Audit Report

OFFICE OF THE INSPECTOR GENERAL

AIRCRAFT FUEL CELL PROCUREMENTS

Report No. 94-001 October 13, 1993

Department of Defense

Acronyms

AMFUEL	American Fuel Cell and Coated Fabrics Company
ATCOM	Army Aviation Troop Command
EFC	Engineered Fabrics Corporation
GAO	General Accounting Office
QDR	Quality Deficiency Report
STIR	Special Technical Inspection and Repair

INSPECTOR GENERAL
DEPARTMENT OF DEFENSE
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ARLINGTON, VIRGINIA 22202-2884

October 13, 1993

MEMORANDUM FOR ASSISTANT SECRETARY OF THE NAVY (FINANCIAL MANAGEMENT)
AUDITOR GENERAL, DEPARTMENT OF THE ARMY

SUBJECT: Audit Report on Aircraft Fuel Cell Procurements (Report No. 94-001)

We are providing this final report for your information and use. This report, the first in a series of reports relating to foreign- and U.S.-manufactured fuel cells procured by DoD, discusses fuel cells procured by the Army for CH-47D Chinook and AH-64 Apache helicopters.

DoD Directive 7650.3 requires that all recommendations and estimated monetary benefits be resolved promptly. We revised some recommendations based on comments from the Army. Therefore, we request the Army to provide final comments on the unresolved recommendations and monetary benefits by December 13, 1993. See the "Response Requirements Per Recommendation" section at the end of each finding for the unresolved recommendations and the specific requirements for comments.

Please contact Mr. Salvatore D. Guli, Program Director, at (703) 692-3025 (DSN 222-3025) or Mr. Ronald W. Hodges, Project Manager, at (703) 692-3178 (DSN 222-3178) if you have any questions on this report. We appreciate the courtesies extended to the audit staff. Appendix K lists the distribution of this report. The audit team members are listed inside the back cover.

Edward R. Jones
Deputy Assistant Inspector General
for Auditing

Office of the Inspector General, DoD

Report No. 94-001 **October 13, 1993**
(Project No. 2CF-8014)

AIRCRAFT FUEL CELL PROCUREMENTS

EXECUTIVE SUMMARY

Introduction. This audit was performed in response to a DoD Hotline complaint regarding the DoD procurement of aircraft fuel cells. The complainant alleged that foreign-manufactured fuel cells were of better quality and had a longer useful life than domestically manufactured fuel cells. The complainant also alleged that domestic manufacturers were attempting to eliminate foreign competition to enable domestic manufacturers to dictate prices. This report was based on our evaluation of the quality of domestic fuel cells procured by DoD for two Army helicopters.

Objectives. The audit objectives were to determine whether DoD acquisition strategies for aircraft fuel cells resulted in fair and reasonable prices and whether DoD received quality fuel cells for the prices paid. We also determined whether internal controls were in place to ensure that DoD obtained quality fuel cells at a fair price.

Audit Results. Although Army acquisition strategies for a variety of helicopter fuel cells resulted in fair and reasonable prices for 15 contracts valued at $10.8 million, the Army received CH-47D Chinook and AH-64 Apache helicopter fuel cells that prematurely failed.

o Faulty repair material and inadequate design specifications caused 98 of the 146 CH-47D and AH-64 helicopter fuel cells evaluated to prematurely fail. Also, premature failures of CH-47D helicopter fuel cells caused the Army to deplete its supply of fuel cells and to ground CH-47D helicopters. If the Army does not correct the premature fuel cell failure problem, continued failure of CH-47D and AH-64 helicopter fuel cells could endanger Army aviators and put helicopters at risk (Finding A).

o The Army did not use the expected life of the fuel cell, identified in military specifications, to make buy and repair decisions. Also, the Army did not develop adequate in-house repair capabilities. The Navy already operates a depot facility that the Army might use for repair of its helicopter fuel cells. The Army can avoid future procurement costs by repairing failed fuel cells and transferring excess fuel cells from the Army inventory to the manufacturer as Government-furnished material (Finding B).

Internal Controls. Internal controls were inadequate to identify weaknesses in the Army implementation of its quality program related to helicopter fuel cells and to identify, report, and correct fuel cell quality problems. We consider the weaknesses to be material. See Part I for the internal controls reviewed and Finding B in Part II for details on the weaknesses.

Potential Benefits of Audit. We determined that $926,500 in procurement costs were avoided in FY 1993 and $468,000 of procurement costs could be avoided during FY 1994 if unserviceable CH-47D and AH-64 helicopter fuel cells are repaired and excess AH-64 helicopter fuel cells are used to meet future production requirements. Although we could not quantify the amount, additional benefits will occur when the manufacturer discontinues the use of faulty repair material, when AH-64 helicopter fuel cell specifications are improved, and when Army officials use the expected life of the fuel cell to make economic buy and repair decisions. Appendix I summarizes the potential monetary and other benefits of audit.

Summary of Recommendations. We recommended that the Army inspect all crash-resistant helicopter fuel cells manufactured by Engineered Fabrics Corporation to identify premature failures, return failed fuel cells to the manufacturer for cost-free repair, and obtain a warranty on future fuel cell purchases from the manufacturer. We also recommended that the Army perform a cost-benefit analysis to determine whether the Army or the Navy can provide efficient depot-level inspection and repair of unserviceable crash-resistant, self-sealing helicopter fuel cells. In addition, we recommended that the Army make buy or repair decisions based on the useful life of the fuel cell established in military specifications and that the Army transfer AH-64 helicopter fuel cells from inventory to the helicopter manufacturer.

Management Comments. The Army agreed to inspect crash-resistant helicopter fuel cells, to obtain a warranty on future fuel cell productions, to make buy or repair decisions based on the fuel cell useful life, to return failed fuel cells to the manufacturer for cost-free repair, and to transfer excess AH-64 helicopter fuel cells to the helicopter manufacturer, as needed. The Army did not agree to perform a cost-benefit analysis to determine whether the Army or the Navy can provide efficient depot-level maintenance for fuel cells. The Army stated that Army policy is to perform maintenance at the lowest level possible and that the Army would review the unit-level repair and recoverability code. The Army agreed to a portion of the monetary benefits; however, the Army has no plans to purchase additional CH-47D helicopter fuel cells and could not transfer excess AH-64 helicopter fuel cells to the current McDonnell Douglas production line.

Audit Response. In response to the Army comments, we revised our recommendations to return failed fuel cells to the manufacturer and to transfer excess AH-64 helicopter fuel cells to the helicopter manufacturer. Regarding the recommendation to perform a cost-benefit analysis to determine whether the Army or Navy can provide efficient depot-level maintenance, we clarified our intent and requested the Army to provide additional comments. We revised the monetary benefits based on the Army comments. A summary of management comments is in Part II of this report. The complete text of management comments, including additional subsequent comments from the Aviation Troop Command, Army Materiel Command, is in Part IV. We request that the Army provide additional comments by December 13, 1993.

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This report was prepared by the Contract Management Directorate, Office of the Assistant Inspector General for Auditing, DoD. Copies of the report can be obtained from the Secondary Reports Distribution Unit, Audit Planning and Technical Support Directorate (703) 614-6303 (DSN 224-6303).

Part I - Introduction

Background

The audit was initiated in response to a Hotline allegation that foreign-manufactured aircraft fuel cells were of better quality and had a longer useful life than domestically manufactured fuel cells. The complainant also alleged that domestic manufacturers were attempting to eliminate foreign competition to enable domestic manufacturers to dictate their own prices to DoD. This report, the first in a series of reports relating to foreign- and U.S.-manufactured aircraft fuel cells procured by DoD, concerns crash-resistant, self-sealing fuel cells manufactured by domestic sources for the Army's CH-47D Chinook and AH-64 Apache helicopters. Future audits will address aircraft fuel cells used by the Navy and the Air Force and the qualification testing requirements for helicopter fuel cells. We were unable to address the price allegation in this report because the Army had not purchased any foreign-made, crash-resistant, self-sealing helicopter fuel cells.

CH-47D and AH-64 Helicopters. The CH-47D and AH-64 helicopters are two of several types of helicopters used by the Army.

CH-47D. The CH-47D helicopter contains a total of six fuel cells: two main and four auxiliary cells. The CH-47 helicopter has been in the operational Army inventory for more than 20 years. Modernization of the aircraft to its latest version, the "D" model, began in 1981 through the prime contractor, Boeing Helicopters. Of a total 472 CH-47D helicopters, 336 (71 percent) were fielded after 1985.

AH-64. The AH-64 helicopter contains one forward and one aft fuel cell. The McDonnell Douglas Helicopter Company (McDonnell Douglas) has produced the AH-64 helicopter since 1982. Of the 746 AH-64s currently in the operational Army inventory, 701 (94 percent) were fielded after 1985.

Crash-resistant, Self-sealing Fuel Cells. Fuel cells for the CH-47D and AH-64 helicopters are crash-resistant and self-sealing and are manufactured to military specification MIL-T-27422B, "Tank, Fuel, Crash-resistant, Aircraft." A fuel cell is a flexible bladder shaped to fit a designated cavity in an aircraft and is designed to hold aircraft fuel. Fuel cells are constructed from fuel-resistant materials such as nitrile (rubber material) or polyurethane (urethane-coated material). Fuel cells are supported by the aircraft cavity and are designed to be removable and repairable. A crash-resistant, self-sealing fuel cell is designed to self-seal punctures from hostile fire and, within certain tolerances, should not leak or burst if the helicopter crashes. A crash-resistant, self-sealing fuel cell is advantageous because it retains fuel, thus reducing fire hazards during a helicopter crash.

During FYs 1988 through 1992, the Army spent more than $10 million on fuel cells for its CH-47D and AH-64 helicopters. The fuel cells for both helicopters carry a 1-year manufacturer's warranty that covers materials and workmanship.

Army Fuel Cell Logistics Support. The Army Aviation Troop Command (ATCOM), St. Louis, Missouri, formerly the Army Aviation Support

Command and Army Troop Support Command, is responsible for providing engineering, technical, and logistical support for Army helicopters. ATCOM requires that maintenance personnel perform programmed maintenance on each aircraft including removal, examination, and limited repair of fuel cells.

Qualified U.S. Fuel Cell Manufacturers. Currently, only two domestic sources are qualified to manufacture aircraft fuel cells for DoD: American Fuel Cell and Coated Fabrics Company (AMFUEL) and Engineered Fabrics Corporation (EFC). Firestone Operating Divisions and Uniroyal manufactured fuel cells for DoD before AMFUEL purchased the two companies in 1983 and 1991, respectively. Goodyear Aerospace Corporation also manufactured fuel cells for DoD before being purchased by Loral Corporation in March 1987. In April 1989, K & F Industries subsequently purchased Loral's Engineered Fabrics Division, which is now referred to as EFC. The chief executive officer of Loral is the majority stockholder of K & F Industries. Between 1988 and 1992, DoD purchased a total of $236 million of fuel cells from all fuel cell manufacturers. Figure 1 shows annual purchases from each contractor.

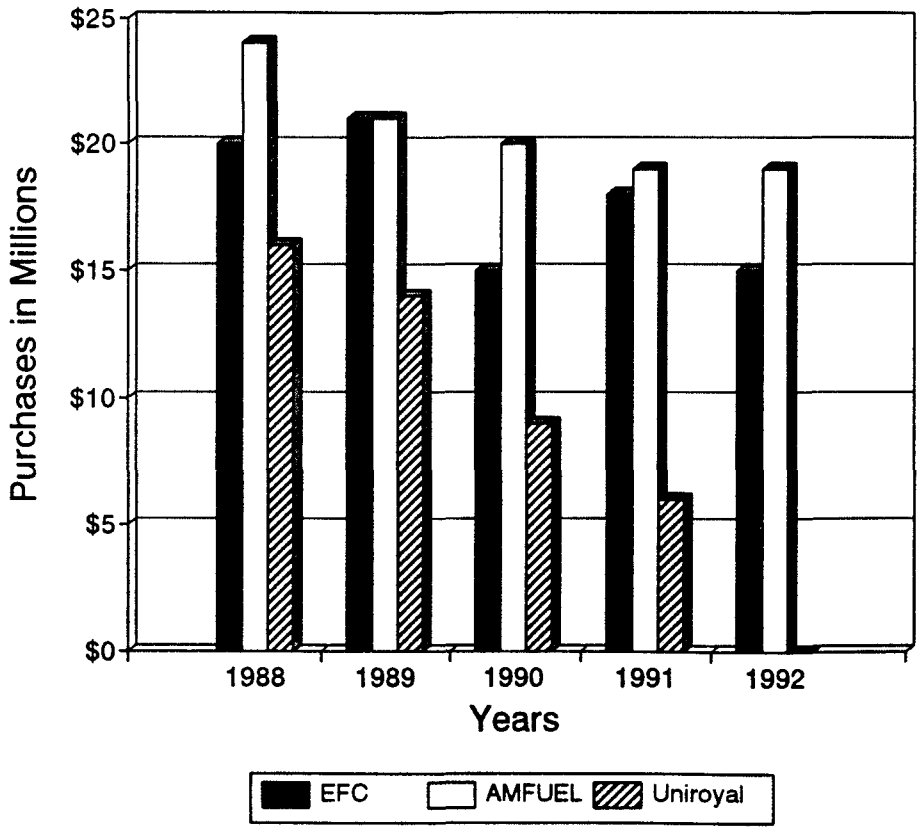


Figure 1. DoD Annual Fuel Cell Purchases From Each Contractor

Objectives

The objectives of the audit were to determine whether DoD acquisition strategies for aircraft fuel cells resulted in fair and reasonable prices and whether DoD received quality fuel cells for the prices paid. We also determined whether internal controls were in place to ensure that DoD obtained quality fuel cells at a fair price.

Scope

Audit Methodology. To satisfy our audit objectives, we determined whether the Army acquisition strategies for fuel cells were based on competition and whether quality problems existed with domestically manufactured fuel cells. We visited Army sites and contractor facilities where fuel cells are manufactured for the Army. The Army did not have any foreign-manufactured, crash-resistant, self-sealing helicopter fuel cells in stock. Therefore, we did not perform cost or quality comparisons of domestic and foreign-manufactured fuel cells used by the Army or determine whether domestic manufacturers were attempting to eliminate foreign competition.

Army Sites. We reviewed DoD and Army management policies and practices related to acquisition, quality, and maintenance of fuel cells and interviewed officials at ATCOM regarding CH-47D and AH-64 helicopter fuel cells. We reviewed 15 procurement contracts issued during FY 1985 through FY 1991, valued at $10.8 million, for competition and price reasonableness, and to determine how many CH-47D and AH-64 helicopter fuel cells were purchased. We also reviewed 147 quality deficiency reports (QDRs) from FYs 1985 through 1992 to determine the type and extent of quality problems experienced with the fuel cells, the age of the fuel cells, and from whom the Army purchased the fuel cells.

