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MAINTENANCE GROUP CHAIRMAN'S FACTUAL REPORT

(PAGES 1- 38)

NATIONAL TRANSPORTATION SAFETY BOARD
NORTHWEST REGIONAL OFFICE
SEATTLE, WA 98188

October 8, 1997

MAINTENANCE GROUP CHAIRMAN'S FACTUAL REPORT

A. ACCIDENT: DCA-96-MA-070

Location: East Moriches, New York

Date: July 17, 1996

Time: 2031 Eastern Daylight Time

Airplane: Boeing 747-131, N93 119

B . GROUP IDENTIFICATION

The group met at TWA's main maintenance base and overhaul facility located in Kansas City, MO, on July 18, 1996. The following group members participated in the investigation.

Chairman:

Debra J. Eckrote	National Transportation Safety Board (NTSB) Seattle, Washington

Members:

Robert A. Radtke	Trans World Airlines (TWA) Kansas City, Missouri
Fred Liddell	International Association of Machinists (IAM) Kansas City, Missouri
Scott G. Metcalf	Federal Bureau of Investigation (FBI) New York, New York
Jim Orchard	Federal Aviation Administration (FAA) Kansas City, Missouri
James H. Connell	Boeing Commercial Airplane Group Kansas City, Missouri
Raymond T, Stettner	Air Line Pilots Association (ALPA) O'Fallen, Missouri

C. SUMMARY

On July 17, 1996, at 2031 EDT, a Boeing 747-131, N93 119, crashed into the Atlantic Ocean, about 8 miles south of East Moriches, New York after taking off from John F. Kennedy International Airport (JFK). The airplane was being operated on an instrument flight rules (IFR) flight plan under the provisions of Title 14, Code of Federal Regulation (CFR), Part 121, on a regularly scheduled flight to Charles De Gaulle International Airport (CDG), Paris, France, as Trans World Airlines (TWA) Flight 800. The airplane was destroyed by explosion, fire, and impact forces with the ocean. All 230 people aboard were killed.

D. DETAILS OF THE INVESTIGATION

The maintenance records for the aircraft from the date of manufacturer in July 1971 to July 17, 1996, were secured by TWA personnel for a detailed examination by the Maintenance Group. TWA management personnel were briefed by the Group Chairman on the NTSB investigation process concerning the acquisition of maintenance records, information and documentation, and TWA maintenance policies and procedures that the Maintenance Group would be reviewing to support the investigation.

Throughout the first week after the accident, records to identify all Airworthiness Directives, Service Bulletins, Open and Completed Modifications, items open from the Minimum Equipment List, the Aircraft Maintenance Log entries from April 1, 1996 to July 17, 1996, and the scheduled maintenance from the last major "D" Check and through five Phase "C" Checks, were gathered to review for compliance information, and recent maintenance performed on the aircraft prior to the accident. As the investigation progressed, information from the other NTSB Group Chairmen caused the Maintenance Group to concentrate on the center wing section and the center wing fuel tank.

At a later date, the Maintenance Group expanded its review of the Aircraft Maintenance Log entries to identify repetitive entries starting July 1, 1994 to the accident date. The review identified repetitive entries for fueling, fuel pumps, fuel flow indications and electrical write-ups. Each of the write-ups identified was tracked until the work task was accomplished and the item closed out in accordance with maintenance manual procedures.

The Maintenance Group met again in August, and documentation was gathered to identify maintenance performed in and around the center wing tank. The component work cards and testing cards for the fuel boost pumps, jettison pumps, the scavenge pump and the APU pump were reviewed to identify the maintenance history on the fuel pumps in the aircraft at the time of the accident, and on the fuel pumps installed on the other TWA 747 aircraft. The TWA overhaul shop was visited to confirm that the overhaul shop was complying with manufacturers' recommendations for overhaul and testing of the fuel pumps.

Component shop records confirmed that none of the 65 fuel quantity tank unit probes or 13 fuel compensators in the accident aircraft fuel tanks had ever been replaced. These units are condition monitored and are not removed unless the unit is not operational.

A review of the center wing tank work cards from the "D" check confirmed that no non-routine maintenance was required or performed on the center wing tank, and no corrosion in the tank was found that required notification to the FAA in support of the Corrosion Prevention Control Program. During the detailed inspection of the center wing tank, the areas that were inspected included, (but were not limited to) the structure, fuel tubing, cables, wiring, and any units exposed or visible through routine open up.

During the maintenance review process, the records confirm that TWA had accomplished mandatory directives, maintained mandatory scheduled maintenance, and maintained a continuous airworthiness maintenance program that incorporates the maintenance alert computer systems (which compiles the flying time and cycles on each aircraft daily, and is the basis for compilation of all time/cycle records maintained on the aircraft, engines, APU, modules and units). The aircraft maintenance planning system tracks and controls aircraft logbook, non-routine, follow-up and call-out requirements for maintenance operations.

The maintenance summarized above, along with TWA maintenance programs, additional maintenance records, historical data and Federal Aviation Administration oversight of the TWA facility, are described in detail in the following text.

1. TWA MAINTENANCE PROGRAM

General Overview

TWA is authorized to conduct operations under 14 CFR Part 121, and its aircraft are maintained in accordance with the continuous airworthiness maintenance program and limitations specified in the TWA Operations Specifications Manual and General Policies and Procedures (GP&P) Manual.

To maintain an airworthy condition, each of TWA's aircraft and their component parts, accessories, and appliances are maintained in accordance with specified time limits and cycles for the accomplishment of the overhaul, replacement, periodic inspection, and routine checks of the aircraft.

Maintenance Tracking Method

TWA's aircraft maintenance program incorporates checks and inspections listed by fleet types. Structural inspections, along with unit changes and certain other specific maintenance functions, are controlled and scheduled by "Operations" (OP) which are numbered and scheduled at specific internals.

The following text identifies the means and time limits in which TWA accomplishes the checks and inspections for the Boeing 747 aircraft. Complete listings of all operations for TWA's entire fleet can be found in TWA's GP&P and Operations Specifications Manual.

The Maintenance Operations Control- 1 (MOC- 1) Maintenance Alert Computer System compiles the flying time and cycles on each aircraft daily, and is the basis for compilation of all time/cycle records maintained on the aircraft, engines, APU, modules and units. The system tracks all scheduled maintenance requirements on each aircraft and alerts requirements to operational planning personnel.

The Aircraft Maintenance Planning System (AMPS) tracks and controls aircraft logbook, non-routine, follow-up and call-out requirements for maintenance operations. The system provides advanced planning information, printed worksheets for maintenance use and a variety of inquiries. Besides the computer-printed AMPS worksheets, the aircraft logbook inspection and maintenance worksheets or cards provide the primary sources of record of all servicing and maintenance work accomplished on the aircraft.

The Aircraft Maintenance Logbook is the official source of aircraft and cabin malfunctions. It is required by Federal Aviation Administration (FAA) regulations and must be on board the aircraft at departure. The multi-page aircraft logbook sheets are used by the flight crew and maintenance personnel to record aircraft malfunctions, work performed, and flight data. Each logbook contains 50 sets of pre-numbered pages. It also contains Logbook Maintenance Deferral Item Control sheets. Logbook pages include a yellow original, which is maintained as a permanent record, a blue copy used as a computer entry worksheet, and a white copy which is sent to Kansas City (MCI) maintenance records.

The yellow pages remain in the logbook until either an Aircraft Service (AS), which is accomplished at intervals not to exceed 100 hours of aircraft time in service; a Time Control Service (TCS), which is accomplished in sequence at intervals not to exceed 1,200 hours of aircraft service; or at a Check "C", which is accomplished in sequence at intervals not to exceed 13 months.

The last AS for the accident airplane was performed on July 13, 1996. At that time, all of the used yellow logbook pages were pulled out and audited for complete sign-off and/or proper deferral. The yellow sheets were then forwarded to Kansas City (MCI). The last page in the book was used at that time and ended the book with number 19650. Anew book was started, and the numbering began with 62551. There had not been another AS, TCS, or Check "C" performed after that date up to the time of the accident, therefore, all of the yellow aircraft logbook pages starting with 62551 remained in the aircraft at the time of the accident.

If a deferral item is entered in the aircraft logbook, the blue logbook page is removed at that time, and the information is entered into the AMPS as soon as practical, but not to exceed one hour after the aircraft departs. The blue copy is used as a computer entry worksheet and can be discarded after the information has been entered into AMPS. On July 17, 1996, the blue tear-out pages had not yet been discarded for aircraft logbook pages 62565 thru 62570, and were made available for review. See Deferred Maintenance Write-ups on the Open Item Work Sheet for details.

Additional guidelines for the following areas can be found in TWA General Policies and Procedures Manual 1-10-0:

1. Routine Maintenance - Scheduling and Control
2. Guidelines Common to All Work
3. Non-Routine Maintenance Handling
4. Logbook Procedures
5. Preparing Paperwork for Maintenance Operations
6. Handling of Completed Paperwork

747 MAINTENANCE AND INSPECTION PERIODS

Structural Inspections

TWA's Structural Inspection Program and the Corrosion Prevention and Control Programs were reviewed to determine the procedures for compliance with these programs. TWA's structural inspection of the aircraft is performed in accordance with the TWA Boeing 747 Structural Inspection Program, as detailed in TWA Engineering Report (ER) Number 1564.

Supplemental Structural Inspections and Tasks required by the Boeing 747-100/200 Supplemental Structural Inspection Document are set forth in TWA ER 1713. The Corrosion Prevention and Control Program is detailed in TWA ER 1832.

TWA's baseline structural inspections (applicable to all TWA Boeing 747 aircraft) are incorporated into the following programs. The Check "C" program (OP 9) is accomplished at intervals not to exceed 13 months. The OP 16 unit changes and structural checks are accomplished at intervals not to exceed 4 years. The OP 11 incorporates tasks that are required as part of the 747 Corrosion Prevention and Control Program. These tasks are required at multiple two-year increments and are to be accomplished at Check "C" - "2C", and at OP 16 visits. The OP 1 is accomplished at intervals not to exceed eight years and must be accomplished in conjunction with an OP 16 visit.

The OP 4, 5, 6, 7, and 8 contain the inspection requirements which are to be accomplished as specified for the baseline structural percentage sampling program.

The OP 2 contains tasks taken from the Boeing 747 Supplemental Structural Inspection Document (SSID), as described in TWA ER 1713, applicable only to certain "candidate" aircraft. OP 2 tasks are scheduled at Check "C" 2E (26 months), OP 16 (4 years), and OP 1 (8 years) on these "candidate" aircraft. Aircraft N9311 9 was not a "candidate" aircraft.

Periodic Service (PS) Check

The PS is accomplished at scheduled layovers of six hours or more at stations staffed by TWA mechanics, or every other operating day maximum, unless a higher maintenance level is accomplished.

