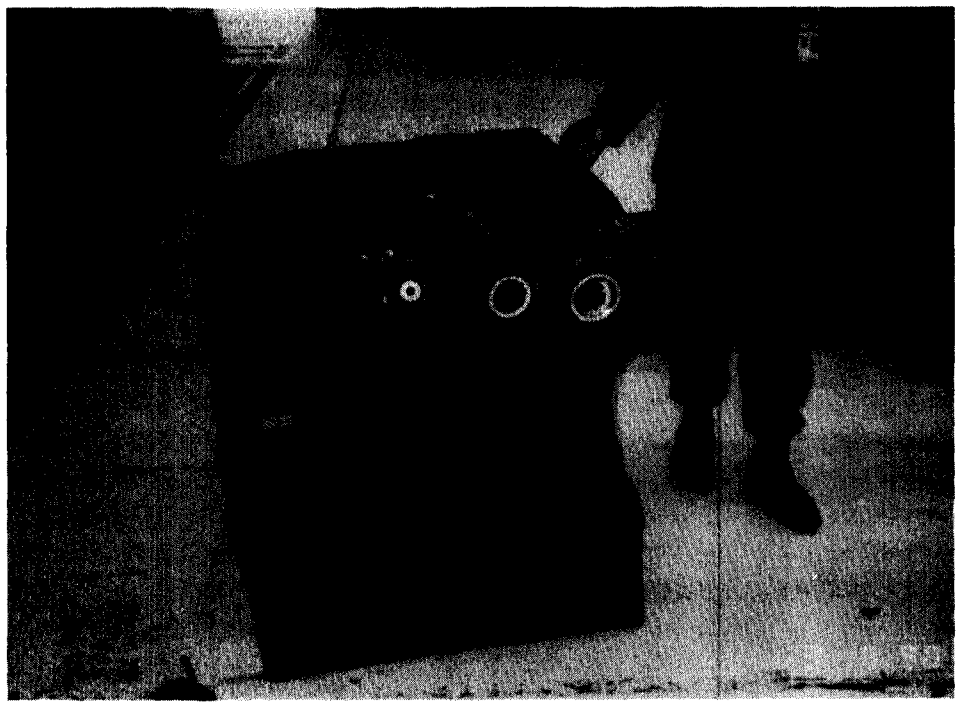
The Air Force Logistics Command procures, supplies, transports, repairs, and maintains items to keep weapon systems ready for combat. Specific responsibilities for these functions are allocated to its five Air Logistics Centers: Warner Robins, Oklahoma City, Ogden, San Antonio, and Sacramento. The Warner Robins Air Logistics Center, Robins Air Force Base, Georgia, is responsible for the F-15 aircraft. The Oklahoma City Air Logistics Center, Tinker Air Force Base, Oklahoma, is responsible for the KC-135 aircraft.

The Air Logistics Centers develop replacement and repair policies and perform depot maintenance on their respective aircraft. They also procure necessary spare parts, such as fuel cells. All bases at which aircraft are stationed are also responsible for repair and maintenance of assigned aircraft and perform tasks similar to the Centers.

F-15 and KC-135 Fuel Cells

A fuel cell is a flexible bag that is designed to contain fuel and can be contoured to the shape of an aircraft's fuselage or wing cavity. Fuel cells on F-15s are made of polyurethane, and fuel cells on KC-135s are constructed of either nitrile or polyurethane. Nitrile, a rubber material, has been used to manufacture fuel cells since World War II, whereas the use of polyurethane, a polyester material, began in 1961. Figure 1.1 shows an F-15 fuel cell.