We evaluated 146 unserviceable CH-47D and AH-64 helicopter fuel cells valued at $828,000 at Corpus Christi Army Depot, Texas; Fort Carson, Colorado; Fort Hood, Texas; and Letterkenny Army Depot, Pennsylvania. A complete list of the fuel cells we evaluated is in Appendix A. We selected the four Army installations with the highest number of unserviceable fuel cells on hand. The fuel cells ranged from 2 to 18 years old. We also interviewed maintenance personnel at each installation to discuss fuel cell problems experienced and type of repairs performed at that level.

Contractor Facilities. We visited Boeing Helicopters and McDonnell Douglas to obtain information regarding fuel cells scrapped and repaired during modernization of the CH-47D helicopter and during production of the AH-64 helicopter. We also visited EFC and AMFUEL to observe the manufacturing processes and to discuss quality problems experienced with fuel cells produced by both companies.

Use of Technical Experts. We obtained the assistance of a Navy engineer from the Naval Aviation Depot, Pensacola, Florida, who had technical expertise with helicopter fuel cells, to determine the cause of failure and the repairability of the unserviceable CH-47D and AH-64 helicopter fuel cells. The Navy engineer also assisted in our evaluation of technical reports relating to fuel cells.

Estimating Procedures. We did not use statistical sampling procedures to select the fuel cells for this evaluation. We could not evaluate those fuel cells installed on CH-47D and AH-64 helicopters at the Army activities visited because an evaluation would have required removal of the fuel cell and grounding of the helicopter. Also, we could not establish a universe of identifiable fuel cells in advance of our visits to Army maintenance locations. Therefore, the total universe of CH-47D and AH-64 helicopter fuel cells was not subject to random selection. We estimated the opportunity to avoid costs on future procurements. Our estimates were based on nonstatistical sampling methods (Appendix B).

Audit Period, Standards, and Locations. This economy and efficiency audit was conducted from July 1992 through March 1993 in accordance with auditing standards issued by the Comptroller General of the United States, as implemented by the Inspector General, DoD. Accordingly, the audit included such tests of internal controls as were considered necessary. As part of our review, we tested the reliability of computer-generated data for fuel cell acquisitions, maintenance, and quality. Although we found errors in automated quality deficiency reporting data, such as incomplete or inaccurate information, we considered the data to be reliable for our primary purpose of identifying premature failures. Appendix J lists the activities visited or contacted.

Internal Controls

Internal Controls Reviewed. We limited our evaluation of the Army implementation of the Federal Managers' Financial Integrity Act to the quality of helicopter fuel cells. Specifically, we evaluated existing Army policy and guidance related to the implementation of internal controls over the quality function. We also examined ATCOM procedures for identifying, reporting, and correcting fuel cell quality problems.

Internal Control Weaknesses Identified. The audit identified material internal control weaknesses as defined by Public Law 97-255, Office of Management and Budget Circular A-123, and DoD Directive 5010.38. The Federal Managers' Financial Integrity Act was not adequately implemented to ensure the quality of fuel cells. Internal controls were not established or effective to identify weaknesses in the Army implementation of its quality program associated with helicopter fuel cells and to identify, report, and correct fuel cell quality problems (Finding B).

The Army realized $84,500 in monetary benefits when the fuel cell manufacturer, EFC, agreed to repair at no cost CH-47D helicopter fuel cells

that had prematurely failed because of the repair material EFC used during production. Recommendations B.1.b. and B.2., if implemented, will correct the material internal control weaknesses. However, we could not determine additional monetary benefits to be realized by implementing Recommendations B.1.b. and B.2. because we could not determine the total number of repairable fuel cells that experienced premature failures related to the inside blistering of the repair material or the inadequate design specification that caused outside delamination from contact with fuel or similar fluids. Implementing the report recommendations, however, should help identify and prevent premature failure of fuel cells and unnecessary scrapping of repairable cells. A copy of the report will be provided to the senior official responsible for internal controls in the Department of the Army.

Prior Audits and Other Reviews

General Accounting Office (GAO). NSAID-90-214 (OSD Case No. 8379), "F-15 Fuel Cells, the Air Force Needs Better Data for Informed Decisions," August 16, 1990. The report stated that the Air Force did not maintain adequate data on F-15 aircraft fuel cells to identify premature fuel cell failures, to establish repair and replacement policies based on the actual life of F-15 aircraft fuel cells, and to evaluate the advantages of an extended manufacturer's warranty. The report also stated that the Air Force did not have the data necessary to determine life-cycle cost advantages of using one fuel cell material over another.

GAO recommended that the Air Force collect F-15 aircraft fuel cell data, such as useful life, failure rates, and maintenance costs, and that management use the data to assess the life-cycle cost of fuel cell materials and the merits of an extended warranty. GAO also recommended that Air Force management use the data to revise the conditions under which fuel cells should be repaired or discarded.

The Air Force generally concurred with the recommendations and stated that the automated maintenance records being installed at the F-15 aircraft depot and base maintenance levels would detail the historical data and other information needed to perform life-cycle cost analyses for the F-15 aircraft fuel cells, including dates the cells were installed and reasons for replacement. The information would also be used by management to make repair or replacement decisions and to determine whether an extended warranty would be feasible for the F-15 aircraft fuel cells.

AFMD-93-8 (OSD Case No. 8674-LL), "Poor Internal Control Has Led to Increased Maintenance Costs and Deterioration of Equipment," January 25, 1993. The audit, conducted at four Army maintenance depots, showed that noncompliance with packaging and storage requirements for repairable equipment by Army units and depots increased scrappage rates and maintenance costs. The report recommended that the commanders of Army major commands that ship repairables to maintenance depots be directed to enforce

DoD and Army regulations concerning packaging of repairables. The Army agreed to issue a compliance directive requiring all units to follow packaging instructions when shipping repairables.

Inspector General, DoD. Report No. 92-140, "Competitive Bidding Practices on Contract F09603-91-C-0624," September 30, 1992, discussed the validity of a bid proposal made by Sekur-Pirelli, a foreign fuel cell manufacturer. The report concluded that Sekur-Pirelli did not offer a price below its expected cost to produce fuel cells for the Air Force H-53 helicopter. The report contained no recommendations.

Part II - Findings and Recommendations

Part II - Findings and Recommendations

Finding A. Helicopter Fuel Cell Failures

CH-47D and AH-64 helicopter fuel cells were prematurely failing. These failures occurred because the material the manufacturer used to rework production defects blistered inside the fuel cells. AH-64 helicopter fuel cells also prematurely failed because design specifications did not prevent outside fuel cell delaminations (separation of the fuel cell exterior surfaces) on contact with fuel or similar fluids. The premature failure of CH-47D helicopter fuel cells depleted the Army inventory of replacement fuel cells and resulted in the Army grounding at least three CH-47D helicopters for as long as 4 months. If left uncorrected, use of faulty repair materials and inadequate design specifications could cause more of the 4,324 CH-47D and AH-64 helicopter fuel cells, valued at $25.7 million, to fail prematurely. Failure to correct the conditions causing premature failure will continue to adversely impact the operational readiness of the helicopters and could endanger Army aviators and put helicopters at risk.

Background

Fuel Cell Design. Fuel cells used in CH-47D and AH-64 helicopters are designed to be crash-resistant and self-sealing. A crash-resistant, self-sealing fuel cell is designed to withstand a 65-foot fall without leaking and seal itself if a projectile penetrates the cell wall. Both helicopters' fuel cells are qualified to military specification MIL-T-27422B, which defines the useful life for fuel cells as the serviceable life of the aircraft in which the fuel cells are installed. Boeing Helicopters and McDonnell Douglas, the respective prime contractors for the CH-47D and AH-64 helicopters, stated that the service life of the two helicopters was established in terms of flight hours. The contractor-estimated useful life of 15 to 18 years for each helicopter is based on average annual usage.

Fuel Cell Manufacturing Process. Although all crash-resistant, self-sealing fuel cells contain four primary layers of materials, the manufacturing process, the number of reinforcing plies, and the materials used vary between manufacturers. Crash-resistant, self-sealing helicopter fuel cells are typically constructed as follows.

o An inner layer of synthetic rubber or coated fabric contains the fuel and protects the nylon fuel barrier.

o A nylon fuel barrier or nylon film prevents fuel from diffusing through the cell wall.

o A sealant of semi-cured natural rubber seals a ruptured area of the cell when the cell is penetrated by a projectile.

o An outer layer of woven nylon or polyester cord provides strength for the cell and a rubber coating forms the exterior of the cell.

AMFUEL uses nitrile, a rubber material, in manufacturing fuel cells for both CH-47D and AH-64 helicopters. EFC constructs its crash-resistant, self-sealing fuel cells from a combination of nitrile, polyester, and polyurethane materials.

Fuel Cell Failure. Fuel cells supply fuel to the helicopter's engine. Fuel cell failure can result in a total loss of engine power, fires, or harmful vapors. Any of those conditions could jeopardize the aircrew, passengers, and completion of the helicopter's mission. Although no definition for fuel cell failure exists, maintenance personnel use condition codes to classify fuel-cell status. Condition codes indicating unserviceability are assigned when the fuel cell can no longer perform satisfactorily as part of the weapon system in which it is installed. The unsatisfactory fuel cell is removed from the helicopter and assigned one of several supply condition codes, such as "F" condition (repairable, but not usable) and "H" condition (not repairable, scrap). Fuel cells that are crash-resistant and self-sealing are critical to the safety of the aircrew. EFC informed us that blistering inside fuel cells could present a safety hazard. Peelings from blistered areas inside fuel cells could clog fuel lines, causing the engine to fail and the aircraft to lose control. Although such a failure has never occurred, fuel cells with inside blistering must be removed and placed in one of the supply condition codes that indicates they are unserviceable.

Premature Failure of Helicopter Fuel Cells

Fuel Cell Useful Life. Military specifications require a 15-year useful life for CH-47D helicopter fuel cells. We examined the CH-47D helicopter fuel cells manufactured by EFC and calculated an average of only 6.5 years before failure. Therefore, EFC fuel cells failed after achieving only 43 percent of the required 15-year useful life. AH-64 helicopter fuel cells manufactured by EFC and AMFUEL showed an average of 5.6 and 5.7 years before failure, respectively, even though military specifications require an 18-year useful life for the cell (Appendix A). AH-64 helicopter fuel cells, therefore, achieved only 32 percent of the required 18-year useful life. Premature failures of the CH-47D and AH-64 helicopter fuel cells are discussed in the following evaluations.

CH-47D Helicopter Fuel Cell Evaluation. Evaluation of 67 CH-47D helicopter fuel cells, with technical assistance provided by a Navy engineer, showed that 58 fuel cells prematurely failed. The fuel cells stored at Corpus Christi Army Depot, Fort Carson, and Fort Hood were unserviceable and considered nonrepairable. Of the 67 fuel cells, 57 were manufactured by EFC and 10 were manufactured by Uniroyal (now AMFUEL). Although the fuel

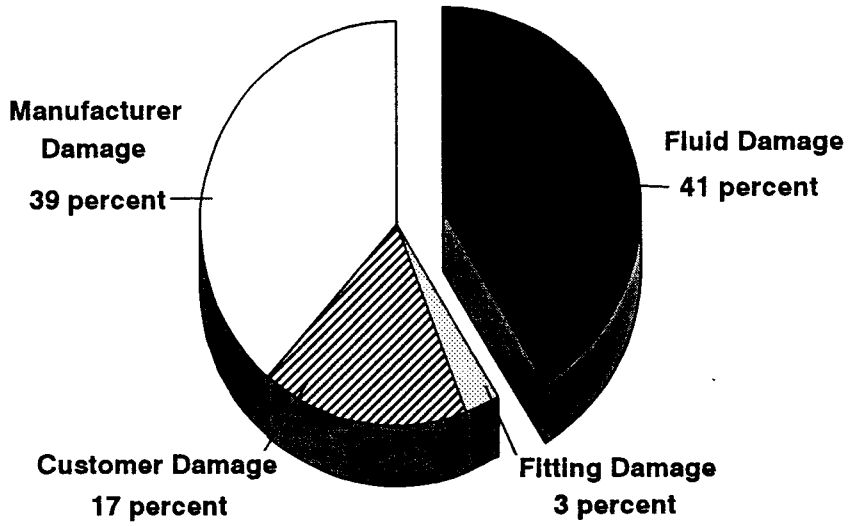
cells were comparably priced, we determined that the AMFUEL fuel cells lasted about 2.5 times longer (16.1 years versus 6.5 years) than the EFC fuel cells (Appendix A). Further examination showed that 50 (88 percent) of the 57 EFC fuel cells were determined unserviceable by Army maintenance personnel because a nylon material (commonly referred to as 82C12), used by EFC to rework the fuel barrier during production, blistered inside the fuel cell (Appendix C). Rework is part of the production process wherein newly manufactured fuel cells, found upon inspection to contain manufacturing defects, are "reworked" to ensure that the fuel cell is free of defects, abrasions, or other scars that may cause the fuel cell to fail. EFC confirmed that the blistered repair material could eventually peel and clog the fuel system, causing the aircraft to lose control. EFC stated that they received no returned fuel cells from DoD exhibiting the problem before the audit and that they considered the problem a rare occurrence.

Scope of CH-47D Helicopter Fuel Cell Problem. To verify that the blistering problem was not a rare occurrence, we took the following additional steps. We requested information regarding the age and manufacturer of fuel cells that passed or failed inspection during the Special Technical Inspection and Repair (STIR) of Operation Desert Storm helicopters. ATCOM did not collect this type of information, but the CH-47 Project Manager's Office was able to obtain the information for the fuel cells that failed inspection during STIR. We also requested information from Boeing Helicopters, the CH-47D helicopter prime contractor, regarding scrap rates and age of fuel cells scrapped during the CH-47D helicopter modernization program. Boeing Helicopters provided scrap rates for the fuel cells on both manufacturers for only the last 2 years of the modernization program. Boeing Helicopters information showed a 14 percent scrap rate (18 of 124) for AMFUEL fuel cells and an 83 percent scrap rate (44 of 53) for EFC fuel cells (Appendix D). Boeing Helicopters did not provide the age of the fuel cells scrapped even though the information was available. ATCOM officials informed us that Boeing Helicopters would charge the Government for the information we needed to determine whether premature failure of helicopter fuel cells was longstanding. ATCOM did not believe that expending funds just to determine how long the problem of premature failure of fuel cells had occurred was cost-effective. Thus, we did not determine the scope of the blistering problem. According to EFC, the blistered fuel cells are repairable. Nevertheless, the Army will expend maintenance time to remove, repair, or replace failed EFC fuel cells as well as experience helicopter downtime because of blistered fuel cells.

Grounded CH-47D Helicopters. In a November 13, 1992, memorandum to the CH-47 contracting office, the CH-47 item manager stated that three CH-47D helicopters were grounded as of that date because replacement fuel cells were not available. The item manager also stated that, based on the current rate of fuel cell failures, three additional helicopters per month would be grounded until replacement cells were obtained. As of February 1993, we concluded that at least three CH-47D helicopters were grounded, some for as long as 4 months, and as many as nine additional helicopters could be grounded due to a lack of replacements for failed fuel cells.