Routine work required for the PS is listed on Form M47-00-01. A PS incorporates checks for the cockpit and cabin; aircraft exterior; and a final check. The last PS performed on the airplane prior to the accident was on July 17, 1996, at JFK before the departure of Flight 800.

(Exhibit B - Periodic Service)

Aircraft Service (AS) Check

The AS is accomplished at intervals not to exceed 100 hours of aircraft time in service. It includes, in addition, all work items performed at the PS. Routine work required at the AS are listed on Forms M47-00-XX. The AS forms are numbered 1 thru 6 and are identified as AS-1 thru AS-6, and are accomplished in sequence until a Time Control Service is accomplished. The AS incorporates checks for the cockpit and cabin, exterior fuselage, wings, gear and empennage; engines and struts; oil, hydraulic, water servicing, and fuel tank sumping; and a final check.

The last AS- 1 was accomplished on July 13, 1996, at JFK after the landing of Flight 803.

(Exhibit C - Aircraft Service)

Time Control Service ('TCS)

The TCS is accomplished at intervals not to exceed 1,200 hours of aircraft service. The TCS zeros the AS checks, and the TCS is zeroed by the Check "C" and the OP 16. Routine work is accomplished on Form M47-00-03.

The last TCS was accomplished on April 15, 1996, at JFK.

(Exhibit D - Time Control Service)

Station Service (SS) (OP-12)

The SS is an interim cabin refurbishment program with limited external aircraft inspection and checks and is accomplished at intervals not to exceed 800 hours of aircraft time. The SS is accomplished in 2 phases and was zeroed by the Check "C" and OP-16.

The last SS was accomplished on May 11, 1996, at JFK, New York.

Check "C" (OP 9)

Check "C" consists of three blocks designated as lE, 2E, and 3E. The checks are accomplished in sequence and at intervals not to exceed 13 months. The Check "C" zeroes the SS, TCS and lower work. Routine maintenance and inspection work required at the Check "C"s are detailed on M139-450 Work Cards. There are no routine inspections for the center wing fuel tank during the Check "C" visits.

The last Check C - 3E was accomplished on November 6, 1995.

Check "D" (OP 16)

The OP 16 is accomplished at intervals not to exceed four years. The routine work is defined in TWA's Operations Specifications Manual, TWA's approved Engineering Reports, Structural Inspection Programs and documents approved for control of repair, overhaul, parts replacement, periodic inspections and routine checks. A control sheet listing all work cards applicable to the OP 16 is maintained in the computer. The Check "D" is the scheduled maintenance in which the interior of the center wing fuel tank is inspected.

The last OP 16 was accomplished on December 14, 1992.

TWA MAINTENANCE BASES

TWA major station maintenance bases that service the 747 are located at New York (JFK), Los Angeles (LAX), Kansas City (MCI), San Francisco (SFO), and St. Louis (STL). TWA mechanics are staffed at these locations.

Contract maintenance providers that will service TWA 747 aircraft are located at Aer Lingus, Shannon, Ireland, Aloha Airlines, Honolulu, Hawaii, and Airport Aviation Services, San Juan Puerto Rico.

Several TWA staffed domestic and international line stations provide maintenance support for routine maintenance, aircraft malfunctions, and non-routine maintenance requirements.

2. AIRCRAFT RECORDS REVIEW

The routine and non-routine work cards for N93 119 from the completion of the Last "D" check, dated December 14, 1992, and through five "C" checks - the last being (Phase 3E) completed on November 6, 1995, to the date of the accident on July 17, 1996, were reviewed to identify discrepancies regarding fuel pump malfunctions, fuel leaks, aircraft fueling issues, electrical discrepancies and any maintenance in and around the center wing section to include the center wing fuel tank. The aircraft maintenance logbook entries were reviewed from July 1, 1994, up to the day of the accident to identify the non-routine work performed in and around the center wing fuel tank to include structural and cabin inspections around the wing center section.

The Scheduled Maintenance Worksheets were reviewed for the period of July 1, 1994 through July 17, 1996, to verify accomplishment of the scheduled maintenance at the appropriate time intervals.

The Minimum Equipment List (MEL) and Configuration Deviation List (CDL) records were reviewed to verify accomplishment of the maintenance tasks and to identify the deferred items that remained open at the time of the accident. In addition, a list of all of the Airworthiness Directives (AD) and the Open and Completed Modification Orders for the aircraft were obtained to identify the ADs and Modification Orders applicable to the center wing section, and to verify compliance of each AD against the aircraft. ATA code entries and the Work Card Control Master Index were used to identify which work cards were scheduled at the various Check C's and last Check D.

N93 119 BASIC AIRCRAFT AND ENGINE DATA

AIRFRAME INFORMATION

Registration Number	N93119
Year Manufactured	July 1971
Serial Number	20083
Put Into Service at TWA	10/27/7 1
Aircraft Total Time:	93,303 Hours
Aircraft Total Cycles:	16,869 Cycles
Date of Last "D" Check	December 14, 1992
Date of Last "C" Check	November 6, 1995

ENGINE INFORMATION

ENGINE #1

Serial Number	662209
Date Installed	December 31, 1995
Total Time Since Overhaul:	47,989 Hours
Total Cycles Since Overhaul:	9,684 Cycles
Cycles Remaining	5,792 Cycles

ENGINE #2

Serial Number:	662593
Date Installed	December 6, 1995
Total Time Since Overhaul:	80,884 Hours
Total Cycles Since Overhaul:	14,609 Cycles
Cycles Remaining	3,474 Cycles

ENGINE #3

Serial Number	662426
Date Installed	June 18, 1996
Total Time Since Overhaul:	80,336 Hours
Total Cycles Since Overhaul:	14,632 Cycles
Cycles Remaining	5,945 Cycles

ENGINE #4

Serial Number	**662463**
Date Installed	**May 11, 1996**
Total Time Since Overhaul:	**77,061 Hours**
Total Cycles Since Overhaul:	**14,016 Cycles**
Cycles Remaining	**8,686 Cycles**

AIRCRAFT HISTORY

TWA purchased the aircraft new from the Boeing Company and added it to the TWA certificate on October 27, 1971. The aircraft was utilized as a commercial transport until the aircraft was sold to Iran on December 15, 1975. Numerous modifications and maintenance were performed on the aircraft in 1975, in preparation for the sale to Iran. Those modifications and inspections are listed in the following text.

Modifications/inspections Completed January 1975

1. **Check flap control handle.**
2. **Check auxiliary power unit bleed air duct.**
3. **Check main flap carriage spindle nut torque.**
4. **Inspect trailing edge flap foreflap sequence carriage**

Modifications/Inspections Completed February 1975

1. **Deactivate beverage bar blender.**
2. **Check #3 bearing breather temperature.**

Modifications/Inspections Completed March 1975

1. **Placard brew cup plate caution.**
2. **Inspect trailing edge jackscrew and rerig snubber.**

Modifications/Inspections Completed April 1975

1. **Check lavatory fire containment.**
2. **Complete first class cabin modification.**
3. **Install aural warning for leading edge flaps.**
4. **Check wing gear truck bumper pads.**
5. **Check continuous water scavenging system.**
6. **Check auto spoiler control circuit.**
7. **Revise normal static system plumbing.**
8. **Check pitot/static tubing drain fitting.**
9. **Modify ATC transponder to meet TSO-C74 B/C requirement.**
10. **Check #2 auxiliary pitot tubing.**
11. **Deactivate left assembly pillow storage compartment.**
12. **Wire installation sidewall ceiling to shelf.**
13. **Rework attendant seat and shelf.**
14. **Install ground proximity warning system.**
15. **Modify forward electric door.**
16. **Install windshield overheat test switch guard.**
17. **Relocate flap control unit spring.**

18. Check auto spoiler control circuit.
19. Improve cabin interphone system
20. Permanent repair of #2 side cowl due to #2 engine failure in flight.

Modifications/Inspections Completed in Mav 1975

1. Check seat belt attach fitting.

Modifications/Inspections Completed in June 1975

1. Install hex table secondary latch.

Modifications/Inspections Completed in August 1975

1. Perform check of passenger entertainment system/passenger service system multiplex system.

Modifications/Inspections Completed in September 1975

1. Check temperature total 2 sensor lines.
2. Change auto tape annunciator program.
3. Deactivate understair bar waste container system.
4. Check throttle control cable/rack endplay.

Modifications/Inspections Completed in October 1975

1. Modify toilet flush pump motor.

Modifications/Inspections Completed in December 1975

1. Reinforce wing lower aft splice plate.
2. Modify right hand side cowl panel bleed port.
3. Remove and install rudder ratio changer actuator/control unit.
4. Modify water injection tank.
5. Replace airborne vibration monitor light plate.
6. Remove electric/electronic equipment for Iran 747 aircraft.
7. Remove passenger cabin items for Iran 747.

Electrical/electronic equipment included: removal of the in-flight movie projectors/elevators and screen/mural assemblies from all zones; removal of galley ovens from all zones; removal of the cabin interphone handsets from the main deck only.

The cabin passenger items included: examining all upper-lounge furnishings for condition, and repair all items as necessary; check lavatories for condition and operation; remove TWA logos from the tail and forward fuselage exterior. Several cabin items were removed from the aircraft and included items such as: tray carts, liquor modules, waste containers, cup dispensers, tray carriers, utility and beverage carriers, seat belt extensions, demo oxygen masks and life vests, portable oxygen cylinders, life rafts and life vests, first aid kits, cargo nets and assemblies.

After the modifications were completed at TWA, the aircraft was ferried to the Boeing Military Aircraft Company, Wichita, Kansas, for further modifications prior to acceptance by Iran,

TWA records indicate that when the aircraft left the TWA facility on 12/15/75, the aircraft total time was 14556:44 hours and 3,250 landings. The modifications that were to be performed while the aircraft was at the Boeing Company were not accomplished. The maintenance records indicate that no write-ups, modifications or maintenance tasks were performed while the airplane was in Wichita Kansas. Iran never took delivery of the airplane and it was returned to TWA's certificate on December 16, 1976. The airplane was returned with a total aircraft time of 14563:47 hours and 3,254 landings. Approximately seven hours of flight time had been accumulated on the aircraft during this period.

After the aircraft was ferried back to the TWA facility, the maintenance records indicate that the aircraft was inspected for Airworthiness Directive compliance to return it to an airworthy condition prior to commercial transport service. The commercial passenger services, TWA logos, paint, interior cabin materials etc. were reinstalled prior to the aircraft returning to commercial service.

HEAVY MAINTENANCE HISTORY

MAINTENANCE RECORDS REVIEW FROM LAST "D CHECK TO JULY 17 1996

Maintenance records were reviewed from the last major "D check, which was completed on December 14, 1992, to the day of the accident on July 17, 1996. Phases 3A B, C, and D "C" checks were performed in May, July, August, and October, 1993. Phase 4A and B "C checks were performed in November 1993, and February 1994. After these dates, TWA subsequently revised its Boeing 747 maintenance program from a phased check "C" to an annual type "C" check. Annual "C" checks were performed on October 14, 1994 and November 6, 1995,

During the review of the non-routine work cards, work performed in the area of the center wing fuel tank from stations 1,000 to 1,300 were noted.