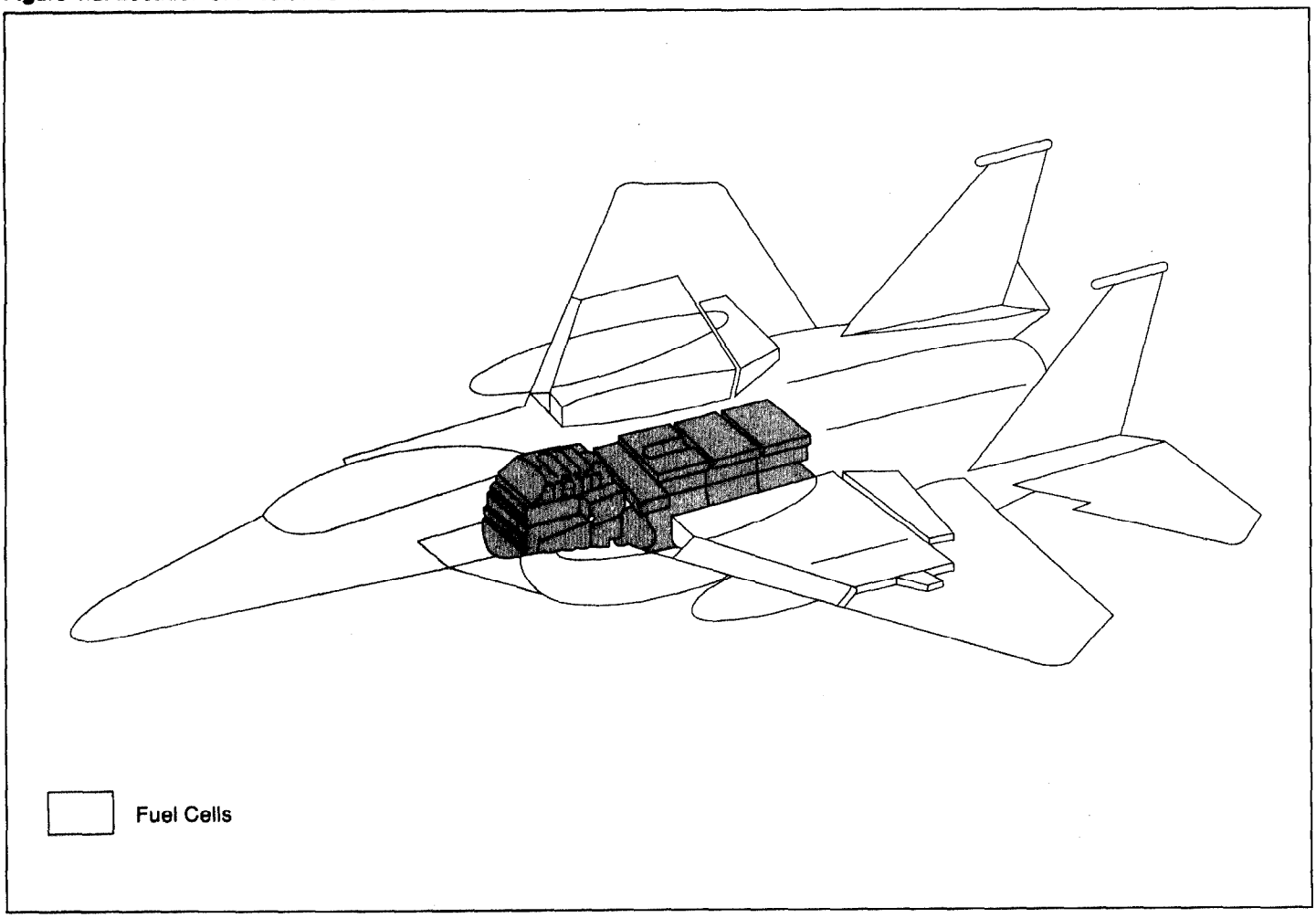
Figure 1.1: An F-15 Fuel Cell



F-15 Fuel Cells

The F-15, an Air Force fighter aircraft that has been in service since the mid-1970s, has four to six fuel cells, depending on the model. Figure 1.2 shows the location of the five fuel cells on the F-15E, the latest version of the aircraft.

Figure 1.2: Location of F-15E Fuel Cells



The cells range in capacity from 40 to 655 gallons and cost from about $2,350 to about $9,750. The largest and most expensive cell is immediately behind the cockpit. Warner Robins officials told us that this cell is constructed of a combination of self-sealing and non-self-sealing material, whereas the other cells are totally self-sealing. The self-sealing quality reduces fire hazard and preserves the aircraft's fuel supply when an object penetrates the cell walls.

Although military specifications prescribe that the service life of fuel cells is to be equivalent to that of the aircraft, McDonnell Aircraft Company, the prime contractor for the F-15, and the Air Force have stated in

procurement specifications for the aircraft that the service life of fuel cells is to be no less than 10 years.[1] However, the warranty provided by the manufacturer is limited to 1 year and covers only materials and workmanship.