AH-64 Helicopter Fuel Cell Evaluation. Evaluation of 79 AH-64 helicopter fuel cells stored at the Corpus Christi and Letterkenny Army Depots and Fort Hood showed that 71 fuel cells prematurely failed (Appendix E). Of the 71 fuel cells, 39 cells were manufactured by EFC and 32 fuel cells were manufactured by AMFUEL. Of the 39 EFC fuel cells, 26 (67 percent) failed because of the previously discussed blistering found in the EFC repair material. For the remaining 45 fuel cells, we determined that the most common cause of fuel cell failures, besides customer-caused failures (storing and handling, fitting damage, and activation), was inadequate design specifications that resulted in delamination of the outside wall of the fuel cell. The outside wall of a fuel cell is made by bonding nitrile or polyurethane rubber to the woven nylon or polyester cords. Delamination occurs when the outside wall of the fuel cell comes into contact with fuel or other similar fluids causing the woven materials contained in the exterior cell wall to separate. Outside delamination of the fuel cell generally is not repairable and requires the fuel cell to be replaced.

Scope of AH-64 Helicopter Fuel Cell Problem. We took additional steps to determine whether Army users reported the outside delamination problem and whether ATCOM took any corrective action to prevent recurrence. We reviewed a total of 70 QDRs submitted to ATCOM on AH-64 helicopter fuel cell failures between 1986 and 1992. Of the 70 QDRs, 29 (41 percent) of the QDRs were for outside delaminations. An analysis of the QDRs and causes listed for premature failures of the AH-64 helicopter fuel cells is shown in Figure 2.



Source: U.S. Army Data

Figure 2. Quality Deficiencies Reported on AH-64 Helicopter Fuel Cells

AH-64 Helicopter Fuel Cell Design Change. According to ATCOM officials, the outside delamination also occurred with the CH-47D helicopter fuel cell. However, the CH-47D helicopter fuel cell manufacturer (at that time Uniroyal) proposed a design change to Boeing Helicopters that would prevent the outside delamination condition from occurring. The design change involved increasing the qualification testing from a 3-day stand test in fuel to a 60-day stand test.

We asked ATCOM officials whether the same design change could be incorporated on the McDonnell Douglas AH-64 helicopter fuel cell. ATCOM officials stated that the change to fix the AH-64 helicopter fuel cell was not reviewed or initiated because the Army would have to pay for an engineering change proposal. As a result, ATCOM officials preferred that McDonnell Douglas initiate the change. Although ATCOM wanted the contractor to bear the cost of the change proposal for the AH-64 helicopter fuel cell, we determined that McDonnell Douglas engineers were not aware of the design change on the CH-47D helicopter fuel cell.

EFC Fuel Cell Failure Evaluation. During our audit, EFC officials were present at two of the four sites visited and generally agreed with us that the fuel cells failed because of blistering inside the fuel cells. In October 1992, we visited EFC to discuss the premature failure of their fuel cells and the need for adequate safeguards for pending and future procurements of CH-47D helicopter fuel cells. As a result of our October 1992 visit, EFC began testing fuel cells by attempting to duplicate conditions that caused the blisters. In addition, the company verbally agreed to offer the Army a no-cost, 5-year warranty on the current solicitation for 91 fuel cells. On February 3, 1993, EFC Material Investigative Report 150-ED-194 concluded that the blistering condition occurred only when the 82C12 repair material was used to repair the fuel barrier. EFC also concluded that the blistering occurred only inside the fuel cell and at temperatures substantially exceeding the design requirements of MIL-T-27422B. In its conclusion, EFC implied that MIL-T-27422B temperature requirements are too low.

We do not fully agree with the EFC conclusion. If excessive heat were a factor, blistering would have probably also affected the unrepaired fuel barriers used in the initial manufacturing process. Thus, it appears that the 82C12 repair material is defective. On February 25, 1993, EFC stated that the company was evaluating alternate repair materials to replace the 82C12 material and that requalifying their crash-resistant, self-sealing fuel cells would take at least 3 months (Appendix F).

Conclusion

Impact of Helicopter Fuel Cell Premature Failures. The Army will have to expend an unknown amount of maintenance time removing, inspecting, and repairing EFC's crash-resistant, self-sealing fuel cells. Of the 146 CH-47D and AH-64 helicopter fuel cells reviewed, 98 (67 percent) experienced premature

failure caused by faulty repair material (blistering) and inadequate design specifications (delamination) (Appendixes C and E). If left uncorrected, use of faulty repair material and inadequate design specifications could cause premature failure on an unknown number of the total 4,324 CH-47D and AH-64 helicopter fuel cells valued at $25.7 million installed in helicopters at the time of the audit. According to EFC, a helicopter with blistered fuel cells should not be flown. Based on EFC's statement and our evaluations of defective fuel cells, we concluded that the blistered materials in fuel cells could jeopardize the safety of the aircrew and passengers and completion of the helicopter's mission.

Inspections Needed on Installed Fuel Cells. The Army should issue an Aviation Safety Action Message that requires maintenance personnel to inspect all EFC crash-resistant, self-sealing helicopter fuel cells to determine whether inside blistering has occurred, and repair or replace the fuel cells as needed. The inspections should be performed on fuel cells between 6 and 8 years old. Further, the Army should continue to have EFC perform no-cost fuel cell repairs related to inside blistering of the 82C12 repair material.

Assurances Needed on Future Fuel Cell Buys. Currently, EFC has three Army contracts valued at $4.7 million to manufacture AH-64 and UH-60 helicopter fuel cells. The Army needs some assurance that these cells will not prematurely fail because they are manufactured under similar manufacturing processes. Our audit has shown that EFC fuel cells for the CH-47D helicopter had an average age of 6.5 years before failure. Therefore, the Army should obtain a 10-year, no-cost manufacturer's warranty specifically for inside blistering of the repair material used on fuel cells currently being processed for Army production helicopters. We also believe ATCOM should initiate a design change proposal for the AH-64 helicopter fuel cell similar to the design change initiated by Boeing Helicopters for the CH-47D helicopter fuel cell.

Recommendations, Management Comments, and Audit Response

We recommend that the Commander, Army Aviation Troop Command:

1. Issue an Aviation Safety Action Message to Army units to inspect all helicopter crash-resistant, self-sealing fuel cells manufactured by Engineered Fabrics Corporation to determine whether inside blistering has occurred due to the 82C12 repair material and to remove or repair the fuel cells as necessary.

Management Comments. The Army concurred and stated that the Army Aviation Troop Command will issue an Aviation Safety Action Message addressing improved repair procedures for fuel cells. The Army also stated that Army engineers determined that no safety issue is involved with the blisters found in the interior of EFC fuel cells and that normal scheduled inspections will identify any problems with the fuel cells.

Audit Response. Although the Army concurred, its comments were not fully responsive. The Aviation Safety Action Message, dated August 16, 1993, provided revised repair procedures to CH-47 helicopter maintenance units for blisters found in the interior of fuel cells. The safety message did not provide revised inspection or repair procedures to maintenance units of other types of helicopters for blisters found in the interior of the fuel cells. Therefore, we request the Army to provide the date the remainder of the planned action is to be accomplished.

2. Continue to have Engineered Fabrics Corporation make no-cost repairs to CH-47D and AH-64 helicopter fuel cells that have prematurely failed because of blistering 82C12 repair material.

Management Comments. The Army concurred and proposed revising the recommendation.

Audit Response. We met with representatives from the Office of the Deputy Chief of Staff of the Army (Logistics) on August 11, 1993, to discuss the draft report. Based on this discussion and management comments, we revised our recommendation. We request the Army to provide additional comments on the revised recommendation when responding to the final report.

3. Obtain a no-cost, 10-year manufacturer's warranty for all existing and future crash-resistant, self-sealing helicopter fuel cells manufactured by Engineered Fabrics Corporation, specifically to protect the Army from premature failure caused by inside blistering of the fuel cells.

Management Comments. The Army concurred with the intent of the recommendation; however, the Army stated that it could not mandate a "no cost warranty" in a solicitation. A 5-year warranty, which was included in a recent competitive solicitation for helicopter fuel cells, was priced by both contractors at more than $1,000 per cell. The Army also stated that it is reviewing the possibility of obtaining a 10-year warranty against blistering on contractor-repaired fuel cells.

Audit Response. The Army planned action, with the understanding that the 10-year warranty will cover inside blistering of newly manufactured fuel cells, satisfies the intent of the recommendation. We ask that the Army provide a completion date in response to the final report.

4. Initiate a design change proposal to McDonnell Douglas Helicopter Company to increase specifications to prevent delamination of the outer cell wall of the AH-64 helicopter fuel cell when the outer cell wall comes in contact with fuel or other fluids, similar to the change made on the CH-47D helicopter fuel cell.

Management Comments. The Army concurred, stating that a value engineering change proposal was in process at McDonnell Douglas Helicopter Company. The change will help prevent delamination of the outer cell wall when the outer cell wall comes in contact with fuel.

Response Requirements Per Recommendation

Responses to the final report are required for the items indicated with an "X" in the chart below.

	Response Should Cover:		
Number	Concur/ Nonconcur	Proposed Action	Completion Date
A.1.			X
A.2.	X	X	X
A.3.			X

Finding B. Management of Helicopter Fuel Cells

ATCOM did not adequately manage the acquisition and maintenance of CH-47D and AH-64 helicopter fuel cells and verify that the Army received a quality fuel cell. This inadequate management occurred because ATCOM did not make buy and repair decisions for CH-47D and AH-64 helicopter fuel cells based on an established useful life. Also, ATCOM did not establish internal controls to identify problems with the quality of CH-47D and AH-64 helicopter fuel cells and to correct reported quality problems. Additionally, the Army did not develop or provide for adequate in-house repair capabilities and did not follow established procedures when handling and storing fuel cells. Consequently, the Army was not making adequate acquisition and repair decisions about fuel cells, nor was the Army aware that CH-47D and AH-64 helicopter fuel cells were failing prematurely. The opportunity exists for the Army to avoid about $1.4 million in future procurement costs by repairing rather than scrapping unserviceable CH-47D helicopter fuel cells and by transferring the excess inventory of AH-64 helicopter fuel cells to the manufacturer's aircraft production line as Government-furnished material.

Background

Within ATCOM, the Quality Management Directorate is tasked to plan, develop, and execute the quality assurance program for aviation material throughout the material life cycle. The Maintenance Directorate, ATCOM, is tasked to manage and direct the functions of maintenance management, maintenance engineering, provisioning, and technical publications.

ATCOM, in accordance with the Federal Managers' Financial Integrity Act, is required to review and report annually on the adequacy of internal management control systems established for each ATCOM functional area. The Army Management Control Plan provides a 5-year schedule for conducting internal management control review evaluations on an Army-wide basis. Managers refer to this plan for the current internal management control review checklists published for their functional area and for the dates by which each checklist must be completed.

Fuel Cell Quality Management. When an aviation item, such as a fuel cell, fails to perform as expected, and the user suspects a quality problem, Army procedures require the user to submit a QDR to ATCOM for investigation and resolution. The Quality Management Directorate is responsible for verifying that QDRs submitted by Army units and contractors are investigated. The Quality Management Directorate assigns the QDR to an action office within the Maintenance, Quality, or Engineering Directorates, based on the number of

hours the item was used and the type of deficiency identified. Each action office is responsible for review and analysis of the QDR data to identify specific problems and to develop trends and solutions.

Fuel Cell Maintenance. For repairable items such as helicopter fuel cells, the Maintenance Directorate is responsible for assigning recoverability codes. The codes designate maintenance responsibility based on the level of expertise required to perform the repairs: unit, intermediate, or depot. Maintenance personnel use the same methods to repair all crash-resistant, self-sealing fuel cells. However, the Maintenance Directorate authorizes lower-level expertise to repair CH-47D helicopter fuel cells than AH-64 helicopter fuel cells, and authorizes a lower level of expertise to determine fuel cell repairability.

Fuel Cell Repairability Determination. DoD Instruction 7220.1, "Uniform Criteria for Repair Cost Estimates Used in Determination of Economical Repair," provides criteria to be used by the Military Departments responsible for equipment maintenance to estimate the cost of major repairs on material and to determine whether the material is economically repairable.

CH-47D. ATCOM changed the recoverability code for CH-47D helicopter fuel cells from depot- to unit-level maintenance as of July 1992. Since repair capability at the unit level is limited, changing the maintenance level from depot to unit means that most unserviceable CH-47D helicopter fuel cells will be determined to be unrepairable and thus will be scrapped.

AH-64. AH-64 helicopter fuel cells are coded as repairable at the depot level. This means that, although aviation unit and intermediate maintenance levels are allowed to make minor repairs, the depot is ultimately responsible for evaluating the fuel cells to determine whether the fuel cells should be repaired or scrapped.

Expected Useful Life as a Criterion for Making Buy and Repair Decisions

ATCOM did not use the expected useful life of CH-47D and AH-64 helicopter fuel cells as a criterion when making buy or repair decisions, even though military specifications for crash-resistant fuel cells provide that the Army should expect a useful life of 15 to 18 years from both fuel cells. As a result, the Army planned to scrap at least 50 CH-47D helicopter fuel cells without realizing that a manufacturer's defect caused the cells to fail or become unserviceable at an average age of 6.5 years. In addition, the Army held an excess inventory of AH-64 helicopter fuel cells because ATCOM overestimated the Army need for replacement fuel cells.

Economic Repair of CH-47D Helicopter Fuel Cells. Before our initial visit to ATCOM in July 1992, the Army completed STIR on 26 CH-47D helicopters (156 main and auxiliary fuel cells) and discovered 77 failed fuel cells. This

represented an approximate failure rate of 50 percent. Our initial analysis of data on 14 of the 77 fuel cells to determine the age showed that 9 of the failed fuel cells were manufactured by Goodyear, now EFC, and were an average age of 6 years old. The remaining five were manufactured by Uniroyal, now AMFUEL, and had an average age of 15 years.

On-site evaluations of a total of 67 unserviceable CH-47D helicopter fuel cells performed from September 1992 through January 1993 showed that 50 of the fuel cells failed prematurely, at an average age of 6 years, because of the breakdown of 82C12, the material used extensively in the EFC manufacturing rework process discussed in Finding A. DoD Instruction 7220.21 requires that the life expectancy of a material should be considered when deciding whether it is economical to repair the material. ATCOM, however, planned to scrap all 67 unserviceable CH-47D helicopter fuel cells, using historically high scrap rates as a basis for the decision not to repair the fuel cells. If ATCOM maintenance officials had used the 15-year expected useful life referred to in MIL-T-27422B as a criterion in this decision, they would have had reason to question why so many of the failing fuel cells were scrapped at ages less than half the expected useful life. The available information also would have served as an indicator that a quality problem existed.