"D" CHECK DATED 12/14/92

The last "D" check prior to the accident began on September 28, 1992 and was completed on December 14, 1992. The total aircraft time was 80,267 hours, and the total cycles were 14,694 cycles, All routine and non-routine maintenance work cards were reviewed to identify work accomplished in the area of the center wing section, center wing fuel tank, fuel pumps, fuel write-ups, and electrical write-ups.

During this check, routine maintenance, as identified by work card numbers and listed in the TWA Operations Specifications Manual, was accomplished. Part of the inspection required the removal of all passenger seats in order to remove the floor and side panels. The floor panels were washed and the tape residue was removed. One floor panel was replaced from station 860 to 960 on the right side The remainder of the floor panels were reinstalled after a tap check and visual inspection.

New carpeting was installed at this time. Non-routine maintenance identified references to missing fasteners in the seat tracks that were corrected. One non-routine work card identified"3 each broken wires below floor panel #179." The broken wires were identified for the automatic disinfection system (fumigation system). The system was &signed to fumigate the aircraft in the case of an infestation, however, the system was never used. Maintenance personnel deactivated the system and the wires were removed. Floor panel #179 is located at fuselage station 1440 through 1500, on the right side.

There was a "detailed inspection" of the floor beams, structure and fuel barrier for their condition over the wing center section, from fuselage station 1,042 to 1,241. A detailed inspection includes structure, fuel tubing, cables, wiring, and units exposed or visible through routine open up. There were no specific non-routine write-ups found for this area,

Four discrepancies were noted regarding the fuel pumps. Two of the discrepancies were noted in the left wing. A fuel leak was found at the outboard and inboard boost pump cable feed-through for the #2 fuel tank. The electric conduits were tightened and safetied for both pumps. One discrepancy noted that the #3 forward boost pump in the right wing was inoperative. Anew forward boost pump was installed and it was operationally checked. The last discrepancy noted that the left wing, #2 outboard fuel jettison pump housing had a gouge, and corrosion was noted at the mating surface. The fuel jettison pump housing was removed and replaced.

Write-ups regarding the passenger air packs were numerous, however, the work accomplished consisted of "routine" duct leak checks that were accomplished in accordance with the maintenance manual instructions.

Inspection of the drain cavity at the canted bulkhead revealed minor surface corrosion and a plugged drain line at fuselage station 1,240. The corrosion was removed and the drain was unplugged.

During the "D" check, the center wing fuel tank was "inspected in detail" by two TWA Inspectors. The Boeing 747 Maintenance Manual, chapters 28-11-00 and 12-09-08 were referenced to accomplish the inspection, The applicable manuals used to accomplish this task are located at the aircraft for the Inspectors and mechanics to reference. TWA scheduled maintenance procedures indicate that the "D" check is the only time in which there is scheduled access to the interior of the center wing fuel tank.

The routine work cards used to accomplish the detailed inspection for the center wing fuel tank were:

A402 - Open Center Tank
A424 - Center Section Dry Bay Open-up
C412 - Install Fuel Valves-Center Tank
C413 - Remove Fuel Valves-Center Tank
D450 - Inspect Wing Center Tank
D451 - Inspect Wing Center Tank Dry Bay
H402 - Close Center Tank
H424 - Close Center Fuselage and Tank

(Exhibit E - Center Wing Tank Routine Work Cards)

Work cards C412 and C413, identify the work performed for the engine cross feed check valves; the center tank scavenge check valve; the center tank scavenge pump inlet/removal check valve and the center tank jettison pump discharge check valves.

The valves are removed from the aircraft and sent to the TWA maintenance shop for shop check and repair as required. The fuel cross feed check valves and the center tank scavenge check valve were sent to the shop and tested. During the test, the valves operationally checked within limitations and no parts were replaced.

The work cards reference, in parenthesis, the number of o-rings to be used and their part numbers. The word "ordered" is hand written next to the reference.

(Exhibit F - Check Valve Work Cards)

The center tank jettison pump inlet/removal check valves and the center tank jettison pump discharge check valves are expendable valves and are not rotable parts. If the valve checks out as operational, it is then put back into service. If the valve does not pass the test, it is discarded. TWA does not maintain shop records for expendable parts.

Work Cards D450 andD451 direct the Inspector to "Detail Inspect All Items In Center Tank," and "Detail Inspect All Items In Center Tank Dry Bay." The TWA General Policies and Procedures Manual defines "Detailed Inspection" as:

> 'The area inspection concept constitutes a very detailed inspection of the designated area, including but not limited to structures, tubing, cables, wiring, and any units exposed or visible through routine open up. Normal assistance to visual inspection will be used as required and may consist of mirrors, magnifying glasses, dye penetrant checks or specialized non-destructive test equipment where applicable,"

During the "D Check, there were no non-routine work cards generated for the center wing fuel tank, and there were no structural discrepancies reported for level 2 or 3 corrosion.

The last unscheduled maintenance performed to the center wing fuel tank, after the "D Check, were for fuel pump removals and installations. The right side jettison pump was installed on May 15, 1995; the left side jettison pump was installed on March 27, 1996, and the scavenge pump was installed on April 22, 1996. Removal and installation of the center wing fuel tank fuel pumps does not require access to the interior of the center wing fuel tank.

INSPECTOR INFORMATION

Currently, TWA employs 226 Inspectors system wide. Inspection personnel are staffed at Kansas City, MO (47 Airframe and 92 Engine Overhaul); St. Louis, MO, (40); Los Angeles, CA (23); New York, NY (21); and San Francisco, CA (3).

The Inspectors are used to inspect mechanical integrity and/or work performed on all TWA aircraft, engines, and components to assure the required standards are met, Full-time inspectors must be properly trained, qualified and authorized to perform inspections on TWA aircraft. The inspectors must posses valid Airframe and Powerplant certificates, pass a visual acuity test, and have a minimum of 15 months with the company as a Mechanic. TWA promotes its inspectors from the Union (IAM) ranks of aircraft mechanics.

Two inspectors performed the "detailed inspection" on the center wing fuel tank at the last "D" Check. Both inspectors signed-off on work cards D450 and D451 on October 6, 1992.

Personnel records provided by TWA indicate that both inspectors had been employed with TWA since the mid 1960's. One inspector retired from TWA on November 1, 1992, the other inspector retired on May 1, 1997. Both inspectors have held Airframe and PowerPlant certifictes since 1970. One inspector held inspection authority since April 1977, and the other held inspection authority since November 1985.

Training records indicate that both inspectors attended and passed the required courses as specified in the General Policies and Procedures Manual.

NON-ROUTINE MAINTENANCE PERFORMED AT "C" CHECKS

A review of the non-routine work cards from the "C" checks after the last "D' check identified maintenance work performed in the area of the center wing section. During the "C" checks, there are no scheduled internal center wing tank inspections. Access to the center wing tank, other than at the "D check, would be performed "as needed" and identified as non-routine.

PHASE 3A "C" CHECK DATED 5/6/93

During this inspection, a fuel jettison pump S/N: 2081 was installed. operational and leak checks were performed.

PHASE 3B "C" CHECK DATED 7/3/93

During this inspection, several leaks at duct clamps and packs were noted. Routine maintenance correction actions were accomplished.

PHASE 3C "C" CHECK DATED 8/13/93

Write-ups for the No. 2 heat exchanger header access plate looseness were noted. Routine maintenance leak checks were accomplished and the header plate was secured.

During the Phase 3D dated 10/5/93, 4A dated 11/28/93, and 4B dated 2/1/94, "C" checks, there were no non-routine write-ups between stations 1,000 and 1,300 for the center wing fuel tank or the packs.

ANNUAL 2E "C" CHECK DATED 10/14/94

All of the carpets and seat covers were changed per Modification Order71T72. The seat cover changes were accomplished in phases during this check. Several write-ups of the packs identified leaks, and routine leak checks were accomplished.

ANNUAL 3E "C" CHECK DATED 11/6/95

Several write-ups regarding leak checks for the packs and the heat exchangers were noted. Routine leak checks were accomplished.

Two new forward passenger oxygen bottles were installed, and a floor panel was removed under row 28 and then reinstalled for access to a metal repair.

FUEL PUMP MAINTENANCE HISTORY

There are 16 fuel pumps in the Boeing 747-131. Eight boost pumps are located with four in each wing, six jettison pumps are located with two in each wing and two in the center wing fuel tank, one scavenge pump is located in the center wing fuel tank, and one auxiliary power unit DC pump is located in the left wing.

The fuel scavenge pump, the APU DC fhel pump and the fuel boost pumps do not have an installation time limit and remain in the aircraft until the pump is inoperative. An inoperative pump is sent to TWA's overhaul/repair facility for inspection, repair/overhaul and testing. After the pump is signed-off as serviceable, it is either put back into service where needed, or prepared for storage per each fuel pump's overhaul manual, storage and shipping requirements.

The fuel jettison pump motors have a TWA 9,000 hour hard time limit. The 9,000 hour limit was established by T WA more than 17 years ago after TWA determined that the mean time between unscheduled removal (MTBUR) for the pump was 11,352 hours. The 9,000 hour scheduled removal for the pumps are at every second "C" check and at every "D" check. The intent of the 9,000 hour limit was to reduce the number of premature and unscheduled removals.

According to the Minimum Equipment and Dispatch Procedures Manual, one jettison pump maybe inoperative, provided the takeoff weight does not exceed performance limitations determined by the engine-out maximum landing weight, the jettison nozzle remains closed, and the No. 1 and No. 4 main tank jettison transfer valves remain closed.

A center wing jettison valve maybe inoperative in the open position, provided that both jettison nozzle valves operate normally and are closed. A center wing jettison valve maybe inoperative in the closed position provided that the center tank fuel is considered as payload and all of the number 2 and 3 boost pumps operate normally.

Number 1 and/or number 4 main tank jettison transfer valves maybe inoperative in the closed position, provided fuel required to be jettisoned does not deplete the inboard main tanks below the quantity in the outboard main tanks plus 1 and 4 reserve tanks.

The TWA Kansas City, MO, Maintenance Coordinator must approve the deferral of an inoperative jettison valve, and the fuel jettison switch cover (F/E panel) must be placarded "INOP."

MAINTENANCE HISTORY OF FUEL PUMPS INSTALLED ON N93119

The maintenance history for each fuel pump is identified by TWA Component Shop Records. Each record identifies the aircraft and date the pump was previously removed from. The discrepancy is recorded, along with the work accomplished. The pump is then tested, signed off, and dated as serviceable

The following text identifies the previous pumps that were installed on N93 119 and the reason for removal, along with the most recent reason for removal, and the work accomplished on the pump that was currently installed onN9311 9 at the time of the accident

1. Scavenge Pump - Serial number M285, was removed from N93 119 on August 15, 1994, due to the pump being inoperative. During the overhaul, it was found that the bearings were worn, causing the rotor to rub, The stators, bearings, blades, valve housing liner and rotor were replaced, The pump was signed-off as overhauled on October 18, 1994, and tested on October 20, 1994. The pump was re-installed in N93 119 on April 22, 1996.