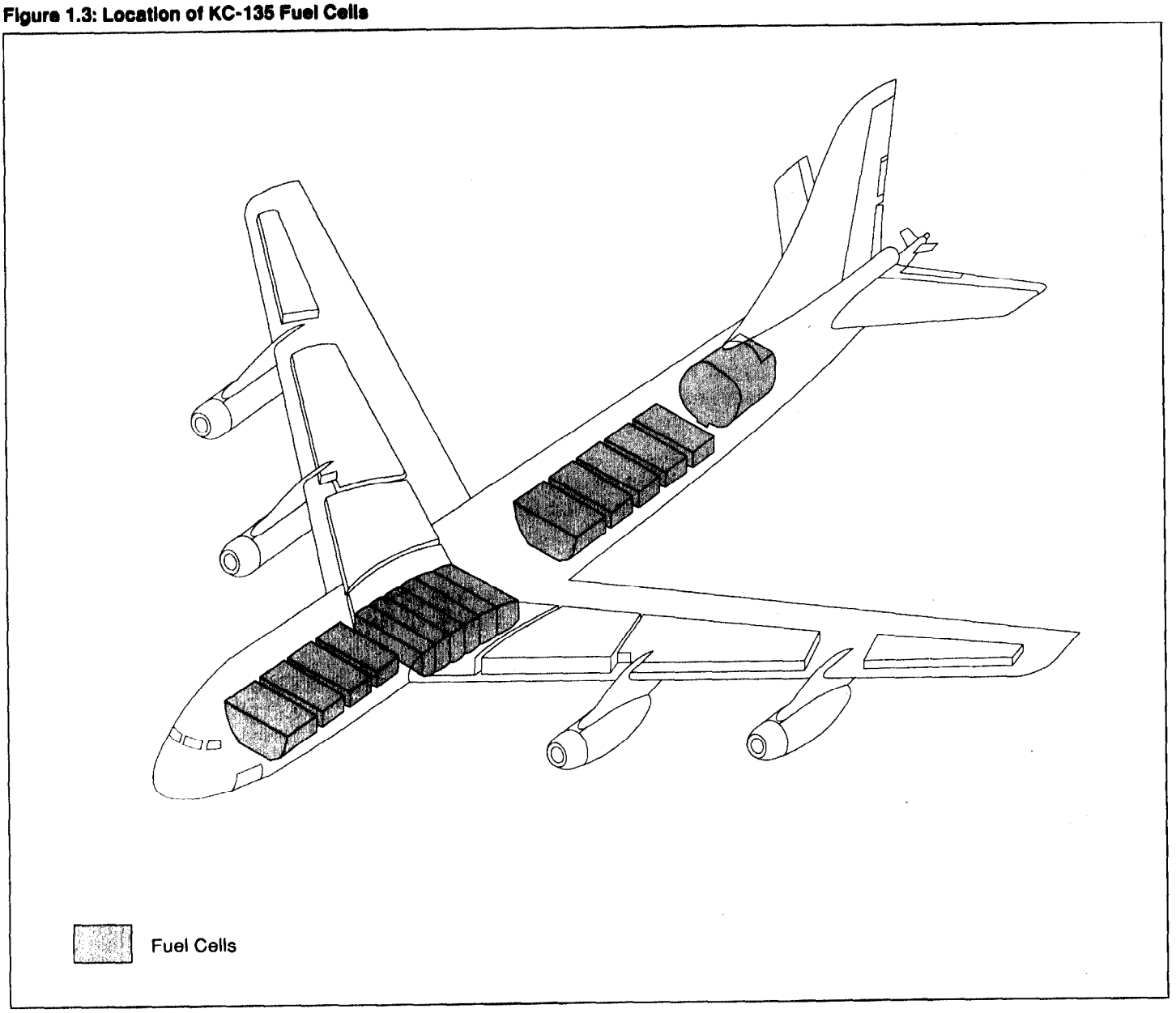
An F-15 Systems Program Management Division official at Warner Robins told us that Engineered Fabrics Corporation (formerly Loral) of Rockmart, Georgia, manufactured the original polyurethane fuel cells for the F-15s and, until recently, was the only supplier of replacement fuel cells for the aircraft. In October 1989 American Fuel Cells and Coated Fabrics Company (Amfuel) of Magnolia, Arkansas, was competitively awarded a contract to supply nitrile cells. No nitrile cells had been delivered at the time of our review. Replacement cells carry the same 1-year warranty as the original equipment. The Air Force plans to spend more than $24 million on F-15 fuel cells in the next 4 years.