Excess Inventory of AH-64 Helicopter Fuel Cells. The Army practice not to use the expected useful life as a criterion in its decision to order replacement fuel cells for the AH-64 helicopter resulted in an excess inventory of AH-64 helicopter fuel cells.

ATCOM did not consider the 18-year expected useful life for AH-64 helicopter fuel cells when ordering replacement cells for AH-64 helicopters. The production phase of the AH-64 helicopter began in 1982, although full scale production did not begin until 1986. Before 1986, only 45 of a total 746 helicopters currently in service had been delivered to the Army. Therefore, 94 percent of the fuel cells installed on the 746 helicopters were only 6 years old or less at the time of our review.

As of December 1992, the Army had 192 serviceable forward AH-64 helicopter fuel cells in its inventory. Setting aside a 2-year reserve of inventory based on the current demand (and taking into account the failure rate), it would take 10 years to use the number of serviceable forward cells currently on hand and 4 years to use the number of aft fuel cells. The projected usage rates do not consider unserviceable fuel cells that could be repaired and returned to a serviceable condition.

ATCOM could avoid $468,000 in future procurement costs by transferring excess AH-64 helicopter fuel cells already in Army supply to McDonnell Douglas to be installed as Government-furnished material on future helicopter production scheduled after June 1994. In addition, the Army would receive maximum benefit from the useful life of the AH-64 helicopter fuel cells already in the Army inventory.

Internal Controls Over Quality Assurance

Existing DoD and Army policy and guidance were sufficient to report and correct most problems related to the quality of items procured. However, the Army lacked internal control objectives and techniques necessary to identify and report quality problems with CH-47D and AH-64 helicopter fuel cells and to correct reported quality problems. In addition, ATCOM did not perform an internal control assessment to identify weaknesses in its implementation of existing policies and procedures related to the Army Quality Program.

Controls to Identify, Report, and Correct Quality Problems. Using the established useful life for helicopter fuel cells should be an internal control objective to verify that the Army is receiving a quality fuel cell for the best price. The benefit of using this simple control objective was demonstrated in our analysis of the age and manufacturer of 14 unserviceable CH-47D helicopter fuel cells detected during the STIR program. We identified a potential systemic problem with fuel cells manufactured by EFC. When we informed EFC of the problem, they agreed to repair at no cost to the Army the repairable cells we evaluated during our first site visit to Fort Hood. As a result, the Army avoided at least $84,500 in unnecessary procurement costs and obtained 13 additional serviceable fuel cells, which prevented additional grounding of CH-47D helicopters. Further on-site evaluation at other Army sites showed that 76 of the 146 unserviceable CH-47D and AH-64 helicopter fuel cells (Appendixes C and E) experienced the same blistering problem; however, only 10 QDRs were submitted to ATCOM to report the problem.

ATCOM also needed to establish controls to verify that Army maintenance personnel take corrective action on reported quality problems. For example, 41 percent of the 70 QDRs submitted for the AH-64 helicopter fuel cell between 1986 and 1992 reported failure because of delamination of the outer cell wall. As discussed in Finding A, ATCOM took no action to correct the AH-64 helicopter fuel cell delamination problem even though the same problem was identified and corrected on the CH-47D helicopter fuel cell. In addition, 8 of the 79 unserviceable AH-64 helicopter fuel cells reviewed were new cells and were never used. Although the eight fuel cells were coded as unserviceable, we were unable to identify a problem with the fuel cells. Identification tags attached to 2 of the 8 fuel cells indicated that they did not fit properly on the helicopter. No QDRs were submitted to report the problem nor was action taken to return the two fuel cells to the manufacturer for replacement or repair.

Assessment of Existing Internal Controls. ATCOM did not assess internal controls over its quality program to validate whether minimum essential controls and procedures related to the quality function were in place and working. Although the Army Management Control Plan showed that the Army Quality Program was scheduled for an internal management control evaluation in FY 1992, the Army did not develop an internal management control review checklist for the functional area.

In a June 22, 1992, memorandum, the Deputy Assistant Secretary of the Army (Financial Operations) acknowledged the Assistant Secretary of the Army (Research, Development, and Acquisition) position that the identification of subtasks and the development of internal management control review checklists were not appropriate for the Army Quality Program (Appendix G). An internal management control evaluation of the Army Quality Program would have required ATCOM to assess specific internal management control objectives and techniques to determine whether quality deficiencies were properly reported and whether reported deficiencies were investigated and corrected. The conditions identified, such as failure to identify and report quality problems with CH-47D and AH-64 helicopter fuel cells and failure to correct reported deficiencies on AH-64 helicopter fuel cells, provide examples of specific weaknesses in the Army implementation of its Quality Program that need to be evaluated and corrected.

In-House Repair Capabilities for CH-47D and AH-64 Helicopter Fuel Cells

The Army did not develop adequate in-house repair capabilities for CH-47D and AH-64 helicopter fuel cells. Army maintenance personnel and fuel cell experts lacked the knowledge and experience necessary to identify the cause of failure on CH-47D and AH-64 helicopter fuel cells and to determine whether the cells were repairable. With the assistance of a Navy fuel cell expert, our evaluation to establish cause of failure and repairability of 146 unserviceable CH-47D and AH-64 helicopter fuel cells provided the following results.

Evaluating the Cause of Fuel Cell Failure. As a result of our August 1992 briefing to ATCOM regarding a potential problem with fuel cells manufactured by EFC, ATCOM sent a technical expert from the CH-47 Project Manager's Office to the field to evaluate the cause of the fuel cell failure. Before our evaluations, which began in September 1992, the ATCOM technical expert reported to us that the inside fuel cell blistering that we later identified was not a manufacturing problem but was caused by Army personnel performing maintenance. He also reported that the fuel cells were not repairable.

The CH-47 Project Manager's Office directed that an EFC representative and a different Army technical expert be present during our fuel cell evaluation at Fort Hood in September 1992. During the evaluation, the Army technical expert concluded that the repairs made to the fuel cells that caused the failures were made by Army maintenance personnel during field operations. However, contrary to the Army technical expert's conclusion, Fort Hood maintenance personnel emphatically stated that they did not perform any type of repairs on the fuel cells and that they were not aware of the repair materials and procedures referred to by the Army technical expert and the EFC contractor representative. In addition, the Navy fuel cell expert quickly pointed out that Navy fuel cells also experienced blistering on areas where the same repair material was applied. EFC, the manufacturer, acknowledged that the repair material was used to rework EFC cells during the manufacturing process. We

concluded that, without the technical knowledge provided by the Navy engineer to identify the blistering problem as a manufacturing defect and to provide insight that the blistering to the fuel cells was an interservice and not just an Army problem, the Army would not have acknowledged that the blistering was a manufacturing defect. Subsequently, EFC would not have initiated action to correct the fuel cell manufacturing defect.

Determining Repairability of Fuel Cells. ATCOM cited high scrap rates, ranging from 70 to 95 percent, on CH-47D and AH-64 helicopter fuel cells as the reason ATCOM did not actively pursue repair of the fuel cells. However, we determined that the scrap rates were higher than necessary because more than half of the fuel cells considered unserviceable were in fact repairable. In addition, the scrap rates cited for repairs were not adequately documented for either helicopter fuel cell.

CH-47D Helicopter Fuel Cells. During July 1992, ATCOM changed the recoverability code for CH-47D helicopter fuel cells from depot- to unit-level maintenance. According to senior ATCOM maintenance officials, their investigations showed that CH-47D helicopter fuel cells returned to the supply system as unserviceable were not repairable and should be scrapped without further investigation. However, we determined that 38 out of 67 (57 percent) of the CH-47D helicopter fuel cells considered unserviceable were repairable (Appendix A). We estimate that ATCOM could avoid $842,000 in future procurement costs by repairing unserviceable CH-47D helicopter fuel cells rather than scrapping them. See Appendix B for methodology used to compute monetary benefits.

AH-64 Helicopter Fuel Cells. The Army did not have a program at the time of our audit to repair AH-64 helicopter fuel cells. As of 1991, all unserviceable AH-64 helicopter fuel cells were shipped to storage facilities, pending further instructions. Before 1991, unserviceable cells were shipped to McDonnell Douglas for analysis. McDonnell Douglas, the designated depot repair facility for the AH-64 helicopter, determined whether the fuel cells were repairable. The repairable cells were then returned to the original fuel cell manufacturer for repair. As of 1991, ATCOM discontinued the policy of shipping unserviceable AH-64 helicopter fuel cells to McDonnell Douglas for evaluation and repair due to reported high scrap rates, ranging from 70 to 95 percent, and low monthly demand for fuel cells. The 70-percent scrap rate was based on data compiled and analyzed by McDonnell Douglas and provided in a memorandum to ATCOM. However, McDonnell Douglas stated in the memorandum that repair costs were low and that the continued evaluation and repair of fuel cells was economical.

Contractor records did not support a high scrap rate for AH-64 helicopter fuel cells. We obtained specific information regarding all unserviceable fuel cells that the Army shipped to McDonnell Douglas for evaluation through 1991. Analysis of McDonnell Douglas data showed a much lower scrap rate as summarized in the table on the following page.

Audit-Calculated Fuel Cell Scrap Rate

Action	Number of Cells	Percent
Shipped	94	100
Repaired*	52	55
Scrapped	42	45

*52 cells repaired includes 8 cells evaluated with no fault found and 10 cells scrapped and replaced by the fuel cell manufacturer at no cost to the Army.

The 45-percent scrap rate shown in the table above is significantly lower than the 70-to-95 percent scrap rate cited by ATCOM. Further analysis showed that the average repair cost was $620 per cell, significantly less than the average unit cost of $5,300 to purchase a new AH-64 helicopter fuel cell. Our analysis supports a policy for continued evaluation and repair of AH-64 helicopter fuel cells.

Evaluation of 79 unserviceable AH-64 helicopter fuel cells at Fort Hood and Corpus Christi and Letterkenny Army Depots showed that 52 (66 percent) of the cells were repairable (Appendix A). Additional fuel cells could have been repairable when initially turned in for repair. Documentation was not available to show how long the cells had been in storage; therefore, we could not determine whether an extended amount of time in storage allowed further deterioration on some cells to the extent that they were no longer repairable. Repairable defects should be repaired as soon as possible because once a fuel cell starts to deteriorate, the deterioration spreads and eventually destroys the fuel cell.

Repair Decisions Based on High Scrap Rates. ATCOM cited high scrap rates as the reason repairs on the CH-47D and AH-64 helicopter fuel cells were not pursued. The high scrap rate on the CH-47D helicopter fuel cell caused ATCOM to change the recoverability code from depot- to unit-level maintenance. Since repair capability at the unit level is limited, the change in recoverability code means that most CH-47D helicopter fuel cells will be scrapped. ATCOM discontinued the policy of shipping unserviceable AH-64 helicopter fuel cells to McDonnell Douglas for evaluation and repair because of high scrap rates. ATCOM had no plans to repair the unserviceable AH-64 helicopter fuel cells in the near future because of the Army excess inventory of AH-64 helicopter fuel cells. ATCOM also may decide to change the recoverability code for AH-64 helicopter fuel cells from depot- to unit-level maintenance. As a result, most of the 79 unserviceable AH-64 helicopter fuel cells would be scrapped as well.

Developing In-house Repair Capabilities. Although a significant number of unserviceable CH-47D and AH-64 helicopter fuel cells are repairable, the capability to repair the fuel cells does not currently exist within the Army. In a

December 15, 1992, memorandum to the Office of the Inspector General, DoD, ATCOM agreed that Army maintenance personnel lacked training and experience in the inspection and repair of fuel cells (Appendix H, pages 54 and 55).

ATCOM Proposed Actions. In its December 15, 1992, memorandum, ATCOM stated that it would clarify existing technical instructions regarding the inspection and repair of blistered fuel cells and provide training on the inspection and repair of fuel cells to unit and intermediate maintenance personnel. In addition, ATCOM planned to immediately fund EFC visits to specific Army activities so that EFC technicians could teach CH-47 structural mechanics and inspectors how to properly inspect and repair fuel cells (Appendix H, pages 55 and 56).

Army Fuel Cell Repair Capabilities. The actions proposed by ATCOM, while beneficial, would not completely correct Army problems with fuel cells. In its December 15, 1992, memorandum, ATCOM did not consider the need to perform fuel cell repairs beyond the unit's limited capability. As a result, unserviceable fuel cells that are not repairable at the unit level will be scrapped.

Fuel Cell Repairs Beyond the Unit-level. The ATCOM management decision to change the recoverability code for CH-47D helicopter fuel cells from depot- to unit-level maintenance was not sound because unit-level maintenance capabilities are extremely limited. For instance, GAO Report NSIAD-90-214 identified problems with a similar policy for F-15 aircraft fuel cells in the Air Force (see Part I, Prior Audits and Other Reviews). The report stated that the Air Force was discarding unserviceable F-15 aircraft fuel cells prematurely because major repairs of fuel cells were beyond the base-level (unit-level) capabilities.

Furthermore, the Navy fuel cell expert advised that maintenance personnel must be extremely cautious when making repairs to the inside of a fuel cell to avoid puncturing or damaging the protective barrier. The barrier prevents fuel from activating the sealant. Repairs to fittings, such as repairs required due to corrosion, are also difficult due to the criticality of the tolerances on the fittings. Repairs beyond the unit level require a more comprehensive knowledge of the how the fuel cell is built and an in-depth understanding of the critical parts of the fuel cell. Accordingly, the Navy and now the Air Force require expertise beyond the unit level to make repairs and to evaluate all unserviceable aircraft fuel cells to determine whether the fuel cells should be scrapped.

Additional Expertise Required. Although ATCOM stated that EFC technicians would provide training, AMFUEL said that EFC's repair material and procedures were not effective in repairing fuel cells manufactured by AMFUEL. Although EFC could teach CH-47 structural mechanics and inspectors some techniques to inspect and repair both fuel cells, we do not believe that, based on AMFUEL's comments, the training would be sufficient to enable Army technicians to adequately repair AMFUEL cells. AMFUEL officials offered to provide no-cost fuel cell repair and maintenance training to

maintenance personnel in all the Military Departments. Although AMFUEL provided training to Navy and Air Force maintenance personnel at various times from 1986 through 1992, the Army never took advantage of the offer.

Navy Fuel Cell Repair Capabilities. The Navy already has an adequate repair facility for helicopter fuel cells. This facility, located at the Naval Aviation Depot, Pensacola, Florida, can provide depot-level repair for Army CH-47D and AH-64 helicopter fuel cells. The in-depth Navy knowledge of fuel cells evolved through day-to-day interaction between Navy in-house engineers and maintenance personnel responsible for fuel cell repairs. The Navy gained this valuable experience in the repair of helicopter fuel cells by taking an aggressive approach to expand existing repair capabilities and to maintain continuity in key engineering and maintenance positions. The Navy has a formal agreement with the Air Force, referred to as a Depot Maintenance Interservice Support Agreement, to repair Air Force helicopter fuel cells and other repairable items not otherwise covered by commercial contract.