2. APU DC Pump - Serial number M365, was removed from N133TW on April 2, 1990, as the pump was inoperative. During the overhaul, it was found that the brushes were worn, and the rotor was damaged. The pump was signed-off as repaired on September 6, 1990, and tested on September 12, 1990. The pump was installed in N93 119 on April 15, 1996.

3. Boost Pump - Serial number 711533, located in the left wing was installed new inN93119 on December 20, 1976. The pump remained operational, and there is no record of repair or overhaul.

4. Boost Pump - Serial number 680003, located in the left wing, was removed from N93 105 on September 16, 1993, due to an open fuse. The pump was repaired by replacing the fuse, rotor and packing. The pump was signed-off as repaired on December 15, 1993, and tested on December 27, 1993. The pump was installed in N93 119 on February 22, 1994.

5. Boost Pump - Serial number 95309A located in the left wing, was removed from N134TW on December 23, 1991, due to the pump being inoperative. During the repair, it was found that the stator was burned. The pump was signed-off as repaired and tested on March 2, 1992. The pump was installed in N93119, on March 13, 1992.

6. Boost Pump - Serial number 000972, located in the left wing, was installed newinN93119 on December 20, 1976. The pump remained operational, and there is no record of repair or overhaul

7. Boost Pump - Serial number 700763, located in the right wing, was removed from N305TW on June 8, 1991, due to the pump being inoperative. During the repair, it was found that the rotor was scored. The pump was signed off as repaired and tested on September 24, 1991. The pump was installedinN93119 on October 14, 1991.

8. Boost Pump - Serial number 711606, located in the right wing was installed newinN93119 on December 20, 1976. The pump remained operational and there is no record of repair or overhaul.

9. Boost Pump - Serial number 690223, located in the right wing, was removed from N53 110 on July 24, 1990, due to a low pressure light. During the repair, it was found that the stator had shorted. The pump was signed-off as repaired on October 5, 1990, and tested on November 3, 1990. Maintenance records indicate that the pump was installed inN9311 9 on October 8, 1990. TWA maintenance personnel believe that the date was incorrectly noted, and the correct installation date was November 8, 1990,

10. Boost Pump - Serial number 711604, located in the right wing, was installed newinN93119 on December, 20, 1976. The pump remained operational, and there is no record of repair or overhaul.

11. Jettison Pump - Serial number 690469A, located in the center wing fuel tank, was removed from N93 108 due to an open fuse and the pump would not flow. During the overhaul, the stator, bearings, and rotor were replaced. The pump was signed-off as overhauled on March 14, 1996, and tested on March 18, 1996. The pump was installed inN9311 9 on March 27, 1996. At the time of the accident, the time remaining for this pump was 7,730 hours, with an estimated run-out date of February 10, 1998.

12. Jettison Pump - Serial number 690394, located in the center wing fuel tank, was removed from N93 108 due to time. During the overhaul, the bearings were replaced. The pump was signed-off as overhauled on December 6, 1994, and tested on December 8, 1994. The pump was installedinN93119 on May 15, 1995. At the time of the accident the time remaining for this pump was 4,588 hours, with an estimated run-out date of June 24, 1997.

13. Jettison Pump - Serial number 700822, located in the left wing, was removed from N133TW due to time. During the overhaul, the bearings and impeller were replaced, and the elements were re-primed. During the build-up, the stator failed and was then repaired. The pump was signed-off as overhauled on February 16, 1995, and tested on February 23, 1995. The pump was installedinN93119 on April 5, 1995, At the time of the accident, the time remaining for this pump was 4,253 hours, with an estimated run-out date of May 30, 1997.

14. Jettison Pump - Serial number 700934, located in the left wing, was removed fromN134TW as the pressure light illuminated with the switch on. During the overhaul, it was found that the plating flaked off the rotor, and there was evidence of short damage to the rotor bearings, and the stator fuse was blown. The stator, rotor, and bearings were all replaced. The pump was signed-off as overhauled on May 24, 1995, and tested on May31, 1995. The pump was installedinN93119 on June 14, 1995. At the time of the accident, the time remaining for this pump was 4,886 hours, with an estimated run-out date of July 16, 1997.

15. Jettison Pump - Serial number 712059, located in the right wing, was removedfi-omN93119 due to time. During the overhaul, the bearings and bearing holder were replaced. The pump was signed-off as overhauled on May 25, 1994, and tested on May 1, 1995. The pump was re-installed in N93119 on May 14, 1995, At the time of the accident, the time remaining for this pump was 4,573 hours, with an estimated run-out date of June 23, 1997.

16. Jettison Pump - Serial number 790293, located in the right wing, was removedfkomN93108 due to time. During the overhaul, the rotor, bearings, both plates, and element were replaced. The pump was signed-off as overhauled on August 8, 1995, and tested on August 28, 1995. The pump was installed in N93 119 on September 10, 1995. At the time of the accident, the time remaining for this pump was 6,114 hours, with an estimated run-out date of October 14, 1997.

(Exhibit G - Component Shop Record Cards and Testing Cards).

FUEL PUMP OVERHAUL PROCEDURES

TWA's Kansas City, MO, maintenance base has an overhaul/repair shop to refurbish all of the pumps utilized for TWA's entire Boeing 747 fleet.

The jettison pumps and the boost pumps are manufactured by Crane Hydro-Aire Division. The scavenge pump and the APU fuel pump are manufactured by Lear Romec, a division of Crane. The TWA maintenance base repaired and overhauled these pumps in accordance with the manufacturers' overhaul manuals and TWA's reliability control program specifications established or approved by TWA engineering.

APPLICABLE SERVICE BULLETINS AND AIRWORTHINESS DIRECTIVES FOR THE FUEL PUMPS

Airworthiness Directive (AD) 79-06-02, effective April 19, 1979, (Exhibit H) required compliance as identified in Boeing Alert Service Bulletin (SB) 747-28A2092, dated February 12, 1979, (Exhibit I) and revised April 27, 1979, The SB, entitled Main Fuel Tank Pump Wiring Inspection, Rework and Modification, was a one-time accomplishment. The inspection, repair, and modification was to preclude electrical arcing into the No. 2 and No. 3 main fuel tanks. This arcing could have resulted from darnaged wires which provide power to the No. 1 and No. 4 main fuel tank boost pumps. Reported chafing and abrasion was attributed to vibration of the wires against the conduit wall. TWA records indicate that the AD was accomplished by TWA maintenance personnel on June 6, 1979.

Since the accident, the FAA has issued AD 96-26-06, effective January 21, 1997, (Exhibit J) which requires a one-time inspection to detect damage to the sleeving and wire bundles of the boost pumps of the numbers 1 and 4 main fuel tanks, and the auxiliary tank jettison pumps if installed, replacement of any damaged sleeving with new sleeving; and repair or replacement of any damaged wires with new wires. The AD further states that if any burned wires are found, inspection of the conduit and replacement of the conduit (if damage is found) is required.

The FAA determined that an environment conducive to vibration exists in the conduit and wire bundles of the boost pumps and the auxiliary tank jettison pumps. This vibration could result in abrasions of the Teflon sleeving and subsequent abrasion to the wire bundles.

Service Bulletin 747-28A2194, dated August 3, 1995, and revised January 18, 1996, (Exhibit K) entitled Fuel - Distribution - Fuel Boost and Override/Jettison Pumps - Inspection, indicated that the action was to access all of the 747 boost and jettison pumps to do an insulation resistance check on each pump. Any pumps that did not pass the insulation resistance check were to be replaced. Boeing recommended that the initial inspection be accomplished at the next opportunity when manpower and facilities were available.

The Service Bulletin indicated that operators had reported fuel leaks on at least eight fuel pumps. The pumps that were removed had between 34,000-67,000 hours since new or overhaul. The leaks were located at the pump/wire bundle interface. One operator reported a fire during maintenance at an inboard main tank jettison pump which resulted from a leak.

The Service Bulletin stated that "... after a long time, water can get inside the potting of the wire terminal assembly and cause corrosion. The corrosion in the wire terminal assembly can cause arcing between the power pins and the pump case. The arcing causes thermal expansion of the materials inside the cap. This expansion causes failure of the cap attachment flange or the attaching screws and a subsequent fuel leak."

A high current during arcing can also melt a hole through the pump end-case and connector, which could also create a leak.

The Service Bulletin directed the test of the pump wiring insulation resistance to make sure that no conductive corrosion was in the wire terminal assembly.

At the time of the maintenance review, TWA personnel reported that SB 747-2%42 194 had not been accomplished onN9311 9 because of a pending AD. Federal Aviation Administration Notice of Proposed Rule Making (NPRM) No. 96-NM-57-AD (Exhibit L) (proposing an AD that was applicable to all Boeing Model 747 and 757 series airplanes.) Because of the pending AD, TWA was in the process of preparing TWA Modification Order Number 72F57, entitled Fuel Boost and Override/Jettison pump Insulation Resistance Check. (Exhibit M). The modification order directed the initial inspection of the 747 fuel pumps for leaks at the fuel pump/wire bundle interface, and to test the insulation resistance of the pump wiring to meet the requirements set forth in the pending AD, Service Bulletin, and Boeing Telex letters. TWA reported that the Modification Order was to be finalized after the AD became effective, in case there were changes made to the AD that were not identified in the SB.

The proposed AD would "require repetitive visual inspections to detect discrepancies of the wire terminal assembly, electrical connector, and wire insulation on the fuel pump, and replacement of the fuel pump with a new fuel pump, ifnecessary." The proposal would also require "repetitive insulation resistance test of the fuel pump wiring."

The pending AD became effective on March 14, 1997, as AD 97-03-17. (Exhibit N). TWA Modification Order 72F57 was finalized on April 1, 1997,

FUEL PUMP WRITE-UPS FROM JULY 1, 1994 THROUGH JULY 17, 1996

Aircraft Maintenance Log dated June 27, 1994, indicated that the number 2 main inboard jettison pump low pressure light illuminated. The maintenance records indicate that the item was deferred and the aircraft was placarded to show the inoperative pump. On July 2, 1994, maintenance personnel performed an operational check to the low pressure indication system several times and the fault could not be recreated.

Aircraft Maintenance Log dated July 2, 1994, indicated that the scavenge pump low pressure light illuminated with 2,100 pounds of fuel remaining in the center fuel tank. The center tank was sumped and the scavenge pump operationally checked okay.

Aircraft Maintenance Log dated July 3, 1994, indicated that the number 1 fuel tank aft boost pump pressure light illuminated with the pump on. The circuit breaker was re-seated and the system operationally checked normal.