KC-135 Fuel Cells

The KC-135 is an Air Force tanker aircraft used to refuel other aircraft in flight and has been in use since 1956. A contracting official at the Oklahoma City Air Logistics Center told us a KC-135 has 16 fuel cells, all of non-self-sealing construction. The cells range in capacity from 561 to 2,345 gallons and cost from about $4,380 to about $10,045. Figure 1.3 shows the location of the 16 cells in the KC-135.

[1]Not all aircraft have procurement specifications. For example, the Air Force's F-5, A-7, and A-10 and the Navy's A-6, F-14, and F/A-18 are covered by military specifications that do not specify a useful life in terms of years. However, the F-16 aircraft, in addition to military specification, has a procurement specification that defines the fuel cell minimum useful life as 11 years.

Figure 1.3: Location of KC-135 Fuel Cells



Unlike the F-15, the KC-135 has no contractor procurement specifications for the service life of fuel cells. An Oklahoma City Air Logistics Center contracting official told us the 1-year warranty for materials and workmanship for the F-15 fuel cells also applies to KC-135 fuel cells.

Amfuel and Engineered Fabrics both supply nitrile cells for the KC-135. Engineered Fabrics also supplied the polyurethane cells.

Objectives, Scope, and Methodology

On June 7, 1989, the Chairman, Subcommittee on Federal Services, Post Office, and Civil Service, Senate Committee on Governmental Affairs, requested that we review the Air Force's experience with F-15 and KC-135 fuel cells. Specifically, the Chairman asked that we determine

- whether F-15 polyurethane fuel cells are failing prematurely,
- whether one fuel cell material offers a substantial life cycle cost[2] advantage over the other,
- whether the Air Force should mandate a 12-year warranty for new F-15 fuel cells,
- why nitrile was chosen as the fuel cell material for the KC-135, and
- whether longevity requirements of fuel cells differ between the F-15 and the KC-135.

To identify specific fuel cell management policies and practices, we interviewed officials at Air Force Headquarters, Washington, D.C., and the Air Force Logistics Command and Aeronautical Systems Division, Air Force Systems Command, Wright-Patterson Air Force Base, Dayton, Ohio. We also observed maintenance procedures, interviewed officials, and reviewed available records at Warner Robins and the Oklahoma City Air Logistics Centers to determine the Air Force's experience with fuel cell life and materials. We reviewed regulations and interviewed Warner Robins officials to determine if the Air Force should mandate a 12-year warranty.

To determine replacement and repair policies and procedures at the base level, we interviewed officials and fuel system technicians, observed fuel cell maintenance procedures, and reviewed repair and maintenance records at Eglin Air Force Base, Fort Walton Beach, Florida; Tyndall Air Force Base, Panama City, Florida; Holloman Air Force Base, Alamagordo, New Mexico; and Luke Air Force Base, Phoenix, Arizona. We selected these bases because they reported the highest incidence of fuel cell failures for the 12-month period ending March 1989. We also interviewed company officials and observed the fuel cell manufacturing process at Amfuel and Engineered Fabrics.

[2]Life cycle cost is the total cost to the government for a system over its full life, including development, procurement, operation, support, and disposal.

We conducted our work between July 1989 and April 1990 in accordance with generally accepted government auditing standards. As requested, we did not obtain official agency comments on this report. However, we obtained the views of Department of Defense and Air Force officials during our review and incorporated their views where appropriate.

Data Needed for F-15 Fuel Cell Management Decisions

The Air Force does not have the necessary data on F-15 fuel cells to determine whether (1) the cells are failing prematurely, (2) one fuel cell material offers life cycle cost advantages over the other, and (3) an extended warranty would be advantageous to the government. Moreover, the Air Force does not have the data needed to establish repair and replacement policies based on the actual life of the F-15 fuel cells. Although it is not required to collect and utilize these data, the Air Force would be more assured that it is making appropriate management decisions if the data were available. A 1985 Air Force study recommended including life cycle analyses in the fuel cell management process. Data collection on KC-135 fuel cells has aided in repair and replacement decisions.