Maximum Use of Existing Repair Capabilities. In light of the Navy's existing technical expertise and the lack of existing Army expertise, establishing an Army in-house repair capability may not be in the best interest of the Army. The benefits to be gained from the Navy's knowledge and experience were demonstrated during our evaluation of the Army unserviceable CH-47D and AH-64 helicopter fuel cells. The Navy fuel cell expert's in-depth knowledge prevented ATCOM from scrapping at least 90 CH-47D and AH-64 helicopter fuel cells that were repairable.

In keeping with the spirit of current Government reform initiatives, we concluded that the Army should perform a cost-benefit analysis to determine whether the Navy or Army can provide the most efficient depot-level inspection and repair of crash-resistant, self-sealing fuel cells.

Storing, Handling, and Shipping Fuel Cells

Review of 146 fuel cells located at 4 Army sites showed that 42 were damaged because of improper storage and handling (Appendixes C and E). Of the 146 fuel cells, 21 were damaged beyond repair. The most significant problem occurred at Letterkenny Army Depot with the AH-64 helicopter forward fuel cell. The forward fuel cell collapses more easily because of its "L" shape, as seen in Figure 3. Fifteen of the forward fuel cells at Letterkenny Army Depot collapsed in their shipping containers and could not be straightened out. When the cells remain collapsed over a period of time, the self-sealing material migrates away from the creases in the fuel cell wall, leaving no self-sealing ability in the area and causing separation between plys.

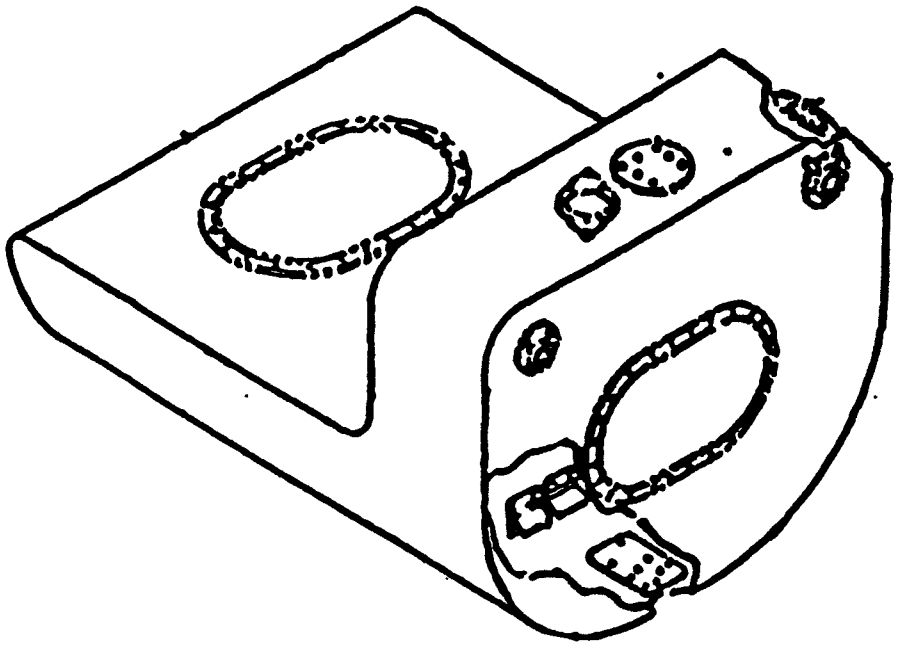


Figure 3. AH-64 Helicopter Forward Fuel Cell

The storing, handling, and shipping problems we identified are similar to those outlined in GAO Report AFMD-93-8 (see Part I, Prior Audits and Other Reviews).

The Army has general guidance for handling and storing self-sealing fuel cells. General Aircraft Maintenance Manual 55-1500-204-25/1, chapter 3, requires that all self-sealing fuel cells must be supported to prevent collapse and creasing. The manual also states that fuel cells should be handled with extreme care to prevent contact with sharp or pointed objects or abrasive surfaces. In addition, EFC Repair and Maintenance Manual AP 430, October 1990, states that hard folds in the wall of a self-sealing tank (fuel cell) will displace the sealant if the tank is folded for more than 4 hours.

In response to the GAO recommendations, the Army agreed to issue a compliance directive requiring all units to follow packaging instructions outlined in DoD and Army regulations when shipping repairables. If these actions are implemented, the problems we identified will be corrected as well and, therefore, no additional recommendations are required.

Recommendations, Management Comments, and Audit Response

We recommend that the Commander, Army Aviation Troop Command:

1. Establish procedures to consider the expected useful life for CH-47D and AH-64 helicopter fuel cells to:

a. Make economic repair and replacement decisions.

b. Use as an internal management control objective to help verify the quality of helicopter fuel cells.

Management Comments. The Army concurred and stated that it will evaluate the current life cycle of fuel cells to ensure proper management with respect to inventory levels, maintenance levels, and sister-Service depot options. The Army stated that it will also assess the recoverability code of all fuel cells with the goal of standardization, if possible, and to assure appropriate economic repair decisions are being made at the unit level. Furthermore, ATCOM will evaluate the qualification procedures for fuel cells to ensure any changes to repair procedures are evaluated and approved by the Army. The Army stated that fuel cell useful life will be factored in as an internal management control objective to assist in the management of fuel cell inventory.

Audit Response. We ask that the Army provide a completion date for the planned actions when responding to the final report.

2. Require an internal control assessment of the Army Aviation Troop Command quality program to identify internal control weaknesses and to determine whether identified weaknesses are reported and corrected.

Management Comments. The Army concurred and stated that the ATCOM will review the QDR program to ensure that quality deficiencies are reported, assessed, and acted on.

Audit Response. The planned action of the Army satisfies the intent of the recommendation. However, the target date for completing the review was not provided in the response. We ask that the Army provide a completion date for the planned actions in response to the final report.

3. Instruct field units to submit quality deficiency reports on all fuel cells that experience inside blistering and outside delamination.

Management Comments. The Army concurred with the recommendation, stating that the Aviation Safety Action Message will address QDRs as a vehicle to identify problems with the quality of material.

Audit Response. The August 16, 1993, Aviation Safety Action Message addressed the need to submit QDRs on CH-47 and MH-47 helicopter fuel cells.

The message did not discuss the need to report quality deficiencies identified on fuel cells for other helicopters. Therefore, we request the Army to provide the date the planned action is to be accomplished in response to the final report.

4. Change the recoverability code to specify that CH-47D helicopter fuel cells are repairable at the depot level.

Management Comments. The Army concurred with the intent of the recommendation and stated that it would reassess the recoverability code to assure unit/scrap decisions are being made with due consideration for procurement costs.

Audit Response. We ask that the Army provide a completion date in response to the final report.

5. Issue excess AH-64 helicopter fuel cells to McDonnell Douglas Helicopter Company as Government-furnished material for installation on future helicopter production.

Management Comments. The Army concurred with the intent of the recommendation, stating that costs associated with modification of contracts with McDonnell Douglas Helicopter Company to terminate ongoing subcontracts for fuel cells could easily overshadow savings realized by using existing fuel cells as Government-furnished material. The Army further stated that the Apache Program Manager is aware of the availability of fuel cells as Government-furnished material for any future requirements.

Audit Response. We agree with the Army comments and have revised our recommendation accordingly. We are aware of a potential future requirement of 44 AH-64 helicopters to be produced upon completion of the current helicopter production schedule through June 1994. We request the Army to provide additional comments to the final report on whether fuel cells in inventory can be used as Government-furnished material.

6. Perform a cost-benefit analysis to determine whether it is more efficient for the Army or the Navy to provide depot-level inspection and repair of Army crash-resistant, self-sealing fuel cells.

7. If the results of the cost-benefit analysis in Recommendation 6. determine that using existing Navy depot repair facilities is more efficient, establish a memorandum of understanding with the Navy to have the Navy provide depot-level inspection and repair of all unserviceable Army crash-resistant, self-sealing fuel cells.

8. Initiate immediate action to repair all unserviceable CH-47D and AH-64 helicopter fuel cells that are repairable in accordance with the established memorandum of understanding with the Navy or at Army facilities, as appropriate.

Management Comments. The Army nonconcurred with the recommendations and stated that it is Army policy to perform maintenance at the lowest level possible. The assessment of unit-level repair and the recoverability code, discussed in the Army response to Recommendation B.1., will determine whether fuel cells are being repaired or scrapped on an economical basis. The Army further stated that if the units are not capable of making the repairs that could be performed by depots on an economical basis, then the Army will reexamine the issue.

Audit Response. We agree that, with proper training, equipment, and procedures, unit-level maintenance personnel should be able to make minor repairs, such as correcting the interior blistering problem. However, Army unit- and depot-level maintenance personnel do not have the equipment or technical expertise to perform major repairs such as those related to fittings or activation of the fuel cell. Activation occurs when fuel comes in contact with the sealant, causing the sealant to swell. For example, Army repair procedures do not authorize repair of activated fuel cells at any level. The Navy is successfully and economically performing these major repairs at the depot level. The Army comments did not address how the Army would perform the assessments or whether the assessments would include major repairs. Therefore, we request that the Army reconsider its position on the recommendations and provide additional comments to the final report.

Management Comments on the Monetary Benefits

Management Comments. The Army concurred with the claimed savings of $84,500, stating that the fuel cells that were repaired by EFC in the field were planned to be disposed of in the field. The Army nonconcurred with the estimated $1 million of monetary benefits related to cancellation of existing AH-64 helicopter fuel cell subcontracts with McDonnell Douglas Helicopter Company. The Army stated that no dollar savings can be realized at this time because the Army has no current AH-64 helicopter production requirements that could use fuel cells as Government-furnished material. The Army also nonconcurred with the estimated $1 million of monetary benefits related to reduction of future CH-47D helicopter fuel cell procurements, stating that the Army never intended to procure 300 CH-47D helicopter fuel cells to replenish the depleted fuel cell inventory. The Army also stated that part of the Army decision not to initiate further procurement considered the fact that actions being taken to institute unit-level repair would reduce future procurement requirements. In a September 2, 1993, memorandum, which we received after the Army comments, ATCOM stated that unit-level maintenance personnel repaired at least 150 unserviceable CH-47D helicopter fuel cells and that without those repairs, procurement of 47 main fuel cells and 103 auxiliary fuel cells would have been required.

Audit Response. We accept the Army response on the $84,500 of monetary benefits. We agree with the Army response to the estimated $1 million of monetary benefits resulting from cancellation of existing AH-64 helicopter fuel

cell subcontracts. However, we are aware of a potential future requirement for 44 AH-64 helicopters, resulting in an estimated $468,000 reduction in future procurement costs. We partially agree with the Army response to the estimated $1 million of monetary benefits related to reduction of future CH-47D helicopter fuel cell procurement costs. Based on the comments from ATCOM, we revised our estimate to $842,000 to reflect the cost of the additional fuel cells that would have been required if the 150 unserviceable fuel cells were scrapped. We ask that the Army, in its response to the final report, reconsider the Army position related to monetary benefits based on our revised estimates of $468,000 and $842,000.

Response Requirements Per Recommendation

Responses to the final report are required for the items indicated with an "X" in the chart below.

	Response Should Cover:			
Number	Concur/ Nonconcur	Proposed Action	Completion Date	Related Issues*
B.1.a.			X	
B.1.b.			X	M
B.2.			X	
B.3.			X	
B.4.			X	
B.5.	X	X	X	M
B.6.	X	X	X	
B.7.	X	X	X	
B.8.	X	X	X	M

*M = monetary benefits.

Part III - Additional Information

Appendix A. Age and Repairability of Unserviceable Fuel Cells

CH-47D Helicopter Fuel Cells Manufactured By EFC[1]

Serial No.	Date Of Manufacture	Age From Date Of Manufacture To 1992 (years)	Repairable[2] Yes	No
81-03344	1981	11	X	
84-07696	1984	8	X	
84-07734	1984	8	X	
84-07737	1984	8	X	
84-07763	1984	8		X
84-07764	1984	8		X
84-07767	1984	8		X
84-07768	1984	8	X	
84-07772	1984	8		X
84-07786	1984	8		X
84-07788	1984	8		X
84-07789	1984	8		X
84-07799	1984	8	X	
84-05394	1985	7	X	
85-01635	1985	7		X
85-01641	1985	7		X
85-01691	1985	7		X
85-01733	1985	7	X	
85-01797	1985	7	X	
85-01801	1985	7		X
85-03759	1985	7		X
85-03761	1985	7		X
85-03765	1985	7	X	
85-03770	1985	7		X
85-03775	1985	7		X
85-03779	1985	7	X	
85-03786	1985	7		X
85-03795	1986	6	X	
86-04479	1986	6	X	
86-04492	1986	6	X	

See footnotes at end of appendix.

CH-47D Helicopter Fuel Cells Manufactured By EFC[1] (cont'd)

Serial No.	Date Of Manufacture	Age From Date Of Manufacture To 1992 (years)	Repairable[2] Yes	No
86-04495	1986	6	X	
86-04522	1986	6	X	
86-04525	1986	6	X	
86-04580	1986	6	X	
86-04613	1986	6	X	
86-04617	1986	6	X	
86-04625	1986	6	X	
86-04639	1986	6		X
86-04645	1986	6		X
86-04646	1986	6	X	
86-04656	1986	6	X	
86-04676	1986	6	X	
86-04682	1986	6	X	
86-04723	1986	6	X	
86-04728	1986	6	X	
86-04732	1986	6	X	
86-05577	1986	6	X	
86-05582	1986	6	X	
86-05598	1986	6		X
87-07280	1987	5	X	
87-07283	1987	5	X	
87-07342	1987	5	X	
87-07344	1987	5	X	
87-07346	1987	5	X	
89-04068	1989	3	X	
89-04122	1989	3	X	

Average Age		6.5 years
Evaluated		57
Repairable		38
Nonrepairable		19
Repair Rate	38 Repairable / 57 Evaluated =	67 percent

See footnotes at end of appendix.

Appendix A. Age and Repairability of Unserviceable Fuel Cells

CH-47D Helicopter Fuel Cells Manufactured By AMFUEL[3]

Serial No.	Date Of Manufacture	Age From Date Of Manufacture To 1992 (years)	Repairable[2] Yes	Repairable[2] No
90-06605	1990	2	X	
M-CU189	1974	18		X
M-CU265	1974	18		X
M-CU324	1974	18		X
MCU-9409	1974	18		X
CU6641	1975	17		X
M-CU768	1976	16		X
M-CU772	1976	16		X
M-CU865	1977	15		X
M-CU942	1977	15		X
M-1024	1982	10		X

Average Age		16.1 years
Evaluated		10
Repairable		0
Nonrepairable		10
Repair Rate	$\frac{0 \text{ Repairable}}{10 \text{ Evaluated}} =$	0 percent

CH-47D Helicopter Fuel Cell Summary		
Evaluated		67
Repairable		38
Nonrepairable		29
Repair Rate	$\frac{38 \text{ Repairable}}{67 \text{ Evaluated}} =$	57 percent

See footnotes at end of appendix.