Aircraft Maintenance Log dated July 7, 1994, indicated that on pre-flight the flight crew reported a problem with the number 1 aft boost pump. The aircraft was placarded and the item was deferred until July 8, 1994, when the connector was reset and cleaned. The aft boost pump was checked for operation and light indication was normal.

Aircraft Maintenance Log dated July 17, 1994, indicated that the number 1 aft boost pump low - pressure light will not go out with the pump on. The aircraft was placarded and the item was deferred until July 18, 1994. The system was trouble-shot and found that the pump was drawing amperage and transferring fuel. Maintenance suspected the low-pressure switch. The number I all boost pump pressure switch was replaced. The operation and checks for leaks were accomplished.

Aircraft Maintenance Log dated August 10, 1994, indicated that the scavenge pump was inoperative. The item was &ferred with a note: "Check 3 phase vac found good. Checked pressure light, found good. Checked vdc for coil, found good. Checked 1X on R296, found no ground with ground safe. Circuit breaker was pulled." The scavenge pump was replaced on August 14, 1994. Operations checked normal

Aircraft Maintenance Log dated September 12, 1994, indicated that the scavenge pump low-pressure light illuminated with 2,300 pounds of fuel remaining in the center wing tank. The item was deferred until September 12, 1994, when the pressure switch was replaced. Leak and operation checks were performed.

Aircraft Maintenance Log dated September 15, 1994, indicated that the scavenge pump low-pressure light illuminated with 2,700 pounds of fuel remaining in the center tank. The light blinked on and off continuously during scavenge. Pump worked okay. The item was deferred until September 15, 1994, when relay R296 was replaced. An operations check was required when the center tank had fuel.

Aircratt Maintenance Log dated October 19, 1994, indicated that the APU "DC pump ON" green light flickering and chattering noise from un&r flight engineer's table, right side. Number 2 boost pump is operating. Re-seated and cleaned connector at number 2 boost pump. Checked operation of APU DC pump "on" light and found normal.

Aircraft Maintenance Log dated February 2, 1995, indicated that the DC pump fails to extinguish with AC power available. Aft number 2 main Boost pump light extinguished. DC pump light did go out with forward boost pump on. The DC pump pressure switch plug was cleaned. An operations check of the APU was normal,

Aircraft Maintenance Log dated March 31, 1995, indicated that the APU DC pump "ON light (green), flicked on and off while the APU was running with normal AC electrical power available to fuel pump. The APU fuel control pressure switch was replaced. Operations checked normal.

Aircraft Maintenance Log dated June 14, 1995, indicated that the center tank left outboard jettison pump was changed for time. When the tank is fueled it will need a leak and operations check. The item was deferred until June 14, 1995. The item was entered incorrectly, and it should have been number 2 main jettison pump, left outboard. This pump was leak and operationally checked after the aircraft was fueled for flight 840.

Aircraft Maintenance Log dated July 5, 1995, indicated that the number four main tank forward boost pump pressure light would not illuminate when the switch was off. The number four tank was sumped and no water was found. The cannon plug on the pressure transmitter was cleaned. Operations checked normal.

Aircraft Maintenance Log dated September 25, 1995, indicated that the boost pump pressure lights on the flight engineer's fuel panel failed to illuminate dim. The lights go out when dim selected. The item was &ferred until September 26, 1995, when the A14 circuit board in master dim control module was secured. Operations checked normal.

Aircraft Maintenance Log dated September 29, 1995, indicated that the scavenge pump low pressure light illuminated with the pump switch on and 1,400 pounds of fuel in the tank. Fuel quantity did not decrease. The item was deferred until September 30, 1995, when 2,000 pounds of fuel was transferred into the center tank and then removed with the scavenge pump. Operations checked normal.

Non-Routine Maintenance Record dated December 1, 1995, indicated that the scavenge pump low pressure light illuminated with 1,500 pounds of fuel. Operationally checked scavenge pump and sumped center tank. All operations checked normal.

Aircraft Maintenance Log dated December 29, 1995, indicated that the scavenge pump low pressure light illuminated with 1,500 pounds of fuel remaining in the center wing tank. It switched on at 1,500 pounds. The item was deferred until January 1, 1996, when the center tank was sumped. Operations checked normal on ground.

Non-Routine Maintenance Record dated January 1, 1996, indicated that scavenge pump low pressure light illuminated with 1,500 pounds of fuel. Operationally check scavenge pump and sump center tank. All operations checked normal.

Aircraft Maintenance Log dated February 27, 1996, indicated that the DC pump light failed to extinguish with AC power available to the aft number 2 main boost pump. Light extinguished. The DC pump operation was checked and found normal on the ground. The light did extinguish.

Non-Routine Maintenance Record dated March 28, 1996, indicates that fuel was transferred into the center tank. An operational and leak check was then performed on the left center jettison pump due to time change, Operations and leak check was normal. Fuel was transferred back out of the center tank.

Non-Routine Maintenance Record dated March 30, 1996, indicated that the number 2 aft boost pump would not test. A relamp did not help. The number 2 aft boost pump light socket was replaced. Operations checked okay.

Non-routine maintenance record dated April 18, 1996, indicated that the APU DC electric pump would not operate. The maintenance records indicate that the APU DC electric pump was replaced, and an operations and leak check was performed.

Aircraft Maintenance Log dated April 21, 1996, indicated that the scavenge pump pressure warning light illuminated when the switch was on, and there was known fuel in the center tank (1,000 pounds). The maintenance records indicated that the scavenge pump and the scavenge pump switch were replaced. The placard was removed and the task was closed out.

Aircraft Maintenance Log dated April 26, 1996, indicated that with the APU running and the AC bus #1 powered, both the #2 aft a/c boost pump and DC APU pump running, the DC pump light blinks on and off. The maintenance records indicated that the operations check for the APU DC pump was normal.

Aircraft Maintenance Log dated May 8, 1996, indicated that with the APU running, the DC pump on-light flickers with the #2 aft boost pump feeding the APU. The maintenance records indicated that the malfunction could not be duplicated on the ground. The APU was started and the DC pump was checked.

Aircraft Maintenance Log dated May 28, 1996, indicated that the boost pump lights on the flight engineer's panel failed to illuminate dim with the switch in the dim position. The bright works okay. The light stayed bright with the switch in the dim position. The bright and dim relay was re-seated. Operational check of the light was normal.

AIRCRAFT LOGBOOK ENTRIES FOR FUEL WRITE-UPS

AIRCRAFT NOT ACCEPTING FUEL

The Aircraft Maintenance Logbook entries from July 1, 1994 through July 17, 1996, indicate that the aircraft experienced several intermittent problems not accepting fuel In most cases the aircraft was pressure fueled and the action was deferred. The following logbook entries identify the discrepancy and the work accomplished.

Non-Routine Maintenance Record dated December 16, 1995, indicated that the aircraft would not accept fuel. The volumetric control was replaced. Operations checked normal.

Non-Routine Maintenance Record dated April 21, 1996, indicated a delay, stating that the aircraft would not take fuel The four main fuel tanks were pressure fueled. During a follow-up check of the system, it was found to operate normal during ground fueling.

Aircraft Maintenance Log dated April 28, 1996, indicated that there was a two-and-a-half hour delay due to the wing fueling valves closed continuously for no apparent reason. The circuit breaker on panel 15, right side electronic had no effect. The fuse on the fuel probe, overflow on black box in electronic had no effect. No breakers were popped. Fueler was finally able to fuel by constantly moving (about every 2 seconds) the fuel switch back and forth between normal and battery. The switch, which is activated by opening fueling panel operated normal. The connector at the panel was cleaned. The item was entered on the Open Item Work Sheet to correct as required.

Aircraft Maintenance Log dated April 30, 1996, indicated that on fueling, aircraft fueling system shut down and aircraft would not take fuel. The item was deferred until May 1, 1996, when the fueling panel magnet was replaced. Operations checked normal.

Aircraft Maintenance Log dated May 2, 1996, indicated that the number 4 main fuel gauge volumetric shut off at "22.4", then the volumetric switch in the main electrical service bay shut off all of the fueling valves at the under-wing fueling station. This write-up references the write-up page dated April 30, 1996, indicating that the fueling system shut down. The item was deferred until May 5, 1996, when theR118 ground handling number two relay was replaced due to no power at B2 terminal, and only 19 vdc on the external power output. The system was then operationally checked as normal.

Non-Routine Maintenance Record dated May 15, 1996, indicated that the fuse and fuse holder were missing from the volumetric controller. Both were replaced.

Non-Routine Maintenance Record dated May 23, 1996, indicated that the aircraft again would not accept fuel The fueling door magnet was replaced and the door was secured. The system then checked normal.

Non-Routine Maintenance Record dated June 4, 1996, indicated that the fuel system "shutdown" while fueling. The volumetric switch and valves were cycled several times and the system then checked normal. Previous reports indicated the possibility of shutting off early. Correction as required. The auto-fuel shut off at approximately 80,000 to 85,000. The overfill circuit breaker was pulled to continue fueling Maintenance suspected that the number one reserve or main refuel valve was not shutting completely.

Aircraft Maintenance Log dated July 7, 1996, indicated that all fuel valves shutoff during fueling and they did not open electrically. The surge tank was sumped and all the valves then operated normally.

After the accident on July 17, 1996, a mechanic reported to the National Transportation Safety Board Operations Group Chairman, that during the fueling process for Flight 800, at JFK, the fuel system shut down. The mechanic reported that a circuit breaker was pulled and the pressure fueling process was continued. After the fueling was complete, the circuit breaker was reset. The mechanic reported than an entry in the Aircraft Maintenance Logbook was not made prior to the departure of the flight.

Maintenance Manual Reference For Fueling Discrepancies

The 747 Maintenance Manual, section 12-11-01, Fuel Tank - Servicing, states that the airplane is normally pressure fueled. The pressure fueling stations are located in the leading edge of each wing between the engine nacelles. The fueling station in the left wing contains the refueling control panel for controlling and monitoring the pressure fueling operation.

This section identifies several problem solving procedures for maintenance personnel to follow in case of a fuel system malfunction

The manual states for a malfunctioning volumetric shutoff control unit that, "should dispatch time prevent repair of a malfunctioning volumetric shutoff control unit, the shutoff system can be disabled by removing the fuse in the volumetric shutoff control unit in the right main equipment center on shelf E3. This permits operation of the refuel valves and fuel quantity indicators, but disables the automatic volumetric shutoff control unit. The fuel level shutoff must be controlled by the individual refuel valve switches for all tanks."

The maintenance write-ups indicate that maintenance personnel were trouble-shooting the intermittent malfunction by ordering and replacing specific items in the system. In the meantime, if a malfunction occurred, the aircraft could be pressure fueled by manually removing the fuse to disable the volumetric shutoff control unit.

FUEL LEAKS

Three aircraft logbook entries were noted indicating a fuel leak between July 1, 1994 and July 17, 1996.