Repair and Replacement Policies for F-15 Fuel Cells

F-15 fuel cells are inspected, and defective cells are repaired or replaced either at F-15 air bases during routine maintenance or at Warner Robins during the aircraft's programmed maintenance cycle. In October 1988 the Air Force Logistics Command initiated a programmed depot maintenance cycle for the F-15, requiring extensive maintenance at Warner Robins every 6 years. During this maintenance, workers remove fuel cells to check the aircraft fuel cavity for corrosion damage. This process often results in damage to cells because they have to be extracted through small openings in the aircraft fuselage, according to F-15 System Program Management Division officials. Also, fuel lines, pumps, and other fuel system components must be removed from within the cells, thus increasing the possibility of damage.

An F-15 System Program Management Division official told us that Warner Robins has set a 9-year useful life for F-15 fuel cells as the basis for repair and replacement policies. According to this official, the 9-year useful life was derived from a single experience in 1987 with problem cells (3B cells in the rear of the aircraft) at Holloman Air Force Base. The official told us that as part of the inspection process, the problem cells were removed, inspected, and found to average 9 years of age. Therefore, F-15 System Program Management Division officials at Warner Robins decided that the useful life of all F-15 fuel cells was 9 years.

When the Air Force established its 6-year programmed maintenance cycle in 1988, it also established a 3-year replacement policy for fuel cells to achieve the useful life of 9 years. This would ensure that fuel cells would be no older than 9 years when the F-15 aircraft would undergo its next programmed maintenance cycle 6 years later. An F-15

System Program Management Division official at Warner Robins told us that the policy requires that fuel cells that have been replaced within the prior 3 years be carefully removed, inspected, and reinstalled and cells that have been in the aircraft for more than 3 years be discarded.

In August 1989 Warner Robins established a repair policy, also based on a 9-year useful life, that only fuel cells 2 years old or less are eligible for repair. Warner Robins officials told us it would take about 1 year to repair and return the cells to service. Therefore, if cells are to be 3 years old or less when reinstalled (to achieve the useful life of 9 years), they must be no more than 2 years old at the time of removal for repair.

F-15 air bases also are authorized to repair and replace fuel cells during routine maintenance, although this practice differs from policies at Warner Robins. At the four bases we visited, we were told that maintenance personnel inspect the F-15s and remove and replace fuel cells only as necessary. No time limit criteria were used.

Air Force May Be Prematurely Discarding Fuel Cells

Warner Robins may be discarding usable fuel cells that fall outside its repair and replacement policies. For example, all fuel cells that have been in F-15 aircraft for more than 3 years and all damaged cells that are removed from the aircraft and are over 2 years old are to be discarded regardless of their condition. Moreover, the F-15 bases that we visited may be discarding cells that are beyond their repair capabilities but are reparable.

In November 1989 Warner Robins awarded a fixed-price, indefinite quantity repair contract under which the contractor will be paid only for those cells actually repaired. Before the contract was awarded, Warner Robins considered repairing the fuel cells in-house, but the number of stored cells needing repair was beyond its repair capability.

In January 1990 Warner Robins supply officials surveyed those cells in the warehouses labeled as reparable to determine how many actually were candidates for repair, that is, 2 years old or less. Of 162 cells, only 20 were found to meet the criteria for repair. At the time we visited the warehouses, the cells were not easily accessible for us to observe their condition and dates of manufacture. However, we observed two cells slated for destruction that were slightly over 2 years old, thus exceeding the criteria for repair.

Cells were removed at F-15 bases, and those that needed repairs beyond the bases' limited repair capability were discarded. For example, self-sealing cells that had been torn were discarded because they were beyond the bases' repair capabilities. Also, base-level fuel system personnel and Warner Robins officials told us that every 3 years the foam[3] inside the fuel cell is removed and replaced. If the fuel cell is defective or damaged during foam removal, the cell is scrapped at the base unless the repairs are minor and can be performed at the base.

Warner Robins officials told us that the fuel cell repair contractor will be able to fix self-sealing cells and perform other major repairs on cells. Because Warner Robins now has this repair capability available, the bases may be discarding fuel cells that could be repaired and returned to serviceable condition.

Air Force Had Not Collected Data on F-15 Fuel Cell Failures

The Air Force had not routinely collected data on when and why individual F-15 fuel cells failed. Some bases collected data on individual fuel cells; however, that information was not recorded or maintained consistently. The Air Force's new automated maintenance records being installed at Warner Robins and F-15 bases could improve data collection efforts.