AH-64 Helicopter Fuel Cells Manufactured By EFC[1]

Serial No.	Date Of Manufacture	Age From Date Of Manufacture To 1992 (years)	Repairable[2] Yes	No
85-03841	1985	7		X
86-03840	1986	6	X	
86-05240	1986	6		X
86-05254	1986	6		X
86-05266	1986	6		X
86-05268	1986	6		X
86-05272	1986	6		X
86-05280	1986	6	X	
86-05284	1986	6		X
86-05289	1986	6	X	
86-05299	1986	6	X	
86-05304	1986	6	X	
86-05310	1986	6	X	
86-05311	1986	6	X	
86-05314	1986	6	X	
86-05319	1986	6	X	
86-05329	1986	6		X
86-05340	1986	6		X
86-05346	1986	6	X	
86-05347	1986	6	X	
86-05375	1986	6		X
86-05379	1986	6	X	
86-05399	1986	6	X	
86-05434	1986	6		X
86-05467	1986	6	X	
86-05469	1986	6	X	
86-05470	1986	6	X	
86-05475	1986	6		X
86-05487	1986	6		X
86-05493	1986	6	X	
86-05499	1986	6		X
86-05500	1986	6	X	
86-05508	1986	6	X	
86-05515	1986	6	X	
86-05516	1986	6	X	

See footnotes at end of appendix.

Appendix A. Age and Repairability of Unserviceable Fuel Cells

AH-64 Helicopter Fuel Cells Manufactured By EFC[1] (cont'd)

Serial No.	Date Of Manufacture	Age From Date Of Manufacture To 1992 (years)	Repairable[2] Yes	No
87-07497	1987	5		X
87-08623	1987	5	X	
88-02349	1988	4	X	
89-03309	1989	3	X	
89-03341	1989	3	X	
89-03345	1989	3	X	
89-03348	1989	3		X

Average Age		5.6 years
Evaluated		42
Repairable		26
Nonrepairable		16
Repair Rate	26 Repairable / 42 Evaluated =	62 percent

AH-64 Helicopter Fuel Cells Manufactured By AMFUEL[3]

0031	1984	8	X	
0045	1984	8	X	
0076	1984	8	X	
0100	1984	8		X
0104	1985	7		X
0127	1985	7		X
0129	1985	7	X	
0130	1985	7		X
0135	1985	7	X	
0144	1985	7	X	
0159	1985	7	X	
0165	1985	7		X
0169	1985	7	X	
0175	1985	7		X

See footnotes at end of appendix.

AH-64 Helicopter Fuel Cells Manufactured By AMFUEL[3] (cont'd)

Serial No.	Date Of Manufacture	Age From Date Of Manufacture To 1992 (years)	Repairable[2] Yes	No
Unknown	1985	7		X
0185	1985	7	X	
0196	1986	6		X
0201	1986	6		X
0215	1986	6	X	
0227	1987	5		X
0248	1987	5	X	
0296	1987	5	X	
0300	1987	5	X	
0304	1987	5	X	
0309	1987	5	X	
0323	1987	5	X	
0333	1987	5	X	
0335	1987	5	X	
Unknown	1987	5	X	
0348	1988	4	X	
0392	1988	4	X	
0425	1988	4		X
0428	1988	4	X	
Unknown	1988	4	X	
0462	1989	3	X	
0584	1989	3	X	
0581	1990	2	X	

Average Age	5.7 years
Evaluated	37
Repairable	26
Nonrepairable	11
Repair Rate $\frac{\text{26 Repairable}}{\text{37 Evaluated}}$ =	70 percent

See footnotes at end of appendix.

AH-64 Helicopter Fuel Cell Summary		
Evaluated		79
Repairable		52
Nonrepairable		27
Repair Rate	52 Repairable / 79 Evaluated =	66 percent

Total CH-47D and AH-64 Helicopter Fuel Cell Summary		
Evaluated		146
Repairable		90
Nonrepairable		56
Repair Rate	90 Repairable / 146 Evaluated =	62 percent

[1]EFC was previously owned by Goodyear Aerospace Corporation and Loral Corporation.
[2]As determined by Navy technical expert.
[3]AMFUEL purchased Firestone Operating Divisions and Uniroyal.

Appendix B. Cost Avoidance on Future CH-47D Helicopter Fuel Cell Procurements

Based on the September 2, 1993, ATCOM memorandum (Part IV, page 74), the Army would have been required to procure a minimum of 150 CH-47D helicopter fuel cells (47 main cells and 103 auxiliary cells) if unit-level repairs had not been performed. Using the most recent prices for main and auxiliary fuel cells, we computed the cost avoidance as shown below.

Number of main fuel cells repaired	47
Average cost per main fuel cell	$ 7,212
Number of auxiliary fuel cells repaired	103
Average cost per auxiliary fuel cell	$ 5,784
Cost avoidance on procurement	934,716[1]
Less average repair cost $620 per fuel cell	(93,000)[2]
Net cost avoidance	$841,716

[1] $7,212 x 47 = $338,964
5,784 x 103 = 595,752
$934,716

[2] $ 620 x 150 = $ 93,000

Appendix C. Causes of CH-47D Helicopter Fuel Cell Failures

Fuel Cells Manufactured by EFC

Serial No.	Date Of Manufacture	Storing/ Handling[1]	Blistering[2]	Activation[3]	Fitting Damage[4]	Delamination[5]	Other[6]
81-03344	1981		X				
84-07696	1984		X	X			
84-07734	1984		X				
84-07737	1984		X				
84-07763	1984			X			
84-07764	1984	X	X	X			
84-07767	1984		X	X			
84-07768	1984		X				
84-07772	1984			X			
84-07786	1984	X	X	X			
84-07788	1984	X	X	X			
84-07789	1984		X	X			
84-07799	1984						Unknown
84-05394	1985		X				
85-01635	1985		X	X			
85-01641	1985		X	X			
85-01691	1985		X	X			
85-01733	1985		X				
85-01797	1985		X				
85-01801	1985		X				
85-03759	1985		X	X			
85-03761	1985		X	X			
85-03765	1985		X	X			
85-03770	1985		X	X	X		
85-03775	1985		X	X			
85-03779	1985		X				
85-03786	1985		X	X			
85-03795	1986		X				
86-04479	1986		X	X			

See footnotes at end of appendix.

Fuel Cells Manufactured by EFC (cont'd)

Serial No.	Date Of Manufacture	Storing/ Handling[1]	Blistering[2]	Activation[3]	Fitting Damage[4]	Delamination[5]	Other[6]
86-04492	1986		X				
86-04495	1986		X	X			
86-04522	1986						Liner Cut
86-04525	1986		X			X	
86-04580	1986		X				
86-04613	1986	X	X				
86-04617	1986	X	X				
86-04625	1986		X				
86-04639	1986		X	X			
86-04645	1986		X				
86-04646	1986		X				
86-04656	1986		X				
86-04676	1986		X				
86-04682	1986		X				
86-04723	1986		X			X	
86-04728	1986		X				
86-04732	1986		X				
86-05577	1986		X				
86-05582	1986		X				
86-05598	1986		X	X			
87-07280	1987		X	X			
87-07283	1987		X				
87-07342	1987	X	X				
87-07344	1987		X				
87-07346	1987		X				
89-04068	1989	X			X		

See footnotes at end of appendix.

Fuel Cells Manufactured by EFC (cont'd)

Serial No.	Date Of Manufacture	Storing/ Handling[1]	Blistering[2]	Activation[3]	Fitting Damage[4]	Delamination[5]	Other[6]
89-04122	1989	X				X	
90-06605	1990	—	—	—	—	X	
Subtotal		8	50	22	2	4	
Fuel Cells Manufactured by AMFUEL							
M-CU189	1974			X			Age
M-CU265	1974			X			Age
M-CU324	1974			X			Age
MCU-9409	1974			X			Age
CU6641	1975			X			Age
M-CU768	1976			X			Age
M-CU772	1976			X			Age
M-CU865	1977			X			Age
M-CU942	1977			X			Age
M-1024	1982	—	—	X	—	—	
Subtotal		0	0	10	0	0	
Total[7]		8	50	32	2	4	

[1] Further damage caused by improper storing and handling by customer.
[2] Failures caused by manufacturer's repair procedures.
[3] Failures caused by fuel coming in contact with sealant, causing sealant to swell.
[4] Damage caused by corrosion to one or more of the fittings on the fuel cell.
[5] Failure caused by fuel or other fluids coming in contact with exterior cell wall, causing woven materials contained in exterior wall to separate.
[6] Age was the main cause of failure for 9 AMFUEL fuel cells at least 15 years old, which is their expected useful life. The other two failures did not fit under other descriptions.
[7] Some fuel cells experienced more than one type of failure; therefore, total number of failures will not equal total cells reviewed. We reviewed a total of 67 CH-47D fuel cells: 57 manufactured by EFC and 10 manufactured by AMFUEL.

Appendix D. CH-47D Helicopter Fuel Cell Scrap Rates From Boeing Helicopters

DEFENSE LOGISTICS AGENCY
DEFENSE CONTRACT MANAGEMENT COMMAND
DEFENSE CONTRACT MANAGEMENT DISTRICT MID-ATLANTIC
PLANT REPRESENTATIVE OFFICE BOEING HELICOPTERS
POST OFFICE BOX 16858
PHILADELPHIA, PENNSYLVANIA 19142-0858

IN REPLY REFER TO DCMDM-PEAC

2 February 1993

SUBJECT: Request for Assistance Related to CH-47 Fuel Cells

TO: Department of Defense Inspector General
ATTN: Myra Frank
400 Army Navy Drive
Arlington, VA 22202-2884

2. In response to telephonic requests from your office, the following information is provided.

a. Number of incoming CH-47 fuel cells scrapped, by vendor:

Am Fuel - 14% (18 of 124)

Engineering Fab - 83% (44 of 53)

This data is for contract DAAJ09-89-C-A010 and is based on records maintained by Boeing Helicopters in the Government Property Unit (GPU).

b. Number of fuel cells purchased by Boeing Helicopters during the last two fiscal years:

Am Fuel:

- 95 ea. main fuel cells for Ch-47D

- 95 ea. long range fuel cells for the MH-47E Special Operations Aircraft. (Am Fuel is the only approved source for this spec. controlled part)

Engineering Fab:

- 58 ea. main fuel cells for CH-47D

This data is for the previous two fiscal years and was extracted by the Boeing Helicopters buyer from computer records maintained in BH Materiel Department. This system maintains information for only the last two fiscal years. Additional data can be requested by the undersigned through BH Contracts Department at your direction.

Appendix D. CH-47D Helicopter Fuel Cell Scrap Rates From Boeing Helicopters

2. If any additional information is required, please contact the undersigned at AVN 444-3817 or Commercial (215) 591-8512.

Rosemary Ormsby

ROSEMARY ORMSBY
Chief, Contract Operations Branch

Appendix E. Causes of AH-64 Helicopter Fuel Cell Failures

Fuel Cells Manufactured by EFC

Serial No.	Date Of Manufacture	Storing/ Handling[1]	Blistering[2]	Activation[3]	Fitting Damage[4]	Delamination[5]	Other[6]
85-03841	1985	X	X		X		
86-03840	1986		X				
86-05240	1986	X	X	X			
86-05254	1986			X		X	
86-05266	1986	X	X				
86-05268	1986	X		X			
86-05272	1986	X	X	X			
86-05280	1986		X		X	X	
86-05284	1986	X	X	X		X	
86-05289	1986	X	X				
86-05299	1986	X		X			
86-05304	1986	X	X			X	
86-05310	1986	X	X				
86-05311	1986						New, Unknown
86-05314	1986	X				X	
86-05319	1986	X	X				
86-05329	1986	X	X	X			
86-05340	1986	X	X	X			
86-05346	1986	X					
86-05347	1986	X					
86-05375	1986			X			
86-05379	1986						New, Unknown
86-05399	1986		X			X	
86-05434	1986	X	X	X		X	
86-05467	1986		X			X	
86-05469	1986		X	X		X	
86-05470	1986		X			X	

See footnotes at end of appendix.

Serial No.	Date Of Manufacture	Storing/ Handling[1]	Blistering[2]	Activation[3]	Fitting Damage[4]	Delamination[5]	Other[6]
86-05475	1986			X			
86-05487	1986		X	X			
86-05493	1986		X	X		X	
86-05499	1986					X	
86-05500	1986		X				
86-05508	1986		X				
86-05515	1986		X			X	
86-05516	1986			X			
87-07497	1987		X	X		X	
87-08623	1987						New, Unknown
88-02349	1988	X	X	X		X	
89-03309	1989	X			X		
89-03341	1989		X		X		
89-03345	1989	X					
89-03348	1989	X	—	X	—	—	
Subtotal[7]		21	26	18	4	15	
Fuel Cells Manufactured by AMFUEL							
0031	1984			X			
0045	1984				X		
0076	1984						Exposed Fabric
0100	1984	X		X			
0104	1985			X	X	X	
0127	1985	X		X	X		

See footnotes at end of appendix.

Serial No.	Date Of Manufacture	Storing/ Handling[1]	Blistering[2]	Activation[3]	Fitting Damage[4]	Delamination[5]	Other[6]
0129	1985						Deteriorated Inner Liner
0130	1985			X			
0135	1985					X	
0144	1985	X					
0159	1985						Unknown
0165	1985	X			X		
0169	1985						Unknown
0175	1985	X					
Unknown	1985			X	X		
0185	1985	X		X			
0196	1986	X		X			
0201	1986	X					Deteriorated Inner Liner
0215	1986	X			X		
0227	1987	X		X			
0248	1987				X		
0296	1987						New, Unknown
0300	1987				X		
0304	1987	X			X		
0309	1987						New, Unknown
0323	1987						New, Did Not Fit
0333	1987	X			X		
0335	1987						New, Did Not Fit
Unknown	1987						Deteriorated Inner Liner
0348	1988						New, Unknown

See footnotes at end of appendix.

Serial No.	Date Of Manufacture	Storing/ Handling[1]	Blistering[2]	Activation[3]	Fitting Damage[4]	Delamination[5]	Other[6]
0392	1988				X		
0425	1988	X			X		
0428	1988				X		
Unknown	1988					X	
0462	1989						Liner Chafed
0584	1989						Liner Chafed
0581	1990	_	_	_	X	_	
Subtotal[7]		13	0	9	14	3	
Total[7,8]		34	26	27	18	18	

[1] Further damage caused by improper storing and handling by customer.
[2] Failures caused by manufacturer's repair procedures.
[3] Failures caused by fuel coming in contact with sealant, causing sealant to swell.
[4] Damage caused by mishandling or corrosion to one or more of the fittings on the fuel cell.
[5] Failure caused by fuel or other fluids coming in contact with exterior cell wall, causing woven materials contained in exterior wall to separate.
[6] Failures for 16 fuel cells were either unknown or did not fit under other descriptions.
[7] Some fuel cells experienced more than one type of failure therefore total number of failures will exceed total cells reviewed. We reviewed a total of 79 AH-64 fuel cells: 42 manufactured by EFC and 37 manufactured by AMFUEL.
[8] Of the 79 cells reviewed, 8 were new so actual number of cells that failed prematurely is 71. Of the 71 fuel cells, 39 were manufactured by EFC and 32 were manufactured by AMFUEL.