Aircraft Maintenance Log dated September 23, 1995, indicated that during the walk-around, the flight engineer observed fuel dripping from the left wing dump chute (fueling was in process). The drip stopped with the termination of the fueling. Engineering note: This is an abnormal condition, possible dump valve problem. Pressure fuel system. Leaks were checked for and none were noticed.

Non-Routine Maintenance Record dated June 18, 1996, indicated that fuel was found leaking from the fuel shut-off valve when checking cross-feed valve operation. This was recorded during an engine change. The number three engine was removed because of an over-temperature and a replacement engine was installed. During the engine preparation of the replacement engine, the cross-feed valve operation is to be checked. The particular engine boost pump circuit breaker is to be closed and an engine fuel shutoff check is to be accomplished per Maintenance Manual 28-22-05. Maintenance personnel transferred fuel into the number three fuel tank and accomplished a shutoff valve check per Maintenance Manual 28-22-05 instructions. The write-up indicates that eight drops per minute were noted from the shut-off valve, which is within limits per the Maintenance Manual instructions which allows for leakage not to exceed 20 drops per minute.

Aircraft Maintenance Log, dated July 10, 1996, indicated that a small amount of fuel was found dripping from the flap assembly on the left wing behind the number 2 engine. The work performed write-up indicated that the number one main control fueling valve core mounting screws were tightened. A leak check was performed and the entry was closed out.

FUEL INDICATION DISCREPANCIES

The Aircraft Maintenance Logs from July 1, 1994 to July 17, 1996, were reviewed to identify write-up discrepancies in the areas of fuel flow, fuel gauge, indications, inaccuracies, fluctuations and inoperable equipment. The following text identities the discrepancy and the work accomplished to close out the item.

Aircraft Maintenance Log dated July 9, 1994, indicated that at the flight engineer's panel, the total fuel indication drums hang up and rotate along with gross weight drums when gross weight is adjusted with set knob. The indicator was replaced with no help, and a note was made that the indicator was bad out of stock. The item was deferred until July 12, 1994, when the totalizer indicator was replaced. The system was calibrated per Maintenance Manual 28-41-00. Operation checks were normal.

Aircraft Maintenance Log dated July 30, 1994, indicated that the flight engineer's number one engine fuel flow read higher than other engines. A cross-feed check withfuel used indicator and quantity decrease confirmed a high fuel flow. The other engine parameters were normal The fuel flow power supply was replaced. An operations check was normal.

Aircraft Maintenance Log dated August 1, 1994, indicated that this was a repeat write-up from July 30, 1994. The item was deferred until August 3, 1994, when the number one engine fuel flow transmitter was removed and replaced. The engine was run and leak checked. The number 2 engine was run to compare the readings. Operation was reported as normal.

Aircraft Maintenance Log dated August 4, 1994, indicated that the number one reserve tank lost fuel, 3.3 at takeoff to 2.5 about four hours later. The transfer valve was checked for leaks. Under the wing was checked for leaks and none were found. A comparison check with drip stick indication was found normal. The sumps were drained.

Aircraft Maintenance Log dated August 10, 1994, indicated that the number one reserve fuel tank lost fuel, about 500 pounds (number one main tank did not increase). The tank was sumped. Both drip stick and gauge read the same. The item was deferred until August 18, 1994, when an operations check of the number one reserve fuel valve was okay.

Aircraft Maintenance Log dated November 21, 1994, indicated that the number one reserve fuel quantity indicator was inoperative. The item was deferred and until the item was complied with, the fuel quantity must be checked by drip stick prior to each takeoff. On November21, 1994, the indicator connector was cleaned and re-seated. Operations checked normal.

Aircraft Maintenance Log dated February 3, 1995, indicated that the totalizer was inaccurate. The Rome ramp indicator indicated 241.2 and gage total was 246.7. Required approximately five hours. The tanks were sumped and were found within maintenance manual limits.

Aircraft Maintenance Log dated February 3, 1995, indicated (on another flight) that the totalizer was inaccurate. The New York ramp indicator (totalizer) indicated 187.5 and the gauge total 191.4-calculated add 600 gallons under actual add. During the flight the totalizer and individual gauge total equaled at 85,000 pounds. The item was deferred until February 5, 1995, when the totalizer was calibrated per maintenance manual 28-41-00. Operations checked normal.

Aircraft Maintenance Log &ted February 11, 1995, indicated that the pilot's number two fuel flow indicator read high. Fuel used indicated high from the engine start until takeoff. Ram bite test on fuel flow module was conducted per maintenance manual instructions. Operations checked normal.

Aircraft Maintenance Log dated April 28, 1995, indicated that the fuel temperature indicator read low in all positions, The item was deferred until April 29, 1995, when the fuel temperature indicator was replaced. Readings were 15 degrees low on tank,engine 1, engine 3, and engine 4. Read 20 degrees low on engine 2.

Aircraft Maintenance Log dated May 5, 1995, indicated that the fuel temperature indicator for engine 2 read high by ten degrees C, when actual temperature was nearer to -10 degrees C. The item was deferred until May 6, 1995, when the fuel temperature bulb was replaced.

Aircratl Maintenance Log dated May 18, 1995, indicated that the gross weight /total fuel weight indicator was inaccurate. The gauge read 1,500 pounds less than the sum of the tank gages. The item was deferred until May 21, 1995, when the operations checked within maintenance manual limits.

Aircraft Maintenance Log dated July 30, 1995, indicated that the fuel quantity in the main tank, number one, decrease 2,000 pounds in four hours in cross-feed configuration. The totalizer matched fuel indicated in the tanks. The item was deferred until August 5, 1995, when the number one fuel quantity indicator was replaced. Full and empty capacitance were checked. The indicator to totalizer were calibrated per maintenance manual references. All of the systems checked normal.

Aircraft Maintenance Log dated August 3, 1995, indicated that an engineering note stated to placard the number one fuel gauge inoperative. Suspected that the fuel gauge was okay, but that there was a definite existing fuel problem. Suspect possibility of fuel siphoning from the number 1 tank (when boost Pumps are off into fuel manifold. Theaircraft was checked for external fuel leaks and none were found. Pressurized fuel manifolds and no transfer of fuel was noted. Checked the fuel burn for engine and all checked normal. Engineering was notified and suspected the problem remains in the indication. The item was closed out on August21, 1995, during the AS-1 check. (NOTE The paperwork for the AS-1 could not be located and suspect that it was misfiled).

Aircraft Maintenance Log dated August 4, 1995, indicated that an engineering note stated that the center wing fuel quantity digital indicator showed 1,300 pounds when analog needle indicated O. The item was deferred until August 5, 1995, when the center fuel quantity indicator was replaced. The fill and empty capacitance was checked and the indicator and totalizer was calibrated per maintenance manual instructions.

Aircraft Maintenance Log dated August 5, 1995, indicated that the number 1 fuel quantity indicator was replaced. The full and empty capacitance were checked and the indicator and fuel totalizer were calibrated.

Aircraft Maintenance Log dated August 7, 1995, indicated that during the course of cross-feeding (4 hours and 30 minutes), with the number one reserve tank valve closed and the boost pumps off in number one main fuel tank, the fuel quantities dropped from 3,500 to 2,850 in number one reserve, and from 21,700 to 19,100 in number one main tank. Fuel used plus fuel remaining equaled original fuel load, so the gauge was reading correctly. The number one reserve tank was fueled and no transfer of fuel occurred with the valve closed. Tank quantities were noted and no transfer was noted from number one or gain in other tanks. This was monitored for eight hours.

Aircraft Maintenance Log dated August 15, 1995, indicated that the flight engineer's fuel flow indicator was inoperative. Fuel used was okay. The forward panel fuel flow indicator was okay. The number four fuel flow indicator was replaced. Operations checked okay.

Aircraft Maintenance Log dated August 23, 1995, indicated that the number four fuel flow stuck at 7,900 pounds. The pilot's fuel flow were normal. The item was deferred until August 24, 1995, when the fuel flow indicator was removed and replaced.

Aircraft Maintenance Log dated October 9, 1995, indicated in an Engineering Note that before fueling, fuel discrepancies between the wing gauges and flight engineers were to be checked. All of the tanks were checked and the fuel sticks were all okay.

Non-Routine Maintenance Record dated December 1, 1995, indicated that the number 1 engine fuel flow was inoperative. Maintenance performed a bite check of the fuel flow and all operations checked normal.

Aircraft Maintenance Log dated December 4, 1995, indicated that the number 1 fuel flow was inoperative. The item was deferred until December 4, 1995, when the flight engineer's fuel flow indicator was replaced. The number 1 fuel flow transmitter connector was cleaned. Operations was checked as normal.

Aircraft Maintenance Log dated December 17, 1995, indicated that the number 4 reserve quantity indication was inoperative. The item was deferred until December 17, 1995, when both wing and cockpit indicators were replaced and calibration was required. The cockpit and wings full/empty were calibrated. Volumetric operations checked normal.

Aircraft Maintenance Log dated December 17, 1995, indicated that the center wing fuel tank gauge fluctuated between 2 and O with no fuel in the tank. The tank was sumped and the indicator calibration full/empty volumetric totalizer was replaced. Operations checked normal.

Aircraft Maintenance Log &ted December 28, 1995, indicated that the number 1 engine fuel flow fluctuates on. The item was deferred until January 1, 1996, when a bite check was performed on the fuel flow amperage,

Aircraft Maintenance Log dated April 27, 1996, indicated that the number 1 fuel flow (numerals) read 10,000 PPH above pointer value. The fuel used and pilot's gauge were okay. The number 1 fuel flow indicator was replaced and the operations checked normal. Operations of the number 1 engine fuel flow at the engineer's position was checked and found okay on start-up.

Aircraft Maintenance Log dated May 13, 1996, indicated that both of the number 4 fuel flow indicators were pegged high and inoperative. The item was deferred until May 15, 1996, when maintenance performed a bite check of the electronic unit, All tests were passed and maintenance suspected wiring. On May 16, 1996, maintenance cleaned and secured the fuel flow transmitter connector with no help indicated. On May 18, 1996, maintenance replaced the number 4 transmitter. After this, the engine fuel flow operations checked normal.

FUEL QUANTITY TANK UNITS

There are a total of 65 fuel quantity tank units probes, and 13 fuel quantity compensators located throughout the 747-131 aircraft. The locations of the fuel quantity tank units are: four in the No. 1 and No. 4 reserve tanks; 13 in the No. 1 and No. 4 main fuel tanks; 12 in the No. 2 and No. 3 main fuel tanks; and seven are located in the center wing fuel tank.

The fuel quantity compensators are located two in the No. 1 reserve tank; one in the No. 4 reserve tank; one in each surge tank; two in the No. 1 and No. 4 main fuel tanks; two in the No. 2 main fuel tank; one in the No. 3 main fuel tank; and one in the center wing fuel tank.

The fuel quantity tank units and compensators are "condition monitored" items and are removed from the airplane when the unit is inoperative. When an inoperative unit is identified, the unit is removed from the airplane and replaced with an airworthy unit. The inoperative unit is then sent to the TWA maintenance base in Kansas City for inspection.