F-15 Program Management Division officials informed us that before October 1988 Warner Robins and the air bases were not required to record specific replacement data on fuel cells. However, in 1988, as part of the depot maintenance program, Warner Robins required that technicians record when each fuel cell was installed so they could determine whether the cells met the 3-year criteria for removal and replacement.

Methods of accumulating fuel cell data were inconsistent among the bases we visited. For example, at Holloman Air Force Base, technicians recorded the date a fuel cell was installed, but when that cell was subsequently removed, technicians replaced the old information with data on the new cell, eliminating any historical record. At Tyndall Air Force Base, technicians retained the dates all cells were installed and removed. However, none of the technicians at air bases we visited was recording specific reasons the cells were replaced.

[3]The foam inside the fuel cell acts as an explosion suppressant. Air Force officials informed us that the foam removal policy was changed in June 1990 to require that the foam be replaced every 5 years, unless it deteriorates earlier.

During our visits to F-15 air bases, fuel system technicians told us that fuel cells were not experiencing excessive failures. The individuals said that some cells experienced problems with internal cell activation, a problem that results in the self-sealing material swelling and destroying the cell wall. Technicians observed this problem often while performing routine fuel system maintenance. The records, however, only reflected that cells were removed and replaced.

An Air Force Logistics Command official told us that the Air Force is automating maintenance records at Warner Robins and F-15 air bases and that the records can detail considerably more data on fuel cells, such as when cells were installed and why specifically they were replaced. According to an Air Force Headquarters official, the system is being installed in phases at F-15 bases and Warner Robins. According to this official, in October 1985 Langley Air Force Base, Virginia, was the first F-15 base to be automated, and in January 1991 Kadena Air Base, Japan, will be the last to be automated. Three of the four bases that we visited were automating their records.

Data Needed for Life Cycle Cost Analysis

Although Warner Robins is accumulating some fuel cell data, it does not have the comprehensive data necessary for life cycle cost analysis. Warner Robins officials responsible for life cycle cost analysis indicated that analyses for F-15 fuel cells would be beneficial, but the officials had no plan to perform the analyses unless directed to do so by the Air Force. The officials explained that Warner Robins' policy is to consider life cycle cost analysis for major acquisitions that occur in a competitive environment, but this does not preclude them from considering these analyses in other acquisitions.

In 1985 the Aeronautical Systems Division, Air Force Systems Command, organized a fact finding team to study fuel cell performance. The study concluded that life cycle cost was one of the more important factors in selecting one fuel cell material (i.e., nitrile or polyurethane) over another. However, the team found that existing data were not sufficient to perform life cycle cost studies because information on a cell's useful life was not available. The team recommended including life cycle cost studies in the fuel cell management process and basing the fuel cell replacement decision on life cycle cost studies and the cell's useful life. The team's conclusions and recommendations were based on a comparison of nitrile and polyurethane fuel cells in several aircraft including the F-4, F-5, F-15, F-16, A-10, C-130, and KC-135. According to the Aeronautical Systems Division official that prepared the final report, the

report was intended to be informational only and required no action on the recommendations. Officials with the F-15 System Program Management Division at Warner Robins told us they were unaware of the study and its recommendations.

Until recently, the Air Force was only purchasing polyurethane fuel cells for the F-15. However, in October 1989 the Air Force awarded a $418,350 contract to Amfuel for 150 nitrile cells. Warner Robins officials responsible for life cycle cost analyses told us that because there are two sources for F-15 cells, life cycle cost analysis would be an important concern in selecting one fuel cell material over the other. However, the officials still had no plans to conduct a life cycle cost analysis unless the Air Force directed them to do so.

According to these officials, life cycle cost analyses require historical data, such as useful life of the cells, a failure rate distribution, maintenance costs for each of the cells, repair costs, and frequency of repair information. According to an Air Force Logistics Command official, the automated maintenance records being installed at the depot and air bases will detail these and other data needed to perform life cycle cost analyses.

Data Were Not Available to Assess Cost-Effectiveness of Extended Warranty

Because the Air Force had not accumulated specific data on F-15 fuel cells, such as the age of fuel cells and reasons for fuel cell failures, it could not determine whether an extended warranty offered by one contractor would be cost-effective for the government. Even though the Federal Acquisition Regulation does not require a warranty for replacement items such as fuel cells, a warranty may be desirable if it is advantageous to the government.