Appendix F. EFC Removal of 82C12 Rework Barrier

ENGINEERED FABRICS
Corporation

669 Goodyear Street
Rockmart, GA 30153
(404) 684-7855
Fax: (404) 684-7438

February 25, 1993

Salvatore D. Guli, Program Director
Department of Defense
Office of Inspector General
Contract Management
400 Army Navy Drive
Arlington, Virginia 22202

Reference: Removal of 82C12 Rework Barrier From Crashworthy Fuel Tank Reworks

Dear Sal:

Previous test results identify EFC 82C12 rework barrier at temperatures of 200F and above as causing blistering in reworks observed in Crashworthy fuel tanks. It is recommended that the 82C12 rework barrier be eliminated and replaced in 82C18 Crashworthy fuel tank reworks.

EFC is evaluating alternate materials to replace 82C12 rework barrier. The scope of the rework material evaluation is to provide a material or material combinations for use inside the fuel tank in plain flat areas and in complex contoured areas. The evaluation includes materials presently used and approved for use in fuel tanks. Materials utilizing the fuel tank nylon barrier is one example of this as seen during your recent visit to EFC. Parallel to the material evaluation and testing, the production process will be continually studied and reviewed to reduce the need for reworks.

Existing and approved materials provide three key advantages to the value of this study. Existing materials are familiar to the users. Existing materials have an accumulated history and have shown success in the fuel tank environment. Finally, existing materials are already approved to Phase I and II Qualification testing of Mil-T-27422B. Only testing to ensure integrity and compatibility at temperatures beyond Mil-T-27422B is needed. These advantages will reduce the evaluation and the testing time required of new materials. The effects will be the rapid replacement of 82C12 rework barrier from Crashworthy fuel tank reworks.

Testing will include the reverification of the adhesion of the composite rework samples to the Nitrile innerliner in fuel. This will be done both at ambient and at elevated temperatures per Mil-T-27422B. To evaluate barrier stability, all composite rework samples will be tested at temperatures beyond the 160F requirements of Mil-T-27422B. The test report will be completed and submitted to the local government representative for approval in approximately 3 months.

V. Y. Brooks,
Compounder Specialist

Appendix G. Deleting Internal Management Control Reviews of the Army Quality Program

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, DC 20310-0103
22 June 1992

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (RESEARCH, DEVELOPMENT AND ACQUISITION)

ATTN: SARD-DEP

SUBJECT: The Army Internal Management Control Program

Reference your memorandum, 18 June 1992, subject: Review of the Army Management Control Plan (extract attached).

The Management Control Plan (MCP) changes requested by your memorandum have been made and will be reflected in the updated MCP for FY 93-97, which is scheduled to be published by 1 October 1992. These changes include the deletion of three subtasks and the associated checklists on page 31 of the MCP: Army Material Systems RAM Program, Army Quality Program, and Production Readiness, Management and Review. The rationale provided for these deletions was that "policy and guidance in these areas are encompassed by DODI 5000.2 and AR 70-1, neither of which require internal controls."

I feel that some clarification is needed on this point. First, no function in the Army is exempt from the requirements of the Federal Managers Financial Integrity Act of 1982 (PL 97-255), and the implementing OMB, DOD and Army directives. Second, the fact that the governing directive might be a DOD Directive or Instruction, rather than an Army Regulation, does not obviate the need for the identification of subtasks or the development of checklists under the Army's Internal Management Control Program.

The only justification required for a decision to delete these subtasks and checklists from the MCP is a determination by the ASA(RDA), as the HQDA Functional Proponent for acquisition management, that such is not appropriate. Your memorandum has provided this determination.

Charles A. Chase
Deputy Assistant Secretary of the Army
(Financial Operations)

Attachment

Appendix H. Actions Taken by ATCOM During the Audit

DEPARTMENT OF THE ARMY
HEADQUARTERS, US ARMY AVIATION AND TROOP COMMAND
4300 GOODFELLOW BOULEVARD, ST. LOUIS, MO 63120-1798

REPLY TO ATTENTION OF

AMSAT-B-L (36-5e) 15 December 1992

MEMORANDUM FOR Mr. Salvatore D. Guli, DODIG, 400 Army Navy Drive, Arlington, Virginia 22202-2884

SUBJECT: Command Comments to the Department of Defense Inspector General (DODIG) Memorandum on Procurement of Aircraft Fuel Cells for CH-47D Helicopters, DODIG Hotline Audit of Aircraft Fuel Cell Procurements (Project No. 2CF-8014) (AMC No. D9240) (ATCOM Project No. 04-0692-410)

1. Reference memorandum, DODIG, 26 Oct 92, subject: Procurement of Aircraft Fuel Cells for CH-47D Helicopters.

2. The enclosed comments represent the Aviation PEO and ATCOM position on the subject DODIG memorandum.

3. Point of contact for this action is Mr. Charles I. Horn, DSN 693-3736 or Commercial (314) 263-3736.

Donald R Williamson

DONALD R. WILLIAMSON
Major General, USA
Commanding

Encl

Mr Guli -
Good work! Although there are some "puts and takes" in our response, your audit brought the right attention to the fuel cell problem. Appreciate very much your effort - that will result in a better product for our Aviation Soldiers.
Joe

Part IV - Management Comments

Appendix H. Actions Taken by ATCOM During the Audit

COMMAND COMMENTS
DEPARTMENT OF DEFENSE INSPECTOR GENERAL
DODIG MEMORANDUM, 26 OCT 92, SUBJECT:
PROCUREMENT OF AIRCRAFT FUEL CELLS FOR CH-47D HELICOPTERS
(ATCOM PROJECT NO. 04-0692-410)

1. The following comments are keyed to the paragraphs in the DODIG memorandum.

a. First paragraph, lines 5, 6, 7, and 8. In reference to the comments made about the problems with EFC's fuel cell, it should be noted that when this problem with blistering was discovered in 1987, we removed EFC as a vendor. Then EFC was requalified in accordance with the revised Boeing Helicopter specification which required a 60 day external fuel resistance test, rather than the 3 day test specified in Military Specification MIL-T 27422B and the previous revision of the Boeing Helicopter specification.

b. First paragraph, lines 8, 9, and 10, state "The fuel cell problems, in our view, could endanger Army aviators and put the aircraft at risk." We strongly disagree with this statement. The problems reported on these fuel cells, namely blistering, in no way comprises the structural or crashworthy integrity of the tanks. If it was suspected that the integrity of the tank was a problem, the affected aircraft would be grounded and the defective tanks removed.

c. The first sub-paragraph of the first paragraph states that the Army recently reclassified the CH-47D fuel cells from repairable to nonrepairable consumables. This is not correct. The U.S. Army did not reclassify the fuel cell to non-repairable, consumable. However, we changed the authorized repair from depot level repair to organizational level repair. The fuel cell was/is coded PAO"OO" repairable at Aviation Unit Maintenance (AVUM). If the AVUM cannot repair the cell, it is sent to Aviation Intermediate Level Maintenance (AVIM) and if the AVIM feels it is repairable but beyond their capability it will be returned to the Depot in condition code "F", unserviceable repairable. To ensure that the units and special technical inspection review (STIR) program personnel understand this, the information will be distributed via electronic mail. The team responsible for the CH-47D fuel cells met and determined that PAO"OO" is the correct recoverability code. The team found that the maintenance personnels' training and experience in the inspection and repair of fuel cells appear to be weak. The CH-47 Project Manager's Office (PMO) personnel are

*Underline added.

working with Ft. Eustis to determine the type and extent of training that needs to be expanded and incorporated into the school curricula. The CH-47 PMO is committed to supporting this effort and will fund training at sites currently holding fuel cells. *

d. Second sub-paragraph of paragraph 1. We agree with the comments on blistering in this paragraph. We have taken and are continuing to take actions to correct the problems with fuel cells. The initial results of our investigation to determine the cause of fuel cell blistering showed that excessively high temperatures within the fuel tank caused the blistering. Our investigation is continuing and will be completed by 31 Jan 93. Fourteen fuel cells were returned to EFC for investigation and possible repair. The EFC found that 13 fuel cells were reparable. All repairs have been completed at no cost to the Government. On 2 Dec 92 the EFC shipped the last one of the 13 repaired fuel cells back to Ft. Hood for installation in aircraft. One fuel cell had to be disposed of due to activation.

e. First paragraph on page 2. ATCOM will revise the current request for procurement of 91 main and 70 auxiliary fuel cells to include a warranty for five years at no cost to the Government. * On 3 Nov 92 Mr. Hodges of the DODIG agreed that this five year warranty was adequate and agreed that the request for proposal (RFP) should not be held up due to the urgent need for spares delivery.

2. In addition to the actions outlined in paragraph 1, we have taken and/or will take the following actions:

a. Additional clarification of the technical manual instructions is being prepared for the field to use in the inspection and repair of blistered fuel cells. This will be approved by the Aviation and Troop Command (ATCOM) Research Development and Engineering Center and then issued to maintenance personnel in the field.

b. Training on the inspection and repair of fuel cells will be provided to AVUM/AVIM maintenance personnel. The CH-47 PMO is committed to providing proper training. The CH-47 PMO will fund EFC to make site visits to Ft. Hood, Ft. Campbell, Ft. Carson, Ft. Bragg, and Hunter Army Airfield to teach CH-47 structural mechanics and inspectors how to properly inspect and repair fuel cells. The great majority of the fuel cells returned to EFC for internal blisters could have been repaired in the field if the proper training and repair procedures were *

2

*Underline added.

in place. This would significantly improve the supply situation. Informal commitments by the president of EFC are that they would train Army personnel at their plant at no cost to the Government. Furthermore, EFC is willing to provide a 2-3 day on-site school at the factory to Army mechanics, technicians and inspectors for training at no cost to the Government.*

c. The biggest users of rejected fuel cells were Fort Campbell (highest CH-47D population), Ft. Hood, and Ft. Bragg. We will target corrective actions to these three locations with others to follow.

3. The DODIG provided valuable service during their investigation by pointing out a problem which allowed the PEO/ATCOM to identify corrective actions and to propose the inclusion of a warranty into new procurement contracts. We anticipate that all required final actions to correct discrepancies identified by the DODIG will be implemented NLT 23 Dec 92.

3

*Underline added.

INSPECTOR GENERAL
DEPARTMENT OF DEFENSE
400 ARMY NAVY DRIVE
ARLINGTON, VIRGINIA 22202-2884

OCT 2 6 1992

MEMORANDUM FOR COMMANDING GENERAL, U.S. AVIATION TROOP COMMAND

SUBJECT: Procurement of Aircraft Fuel Cells for CH-47D Helicopters

On June 18, 1992, we announced the Audit of Aircraft Fuel Cell Procurements, Project 2CF-8014. The audit was undertaken in response to a Hotline allegation of purported irregularities involved in the procurement of aircraft fuel cells. During the survey phase, we discovered problems with CH-47D fuel cells that have affected the readiness of CH-47D helicopters. These cells were made by Goodyear, now Engineered Fabrics Corporation (EFC), one of two U.S. fuel cell manufacturers. The fuel cell problems, in our view, could endanger Army aviators and put aircraft at risk. We believe it is important that we bring these problems to your attention immediately in view of an impending purchase of fuel cells for CH-47D helicopters. Our preliminary survey results showed the following:

- the Army recently reclassified CH-47D fuel cells from repairable to nonrepairable, consumable items. Subsequent to this reclassification, we found that 13 of 23 (60 percent) fuel cells in our review, earmarked for disposal and less than 12 years old, were repairable;

- blistering occurred on the inside and outside of the EFC fuel cell wall for fuel cells manufactured during the 1985-1987 time period. The inside blistering was noted on aircraft fuel cells examined as part of the Special Technical Inspection Review (STIR) program as a result of the Desert Storm conflict. The cause of the inside blistering has not been identified by an independent analysis and previous specification changes made by Boeing Helicopter, the prime contractor, corrected blistering on the outside of the fuel cell wall;

- CH-47D fuel cells lacked a specified service life. Military Specification 27422B suggests that a fuel cell should last the "service life of the aircraft." We have not been able to establish the specified service life for the CH-47D helicopter. Records have shown that fuel cells provided by the other U.S. manufacturer, Amfuel (formerly Uniroyal), lasted in most cases in excess of 15 years before failures occurred. However, performance specifications do not cite specific fuel cell longevity requirements.

- there is zero balance of replenishment main fuel cells for CH-47D aircraft at this time;

We are concerned that in view of the above conditions, the current procurement of 91 fuel cells will proceed without adequate safeguards. In addition, the Army must focus on the issues addressed in this letter for the follow on procurements of even larger numbers of fuel cells. We clearly recognize the Army's urgent need for CH-47D fuel cells. However, we believe that it is in the best interest of the Army that the current solicitation for the 91 fuel cells be amended prior to "best and final" offers, to include requirements for a 10-year manufacturer's warranty. A no cost 5-year warranty was verbally offered by the president of EFC in a recent meeting held at that company. Three ATCOM representatives also attended the meeting. A 10 year warranty is not unreasonable and would serve to protect the Army's interest until the quality issue regarding CH-47D fuel cells is resolved. Fuel cell quality and dependability along with warranted assurances appear to be easily attainable.

Should you require additional information or require a briefing on the issues addressed in this letter, please contact me at (703) 692-3025, DSN 222-3025, or Mr. Ron Hodges, Project Manager, at (703) 692-3178, DSN 222-3178.

Salvatore D. Guli
Program Director
Contract Management Directorate

cc: AMC Headqurters
General Irby, PEO Aviation

Appendix I. Summary of Potential Benefits Resulting From Audit

Recommendation Reference	Description of Benefit	Amount and/or Type of Benefit
A.1.	Economy and Efficiency. Avoids unnecessary costs for premature failure of CH-47D and AH-64 helicopter fuel cells.	Nonmonetary.
A.2.	Economy and Efficiency. Avoids costs to repair premature failure of CH-47D and AH-64 helicopter fuel cells.	Undeterminable.
A.3., A.4.	Economy and Efficiency. Avoids unnecessary costs for premature failure of CH-47D and AH-64 helicopter fuel cells.	Undeterminable.[1]
B.1.a.	Program Results. Provides basis for decisions regarding economical repairability and projected demand for fuel cells.	Undeterminable.[2]
B.1.b.	Internal Controls. Identifies premature failure of fuel cells and holds contractors accountable for manufacturer deficiencies.	Funds put to better use because Army avoided $84,500 in unnecessary procurement costs when contractor agreed to repair defective fuel cells at no cost.
B.2.	Internal Controls. Identifies weaknesses in implementation of the internal control program for the quality function.	Nonmonetary.