The fuel quantity tank units were manufactured by Honeywell. TWA inspects/repairs/overhauls the units in accordance with the Honeywell overhaul manuals and TWA's reliability control program specifications established or approved by TWA engineering.

TWA overhaul shop records indicate that all fuel quantity tank units and compensators installed in N93 119 are the original units that were installed during manufacture in 1971.

Unless there is a malfunction of the fuel quantity tank units or compensators that requires unscheduled maintenance, the units are inspected during the scheduled "D' Check.

POWERPLANT REVIEW

The aircraft maintenance log was reviewed from July 1-17, 1996, and identified engine discrepancies and the work accomplished. The following text identifies the engine write-ups.

Engine position number 1, serial number 662209, was remwed from N93 119 on June 26, 1995, for hot section distress. The repair was performed at Kansas City (MCI) on November 16, 1995, and the engine was re-installed, at New York (JFK), in position number 1 on December31, 1995.

Maintenance write-ups and work performed on the engine since July 1, 1996, were:

- July 1, 1996- The Exhaust Gas Temperature (EGT) exceeded the limits to 920 degrees C for 90 seconds. An inlet and exhaust inspection waa performed, along with a duct leak check. All was reported as normal.
- July 1, 1996- The EGT exceeded the limits to 920 degrees C for 30 seconds. This temperature was located in area "A" on the over-temperature chart. The over-temperature was caused by a maximum power takeoff. The maintenance records indicate that the number one EGT indicator was replaced. The inlet and exhaust were checked, inspected and found "okay."
- July 13, 1996- The number one Engine Pressure Ratio (EPR) indicator was sticking. The maintenance records indicate that the engine EPR indicator was replaced and then checked.

. July 14, 1996- The number 1 engine EGT exceeded 970 degrees C for five seconds. The temperature was located in area "C" on the over-temperature chart. The over-temperature was caused by unexpected rapid spool-upon the engine for takeoff. The maintenance records indicate that an inlet and exhaust duct leak check was accomplished. The hot section and turbine section were borescoped and checked as "okay."

- July 17, 1996- The number 1 EPR indicator was sticking. The maintenance records indicate that the EPR module was replaced and an operations check was then performed.

- July 17, 1996- The number 1 EGT exceeded limits to 925 degrees C for approximately two seconds. The temperature was located in area "A" on the over-temperature chart. The over-temperature was caused by an unanticipated rapid spool-up of the engine for takeoff. The maintenance records indicate that the inlet and exhaust were checked and no abnormalities were found.

At the time of the accident, the engine had accumulated a total time since overhaul of 47,989 hours, and 9,684 cycles since overhaul.

Engine position number 2, serial number 662593, was removed from N133TW on July 8, 1995, for metal on the chip detector The main gearbox was replaced at New York (JFK) on July 24, 1995. The engine was installed on N93 119, in the number 2 position, on December 6, 1995.

Maintenance write-ups and work performed on the engine since July 1, 1996, were:

- July 14, 1996- The number 2 EGT exceeded the limits to 940 degrees C for 5 seconds, The temperature was located in area "B" on the over-temperature chart. The over-temperature was caused by an unexpected rapid spool-up on the engine for takeoff. The maintenance records indicate that an inlet and exhaust duct leak check was performed. A 9* and 15th stage and combustion borescope inspection was accomplished and all were checked "okay."
- July 15, 1996- The number 19 and number 25 fan blades had small nicks. The nicks were blended.
- July 17, 1996- The EGT exceeded the limits to 925 degrees C for approximately 2 seconds. The temperature was located in area "A" on the over-temperature chart. The over-temperature was caused by an unanticipated rapid spool-up of the engine for takeoff. The maintenance records indicate that the inlet and exhaust were checked and no abnormalities were found.

At the time of the accident, the engine had accumulated a total time since overhaul of 80,884 hours, and 14,609 cycles since overhaul.

Engine position number 3, serial number 662426, was removed from N305TW on June 8, 1996, for J powered conversion at New York (JFK). The engine was installed on the aircraft in position number 3 on June 18, 1996, at JFK.

Maintenance write-ups and work performed on the engine since July 1, 1996, were:

- July 1, 1996 -No malfunction, the oil quantity was checked and serviced to full. The cap was secured and the access door was closed. This logbook notation began on June 23, 1996, when the number 3 oil quantity indicator was reported as inoperative, The minimum equipment and dispatch procedures for an inoperative oil quantity system requires the oil quantity to be verified at maximum recommended capacity prior to each departure Logbook sign-off must be by a certified airframe and powerplant mechanic or flight crew member. This item remained open through July 17, 1996,

- July 5, 1996- The number 3 engine would not go into reverse. The maintenance records indicate that the engine was run and the thrust reverser was operationally checked. The operation was normal and the item was closed.

- July 7, 1996- The number 3 engine failed to go into reverse. The reverse lever interlock failed to release. The maintenance records indicate that the lockout bolts on the number 3 thrust reverser were installed, and the flex drive cables from the drive motor were removed. The thrust reverser was placarded as inoperative.

- July 15, 1996- All of the fan blades on the number three engine were rough. The maintenance records indicate that all of the edges were sanded smooth. The number 22, 28, and 32 fan blades had nicks on the leading edge. The nicks were blended.

At the time of the accident, the engine had accumulated a total time since overhaul of 80,336 hours, and 14,632 cycles since overhaul.

Engine position number 4, serial number 662463, was removed from N93 104 on December 21, 1995, due to high oil consumption. The engine was repaired and installedonN93119, in the number 4 position, on May 11, 1996.

Maintenance write-ups and work performed on the engine since July 1, 1996, were

- July 14, 1996- The number 4 engine EGT exceeded 960 degrees C for five seconds. The temperature was located in area "B on the over-temperature chart. The over-temperature was caused by an unexpected rapid spool-up of the engine for takeoff. The maintenance records indicate that the inlet and exhaust were checked and the 9* and 15th stages were borescoped and then were checked "okay."
- July 15, 1996- The EGT indicator was replaced after the EGT was exceeded out of Athens on Flight 881.

At the time of the accident, the engine had accumulated a total time since overhaul of 77,061 hours, and 14,016 cycles since overhaul.

CABIN ELECTRICAL AIRCRAFT LOGBOOK ENTRIES

The cabin electrical write-ups and sign-offs were reviewed from the aircraft logbook entries dated April 1, 1996, through July 17, 1996. The write-ups consisted of several entries of malfunctioning lighting for the passenger seating overhead reading lights, lights in the lavatories, galleys and overhead ceiling lights. Additional write-ups were noted to the passenger audio system.

A one-time entry of burned out overhead reading lights was noted for 71 seats located throughout the zones, The work performed for each seat was a "relamp" (replacement of the light bulb) of the inoperative light, followed by an operational check.

Multiple write-ups of two to four times for the passenger overhead reading lights were noted throughout the zones. Two seats with multiple entries were located in the Upper Deck; eight entries were noted in Zone B; six entries were noted in Zone C; seven entries were noted in Zone D; and two entries were noted in Zone E. In each case, the work performed was a "relamp" of the inoperative light followed by an operational check,

Multiple write-ups of two to five times were noted for lavatories J, L, U1, R, K and M. In each case, the work performed was a "relamp" followed by an operation check. Lavatories S, E, and H only had one write-up.

Multiple write-ups of two to eight times were noted for galleys B, C, D and E. In each case, the work performed was a "relamp" of the fluorescent lights followed by an operational check. Galley A had only one write-up.

The overhead ceiling lights that were written as inoperative were located in Zone C, left side isle between rows 21 through 27; the isle between the center lavatories, Zone D, left side isle at row 33, and Zone D, right side between rows 41 through 43. In each case, the fluorescent light was "relamped" followed by an operational check.

Audio system faults were noted at rows of seats located throughout the zones. Audio entries were noted in Zone B, row 8 through 16, seats 8, 9, and O. Both sides of Zone C, rows 17 through 28, seats 1, 2,3, 8,9, and O. The center seating section of Zone D, rows 33 through 37, seats 5,6, and 7. The right side of Zone E, rows 40 through 54, seats 8, 9, and O. In each case, the write-up was described as "static" in the audio system. The work performed consisted of resetting the passenger service system, securing loose connectors, replacing or reseating seat control units or reseating the seat electronic box.

Non-routine entries dated 4/25/96, 4/29/96, 5/31/96, 6/2/96, 6/30/96, 7/2/96, and 7/7/96, directed maintenance to check all passenger reading lights in all zones for proper operation, check all passenger call lights in all zones for proper operation, and to check all interior lights for proper operation. The work performed in each case described that the lights were checked and relamped as needed.

(Exhibit O- Cabin Electrical Write-ups).

MAINTENANCE PERFORMED AT NEW YORK (JFK) ON JULY 17.1996. PRIOR TO FLIGHT 800 DEPARTURE

Several write-ups were entered into the Aircraft Maintenance Log from the inbound Athens, Greece, Flight 881. The write-ups included

1. Both the # 1 and #2 engines exceeded the Exhaust Gas Temperature (EGT) limits of 925 degrees for two seconds. The over-temperature was caused by an unanticipated rapid spool-up of the engines during takeoff out of Athens. Maintenance checked the inlet and exhaust on both engines and no abnormalities were found.

2. The number three engine oil tank was checked and serviced with oil. There were no malfunctions. This was a deferred item from July 7, 1996, that stated it was required to physically check the oil quantity due to a discrepancy with the oil quantity gauge.

3, Two cabin write-ups reported that the splash guard in the aft upper deck lavatory was missing. Maintenance reset the splashpan and reported a normal operation. The second write-up reported that the drain in Galley "C" had a very bad leak and soaked the floor. Maintenance cleared the obstruction from the drain and reported a normal operation.

4. The number one Engine Pressure Ratio (EPR) indicator was sticking. Maintenance personnel replaced the EPR module and it was operationally checked.

5. A "Periodic Service" inspection was completed, along with a landing gear tire pressure check. (See attachment E for Periodic Service Inspection Report).

DEFERRED MAINTENANCE WRITE-UPS ON THE "OPEN ITEM WORK SHEET " DATED JULY 17, 1996.

Ten deferred maintenance items remained open on the 'TWA All Open Item Work Sheet" dated July 17, 1996, at New York (JFK), for the Flight 800 departure,

The open/deferred items include

1. Non-Routine Maintenance Record, dated June 9, 1996 at St. Louis, MO, Flight 721. The write-up reported that the underside of the left wing, between the fuselage and the wing gear at the trailing edge, forward of the flap, had a "30' " crack in the fiberglass panel. The crack was repaired per a time-limited engineering repair. The repair performed was a sandwich repair with two rows of bolts. The crack was stop drilled in the center section of the lower panel. TWA's engineering department reported that the fiberglass panel p/n: 65B 11640-1, that was repaired, is approximately five-feet in length. The write-up indicates "30'," which TWA reports most likely meant to indicate "30 inches." The item was to remain open until a new panel could be produced.