Military and procurement specifications establish the requirements for performance, design, development, test, and compatibility of fuel cells. A warranty provides contractor guarantees about the nature, usefulness, or condition of furnished materials. The principal purposes of a warranty are to describe the rights and obligations of the contractor and the government in those instances when defective items are delivered and to foster quality performance. Generally, warranties remain in effect for a stated period of time after the contract items are accepted or until a specified event occurs.

Original and replacement F-15 fuel cells have a 1-year warranty for materials and workmanship. However, Amfuel, in an unsolicited offer,

had requested that the Air Force require a 12-year warranty to improve the longevity of the fuel cells and had offered to provide such a warranty on its nitrile cells at no cost to the government. Warner Robins officials had not evaluated the merits of this offer. They told us a warranty would be difficult to enforce because fuel cells are often damaged by Air Force personnel while being removed or reinstalled during routine maintenance. The Federal Acquisition Regulation stipulates that the contractor's warranties extend to all defects discovered during the warranty period but do not include damage caused by the government. Because the Air Force does not maintain data on reasons for cell failures, it would be difficult to document whether failures were caused by mishandling, poor workmanship, or inferior materials.

Historical Data on KC-135 Have Helped in Decision-Making

The Oklahoma City Air Logistics Center has KC-135 fuel cell data that have helped officials make repair and replacement decisions. According to officials at the Center, these data assisted them in identifying problems with polyurethane fuel cells.

Before 1981 KC-135 fuel cells were made of nitrile. We were told by contracting and material management officials at the Center that in 1981 the Center began using polyurethane fuel cells to save money and reduce aircraft weight. However, the Center returned to nitrile cells in 1987 because of failures with the polyurethane cells. For example, bases reported that cells were experiencing interior cracking and problems with fittings separating from the body of the fuel cell. Records maintained since 1986 by a KC-135 fuel cell equipment specialist showed the types and frequencies of the failures, which facilitated the decision to choose nitrile as the fuel cell material.

The fuel cell equipment specialist also kept data on the age of fuel cells and the number of patches on each fuel cell for each aircraft. According to officials at the Center, the data provided them with the necessary information to set repair and replacement policies based on the age and condition of the fuel cell. For example, if a fuel cell is between 0 and 19 years old, the number of patches allowed before replacing the fuel cell is 31 to 45. Up to 45 patches would be allowed on newer cells, but as a cell ages, the number of patches allowed would decrease.

An F-15 System Program Management Division official at Warner Robins told us that the experience gained with KC-135 fuel cells may not be directly applicable to F-15 fuel cells because the aircraft have different operational environments and missions. For example, the KC-135

tanker experiences less vibration and stress than the F-15 fighter. A contracting official at the Oklahoma City Air Logistics Center told us that the KC-135 fuel cells are non-self-sealing and easier to repair, whereas F-15 fuel cells are self-sealing and require more specialized repair. Even though the F-15 and the KC-135 operational environments and missions differ, the KC-135 experience shows how the accumulation of historical data on fuel cells can facilitate informed decision-making on material choice and repair.

Conclusions

The Air Force needs better data on its experience with current F-15 fuel cells to determine whether it is buying the most cost-effective fuel cell material and whether an extended warranty would be advantageous to the government. Although the automated maintenance data system being installed at Warner Robins and all F-15 bases is designed to detail the needed data, the Air Force needs to ensure that data are fully and accurately reported.

Better data are also needed to establish repair and replacement policies that are based on the actual life of the F-15 cells. The lack of adequate data on which to base repair and replacement policies can lead to F-15 fuel cells being removed at Warner Robins and F-15 bases and discarded, even though the cells have considerable useful life remaining. The lack of data precluded us from identifying specific cases in which this was happening. However, we believe that when the Air Force begins receiving and analyzing data from its automated data system, it will be in a much better position to validate or, if necessary, revise its repair and replacement policies for F-15 fuel cells.

Recommendation

We recommend that the Secretary of the Air Force ensure that data on F-15 fuel cells, such as the useful life, failure rate distribution, and maintenance costs, are collected at Warner Robins and all F-15 bases as part of the automated maintenance records and that these data are (1) fully and accurately reported through the system, (2) used to assess the life cycle cost of the fuel cell materials and the merits of an extended warranty in future fuel cell procurement, and (3) used to validate and, if necessary, revise the conditions under which fuel cells should be repaired or discarded.

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