See footnotes at end of appendix.

Appendix I. Summary of Potential Benefits Resulting From Audit

Recommendation Reference	Description of Benefit	Amount and/or Type of Benefit
B.3.	Program Results. Improves reporting of quality deficiencies related to fuel cells.	Nonmonetary.
B.4.	Program Results. Prevents repairable CH-47D helicopter fuel cells from being scrapped.	Nonmonetary.
B.5.	Program Results. Makes use of excess AH-64 helicopter fuel cell inventory by providing as Government-furnished material to the helicopter manufacturer on future Apache production requirements.	Avoidance of $468,000 of future AH-64 helicopter fuel cell requirements would allow FY 1995 procurement funds to be put to better use.[3]
B.6.	Economy and Efficiency. Determines the most efficient method for depot-level repair of Army fuel cells.	Undeterminable.
B.7.	Program Results. Improves Army's ability to accomplish depot-level inspection and repair of fuel cells.	Nonmonetary.
B.8.	Program Results. Prevents further deterioration and the premature scrapping of repairable helicopter fuel cells.	Funds put to better use by repairing unserviceable CH-47D helicopter fuel cells thereby avoiding $842,000 in FY 1993 procurement costs (Appendix B).[4]

See footnotes at end of appendix.

[1]Although we could not quantify the amount, additional monetary and maintenance benefits will occur when manufacturers discontinue the use of faulty repair material and AH-64 helicopter fuel cell design specifications are improved.
[2]Additional monetary benefits will be realized when the Army uses an expected useful life to make buy and repair decisions on fuel cells.
[3]Actual monetary benefits will be determined when the Army renegotiates contracts to use the existing fuel cells as Government-furnished material.
[4]Actual monetary benefits were realized based on action taken by ATCOM as a direct result of our identification of the premature scrapping of repairable CH-47D helicopter fuel cells during the Special Technical Inspection and Repair program.

Appendix J. Activities Visited or Contacted

Office of the Secretary of Defense

Under Secretary of Defense for Acquisition, Washington, DC
Director of Defense Procurement, Washington, DC
Assistant Secretary of Defense (Production and Logistics)

Department of the Army

Army Materiel Command, Alexandria, VA
  Army Aviation Troop Command, St. Louis, MO
Army Forces Command, Atlanta, GA
  Special Technical Inspection and Repair Project Office, Fort Campbell, KY
  Integral Support and Services Division, Fort Campbell, KY
  Maintenance Division, Fort Carson, CO
  Maintenance Division, Fort Hood, TX
  Maintenance Division, Corpus Christi Army Depot, TX
  Quality Assessment Division, Corpus Christi Army Depot, TX

Defense Activities

Defense Logistics Agency, Alexandria, VA
  Defense Contract Management Command, Alexandria, VA
    Defense Plant Representative Office, Boeing Helicopters, Philadelphia, PA
    Defense Plant Representative Office, McDonnell Douglas Helicopter Company, Mesa, AZ
  Defense Logistics Studies Information Exchange, Battle Creek, MI
  Defense Distribution Depot, Corpus Christi Army Depot, TX
  Quality Division, Defense Distribution Depot, Letterkenny Army Depot, PA

Non-Defense Activities

General Accounting Office, Washington, DC
American Fuel Cell and Coated Fabrics, Magnolia, AR
Boeing Helicopters, Philadelphia, PA
Dyne Corporation Maintenance Facility, Fort Campbell, KY
Dyne Corporation Maintenance Facility, Killeen, TX

Non-Defense Activities (cont'd)

Engineered Fabrics Corporation, Rockmart, GA
McDonnell Douglas Helicopter Company, Mesa, AZ
Reliance Aeroproducts International, Incorporated, Fort Worth, TX

Appendix K. Report Distribution

Office of the Secretary of Defense

Under Secretary of Defense for Acquisition
Director of Defense Procurement
Comptroller of the Department of Defense
Deputy Under Secretary of Defense (Logistics)

Department of the Army

Secretary of the Army
Assistant Secretary of the Army (Installations, Logistics, and Environment)
Commander, Army Materiel Command
  Commander, Army Aviation Troop Command
Commander, Army Forces Command
Auditor General, Department of the Army

Department of the Navy

Secretary of the Navy
Assistant Secretary of the Navy (Financial Management)
Auditor General, Naval Audit Service

Department of the Air Force

Secretary of the Air Force
Assistant Secretary of the Air Force (Financial Management and Comptroller)
Auditor General, Air Force Audit Agency

Defense Activities

Director, Defense Contract Audit Agency
Director, Defense Logistics Agency
  Commander, Defense Contract Management Command

Non-Defense Federal Activities

Office of Management and Budget
National Security and International Affairs Division, Technical Information Center, General Accounting Office

Chairman and Ranking Minority Member of Each of the Following Congressional Committees and Subcommittees:

Senate Committee on Appropriations
Senate Subcommittee on Defense, Committee on Appropriations
Senate Committee on Armed Services
Senate Committee on Governmental Affairs
House Committee on Appropriations
House Subcommittee on Defense, Committee on Appropriations
House Committee on Armed Services
House Committee on Government Operations
House Subcommittee on Legislation and National Security, Committee on Government Operations

Senator John Glenn, U.S. Senate
Congressman George Darden, U.S. House of Representatives
Congressman John D. Dingell, U.S. House of Representatives
Congressman David L. Hobson, U.S. House of Representatives

Department of the Army Comments

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DEPARTMENT OF THE ARMY
OFFICE OF THE DEPUTY CHIEF OF STAFF FOR LOGISTICS
WASHINGTON, DC 20310-0500

DALO-AV

30 AUG 1993

MEMORANDUM THRU

DEPUTY CHIEF OF STAFF FOR LOGISTICS

F ~~DIRECTOR OF THE ARMY STAFF~~ MICHAEL L. RAMIREZ, LTC, GS, ADAS 9/2/93

ASSISTANT SECRETARY OF THE ARMY (INSTALLATIONS, LOGISTICS AND ENVIRONMENT)

FOR INSPECTOR GENERAL, DEPARTMENT OF DEFENSE (Auditing)

SUBJECT: Draft Audit Report on Aircraft Fuel Cell Procurements (Project No. 2CF-8014)--INFORMATION MEMORANDUM

1. HQDA IG memorandum of 18 Jun 93 (Tab A) asked ODCSLOG to respond to your memorandum of 16 Jun 93 (Encl to Tab A). Your memorandum requested a review and comment on the subject draft audit report (Tab B).

2. The enclosed comments are provided in response to the audit findings (Tab C).

3. The following comments are provided to address the monetary benefits addressed in the audit:

a. Recommendation B-1-b. Concur with the claimed savings of $84,500. The fuel cells that were repaired by Engineered Fabrics Corporation (EFC) in the field were being disposed of in the field.

b. Recommendation B-5. Nonconcur with the DODIG's estimated $1 million savings. No dollar savings can be realized at this time because there are no current Apache production requirements that we can provide fuel cells as government furnished parts.

c. Recommendation B-8. Nonconcur with the DODIG's estimated $1 million savings. The Army never intended to procure 300 CH-47D fuel cells to replenish the depleted fuel cell inventory

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DALO-AV
SUBJECT: Draft Audit Report on Aircraft Fuel Cell Procurements (Project No. 2CF-8014)--INFORMATION MEMORANDUM

as stated in the audit. The Army bought only 70 auxiliary and 91 main fuel cells since the inception of STIR. Part of our subsequent decision not to initiate further procurement considered the fact that the actions being taken to institute field level repair would reduce future procurement requirements.

3 Encls [Not Enclosed]

SAMUEL L. KINDRED
Colonel, GS
Chief, Aviation Logistics Office

CF:
VCSA
SAIG-PA

Coordination:

ASA (SARD-SA) - Concur, LTC Planchak/614-2303 (by phone)
ASA (SARD-DF) - Concur, LTC Murphy/695-7616 (by phone)
ASA (SFRD-KP) - Concur, Mr. Sullivan/756-2086 (by phone)
AMC (AMCIR) - Concur, Mr. Kurzer/274-9025 (by phone)
ATCOM (AMSAT-IR) - Concur, Mr. Horn/693-3736 (by phone)

MAJ Budney/70487

2

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Final Report Reference

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ARMY COMMENTS ON
DRAFT AUDIT REPORT ON
AIRCRAFT FUEL CELL PROCUREMENTS
(Project No. 2CF-8014)

Recommendation A-1.
Issue an Aviation Safety Action Message to Army units to inspect all helicopter crash-resistant, self-sealing fuel cells manufactured by Engineered Fabrics Corporation to determine whether inside blistering has occurred due to the 82C12 repair material, and to remove or repair the fuel cells as necessary.

Army Position: Concur.
U.S. Army Aviation Troop Command (ATCOM) will issue an Aviation Safety Action Message, on or about 31 August 1993, that will address improved repair procedures for fuel cells. No special inspections will be required. Engineering personnel have determined there is no safety issue involved and that normal scheduled inspections will identify any problems with the fuel cells.

Recommendation A-2.
Require Engineered Fabrics Corporation to make no-cost repairs to CH-47D and AH-64 fuel cells that have prematurely failed because of blistering 82C12 repair material.

Revised

Army Position: Concur with recommendation as rewritten:
"Recommend the Army continue to return fuel cells, blistered as a result of 82C12 repair material, to the contractor for repair at no cost as requested by Engineered Fabrics Corporation."

Recommendation A-3.
Obtain a no-cost, 10-year manufacturer's warranty for all existing and future crash-resistant, self-sealing helicopter fuel cells manufactured by Engineered Fabrics Corporation, specifically to protect the Army from premature failure caused by inside blistering of the fuel cells.

Army Position: Concur with intent.
The Army cannot mandate a "no cost warranty" in a solicitation. The recent competitive solicitation DAAJ09-93-C-0321 for fuel cells included a five year warranty which was priced by both contractors at over $1,000 per cell. The warranty was made part of the contract award. Cells already procured will not have this warranty; however, the Army is reviewing the possibility of obtaining a 10 year warranty against blistering on contractor repaired cells. The acceptance of repaired cells will be made a part of the review on qualification procedures for manufacturing and process changes at the contractors' plants.

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Recommendation A-4.
Initiate a design change proposal to McDonnell Douglas Helicopter Company to increase specifications to prevent delamination of the outer cell wall of the AH-64 fuel cell when it comes in contact with fuel or other fluids, similar to the change made on the CH-47D fuel cell.

Army Position: Concur.
A Value Engineering Change Proposal (VECP) is in work at McDonnell Douglas Helicopter Company. The change will help prevent delamination of the outer cell wall when it comes in contact with fuel.

Recommendation B-1.
Establish procedures to consider the expected useful life for CH-47D and AH-64 helicopter fuel cells to:
a. Make economic repair and replacement decisions.
b. Use as an internal control objective to help verify the quality of helicopter fuel cells.

Army Position: Concur.
The Army will evaluate the current life cycle of fuel cells to ensure proper management with respect to inventory levels, maintenance levels, and sister service depot options. The Army will also assess the recoverability code of all fuel cells with the goal of standardization, if possible, and to assure appropriate economic repair decisions are being made at the unit level. ATCOM will evaluate the qualification procedures for fuel cells to ensure any changes to repair procedures are evaluated and approved by the Army. Fuel cell useful life will be factored in as an internal control objective to assist in the management of fuel cell inventory.

Recommendation B-2.
Require an internal control assessment of the Army Aviation Troop Command quality program to identify internal control weaknesses and to determine whether identified weaknesses are reported and corrected.

Army Position: Concur.
ATCOM will review the Quality Deficiency Report (QDR) program to insure QDR's are reported, assessed and acted on.

Recommendation B-3.
Instruct field units to submit quality deficiency reports on all fuel cells that experience inside blistering and outside delamination.

Army Position: Concur.
The Aviation Safety Action Message will address QDR's as a vehicle to identify problems with the quality of material.

2

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Final Report Reference

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Recommendation B-4.
Change the recoverability code to specify that CH-47D fuel cells are repairable at depot level.

Army Position: Concur with intent.
As stated in our response to B1, the Army will reassess the recoverability code to assure unit repair/scrap decisions are being made with due consideration for reprocurement costs.

Recommendation B-5.
Issue excess AH-64 fuel cells to McDonnell Douglas Helicopter Company as Government-Furnished material for installation on the helicopter production line scheduled through June 1994, and require McDonnell Douglas Helicopter Company to amend or cancel existing contracts for AH-64 fuel cells to procure only those fuel cells required to support production requirements that cannot be satisfied with Government-furnished material.

Revised

Army Position: Concur with intent.
Costs associated with modification of contracts with McDonnell Douglas Helicopter Company to terminate ongoing subcontracts for fuel cells could easily overshadow savings realized by using existing fuel cells as government furnished materiel (GFM). The Apache PM is aware of the availability of fuel cells as GFM for any future requirements.

Recommendation B-6.
Perform a cost-benefit analysis to determine whether it is more efficient for the Army or Navy to provide depot-level inspection and repair of Army crash-resistant, self-sealing fuel cells.

Army Position: Nonconcur.
It is Army policy to perform maintenance at the lowest level possible. The assessment of unit level repair and recoverability code (B1) will determine if fuel cells are being repaired or scrapped on an economical basis. If the units are not capable of making repairs, which could be performed by depots on an economical basis, this issue will be reexamined.

Recommendation B-7.
If the results of the cost-benefit analysis in Recommendation 6. determines that use of existing Navy depot repair facilities is more efficient, establish a memorandum of understanding with the Navy to have the Navy provide depot-level inspection and repair of all unserviceable Army crash-resistant, self-sealing fuel cells.

Army Position: Nonconcur.
See Army position in recommendation B-6.

3

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Recommendation B-8.
Initiate immediate action to repair all unserviceable CH-47D and AH-64 fuel cells that are repairable in accordance with the established memorandum of understanding with the Navy or at Army facilities, as appropriate.

Army Position: Nonconcur.
See Army position in recommendation B-6.

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Aviation Troop Command Comments

AMSAT-I-SACA (710) 2 September 1993

MEMORANDUM FOR OAIG-AUD-CMD

SUBJECT: Audit of Fuel Cell Procurements

1. The following is provided per our fonecon this date.

2. To date, only 70 auxillary and 91 main fuel cells have been procured since the inception of the Special Technical Inspection and Repair (STIR) program. Part of our subsequent decisions in the early stages of this program not to initiate further procurement, considered the fact that actions taken to refine field level repair would reduce future demands. The actual results of this field level repair as of 8 July 1993 are as follows:

	TOTAL	MAIN	AUX
Unserviceable cells reviewed by STIR personnel:	257	97	160
Less cells not repairable:	107	50	57
Number of cells determined to be reparable:	150	47	103
Percent of cells that are reparable:	58%	48%	64%

3. Based upon the above data, had field level repair not been emphasized and refined, a minimum of 150 additional cells would have been required from new procurement; 47 mains and 103 auxillary.

ALAN R. MCCANDLESS
Chief, CH-47 Section