2. Non-Routine Maintenance Record. dated June 30, 1996, at Tel-Aviv-Yafo, Israel. The write-up reported that the arm rest cover at row31, seat 7 was torn. The item was deferred, reporting that the seat needed a new cover,

3. Aircraft Maintenance Log, dated July 4, 1996, at Madrid, Spain, Flight 903. The write-up reported that the left hand "canoe" fairing for the number two trailing edge flap was twisted. The fairing was removed due to a broken rear attachment fitting. The flap carriage was reported as normal.

The item was approved for deferral by the Maintenance Coordinator, Kansas City, MO. The Minimum Equipment and Dispatch Procedures, Configuration Deviation List, reported that "the movable portion of the entire fairing may be missing from one flap track provided: For takeoff, reduce runway zero wind and climb limit weights 2,700 pounds; and for landing, reduce critical temperature 1 degree F. If forecast temperature is above the adjusted critical temperature, see landing instructions."

A placard, with the associated limitations listed was to be affixed in the cockpit, in clear view of the pilot and other appropriate crewmembers.

4. Aircraft Maintenance Log, dated July 5, 1996, at New York (JFK), Flight 841. The write-up reported that there were spots on the upper deck carpets. The item was deferred because there was no time to accomplish the task.

5. Aircraft Maintenance Log, dated July 7, 1996, at Tel-Aviv-Yafo, Israel, Flight 884. The write-up reported that the number three engine failed to go into reverse and the reverse lever interlock failed to release. The pneumatic drive motor was replaced, however, the upper flex drive cables had been sheared and needed to be replaced. The cables could not be replaced at the time, as the facility stock was depleted.

The item was deferred with the approval of the Maintenance Coordinator, Kansas City, MO. The Minimum Equipment and Dispatch Procedures report that the items must be repaired within ten calendar days. The procedures stated that, "one (thrust reverser) may be inoperative provided anti-skid and autospoilers systems operate normally; no damage exists which would impair structural integrity of the affected reverser; and an approved procedure is established to verify that the inoperative thrust reverser is locked in the forward thrust position."

The item remained open and unchanged until July 17, 1996, at New York (JFK). Both of the upper cables to the air motor had been replaced and the cables were rigged to the air motor. The operation was checked, however, the thrust reverser would not fully go into reverse. The reverser was stowed and the cables were removed from the motor. The reverser was locked out with lockout bolts and safetied. The cowling was then closed. The TWA Director of Maintenance Support approved a ten day MEL limit extension on July 17, 1996, as the initial 10 day limit for repair expired on the same day. The extension was requested because of the need for a new drive motor and time to accomplish the repair. TWA also reported that three other aircraft were out of service andN93119 was needed to maintain scheduling. The item remained open and the placard remained in the flight station.

6, Aircraft Maintenance Log dated Julv 7, 1996, at New York(JFK), Flight 885. The write-up reported that the #3 engine was serviced with oil by maintenance, and the gauge read four quarts. After the engine was started the gauge reading dropped to 2.3 quarts and stayed there.

The item was approved for deferral by the Maintenance Coordinator, Kansas City, MO, The Minimum Equipment and Dispatch Procedures report that the items must be repaired within ten calendar days. The procedures state that "one (oil quantity gauge) may be inoperative if it is verified before each takeoff that the oil tank is filled to the maximum recommended capacity; there is no evidence of above normal oil consumption or leakage; and oil pressure indicating, low oil pressure warning, and oil temperature indicating systems operate normally and are monitored."

The affected gauge (F/E panel) is to be placarded "INOP." Prior to the departure of Flight 800, these procedures were signed-off as accomplished,

7, Aircraft Maintenance Log dated July 11, 1996, at New York (JFK). The first write-up reported that the Galley in zone "C" drained very slowly. The work performed was to clear the drain, and the item was signed-off as operational Flight 853, on July 12, 1996, at Rome, Italy, reported that the C5D drain at "C" galley was still clogged. The work performed was to clear the C5D drain. On July 12, 1996, at New York (JFK), an entry was made to the "All Open Item Work Sheet," indicating the clogged drain and previous trouble shooting. Air had been blown into the line, however, the clog remained. The item was deferred as there was no time to accomplish the task. The item remained open.

8. Aircraft Maintenance Log, dated July 15, 1996, at New York (JFK), Flight 800. The write-upon the Aircraft Maintenance Log page had not been pulled out of the airplane at the time of the accident. The entry on the "All Open Item Work Sheet" reported that the 3 Left, leading edge flap amber light stays on with the leading edge flaps up. The flaps were cycled and retracted electrically with no changes. The item was deferred due to no time to complete the task.

The Minimum Equipment and Dispatch Procedures state that the inoperative item must be repaired within ten calendar days. The procedure states that "one amber or green light for each indicating segment on the F/E flap position module maybe inoperative provided both forward panel lights operate normally. When any indicating light is inoperative, proper leading edge device position must be monitored utilizing operative lights after each mwement of flap handle to position 0, 1, or 5 ." The affected lights must also be placarded "INOP."

9. Aircraft Maintenance Log, dated July 15, 1996. The write-upon the Aircraft Maintenance Log page had not been pulled out of the airplane at the time of the accident. The entry on the "All Open Item Work Sheet" indicates that the R3 door pressure gauge was not visible. The pressure gauge was checked and found okay, however, the item was deferred as the chute cover needed to be reworked.

10. Aircraft Maintenance Log, dated July 17, 1996, at Athens, Greece, Flight 880. The log entry indicates that the captain's weather radar indicator was inoperative, with no range marks or antenna sweep.

The item was approved for deferral by the Maintenance Coordinator, Kansas City, MO. The Minimum Equipment and Dispatch Procedures state that the inoperative unit must be repaired within ten calendar days. The procedures state that "one receiver/transmitter unit and/or one display unit may be inoperative." The inoperative unit or component must be placarded in the flight station.

747 WING/PYLON MODIFICATION COMPLIANCE

TWA was authorized a 24-month extension by the Federal Aviation Administration to comply with the wing/pylon modifications over a five year period. The work was to be accomplished in four phases and completed in intervals.

The following are modifications which had not yet been accomplished at the time of the accident:

ITEM	SERVICE BULLETIN	TWA MOD ORDER
• Diagonal Brace Replacement	54-2123	72A03 (NEW)
• Mid-spar Fitting	54A2152	72A04 (NEW)
• Engine Mount Rework	41 A2269	95P49
• Upper Link Replacement	54-2027	89777 (Need To Generate New MO)

Retention devices had been deferred and would be accomplished on another Modification Order.

The following are modifications that had been accomplished at the time of the accident:

ITEM	SERVICE BULLETIN	TWA MOD, ORDER
• Fuse Pin Replacement	54-2155	71R99
• Upper Link Replacement O.B.	54-2030	96492
• Diagonal Brace Attach Fitting	54-2062	70J03
• Forward Engine Mount Bulkhead	54A2069	70J05
• Mid-spar Clevis	54-2118	70W01
• Pending FAA Approval	54A2179	
• Mid-spar Fuse Pin Stripe	54A2151	71P23
• Attach Fitting Fasteners	57A2235	70X23

ADDITIONAL MAINTENANCE RECORDS DOCUMENTATION

AIRWORTHINESS DIRECTIVES

An Airworthiness Directive (AD) status report was provided that listed all of the applicable AD's for N9311 9. (Exhibit P) The status report identified the AD by number, the effective date, the subject and the date of compliance. The list was reviewed to determine the AD's status, i.e. one time accomplishment, repeat inspection, terminating action etc.

TWA utilizes a computer process that provides the current AD status. The status reports are formulated from information generated from five computer data banks. The computer banks are:

1. MOC- 1 Maintenance Tracking
2. Modification Order System
3. AD to Aircraft Number applicability, with Accomplishment and Control Data
4. AD Cross Reference to Amendment
5. AD Remarks for Improved Clarification

It is the responsibility of the Director - FAA/ATA Liaison and Quality Assurance to receive, record and coordinate the AD's and other Federal Aviation regulations affecting ground operations. The Airworthiness Directives (AD) applicable to the center wing fuel tank are:

AD 90-25-05-747 Corrosion Control Program was effective on December 31, 1990. (Exhibit Q). Compliance of this AD was to be within one year after the effective date, revise the FAA-approved maintenance program to include the corrosion control program specified in Boeing Document Number D6-36022, Aging Airplane Corrosion Prevention and Control Program. TWA incorporated the required repetitive inspections set forth in the AD and the Boeing Document for inspection of corrosion throughout the airplane. The AD is identified via a TWA corrosion task number identified on the work cards.

Work Cards D450 andD451, Inspection of the center wing fuel tank and dry bay, identify task number C57-13 1-01, The last corrosion inspection performed on the center wing fuel tank was performed during the "D Check which was completed on December 14, 1992. During the detailed inspection of the center wing fuel tank, there was no corrosion noted,

AD 91-03-13-747 Center Wing Fuel Tank, was effective March 11, 1991. (Exhibit R). TWA accomplished this AD on December 11, 1992. The date of accomplishment was a terminating action. The AD required the verification of proper application of the center wing fuel tank secondary fuel barrier to prevent fuel or fuel vapors from entering the cargo or passenger compartments. The inspection of the center wing fuel tank secondary barrier application was to be accomplished in accordance with Boeing Service Bulletin 747-57-2253, revision 1, dated July 5, 1990. (Exhibit S). If the barrier was improperly applied, it was to be repaired prior to further flight. TWA records indicate that the barrier was properly installed and the AD was signed off in compliance.

MODIFICATION ORDERS

A list of the open and completed modifications for the aircraft were reviewed. Modification orders (MO), that could be generated by an AD and/or Service Bulletin, were reviewed to identify, in the case of the open modifications, the scheduled date of compliance, and in the case of the completed modifications, the date of accomplishment.

The list was reviewed to identify modification orders specific to the center wing tank. The list of open modifications identified Modification Order 72F57, (Exhibit M) referencing SB 747-28A2 194- Fuel - Distribution - Fuel Boost and Override/Jettison Pumps (Exhibit K) - Inspection as open.

The list of completed modifications identified

- MO71E83 - Leak/Operational Check of the APU, Boost, Jettison Pump and Refuel Valves accomplished on November 2, 1990.

- MO 98644- Removal of the Fuel Valve Actuator Electro-Magnetic Interference Filter accomplished on February 26, 1977.

MAJOR AND MINOR REPAIRS

A list of all major and minor repairs performed on the airplane since the "D" check dated 12/14/92, was provided for review. There were two major repairs performed on the aircraft. The first major repair dated 11/1 3/92, indicated corrosion damage to the left hand wing front spar web just above the lower chord. The repair consisted of cutting out the corroded section of the web and splicing in a new section between Front Spar Station 584 and 614. The second major repair dated 9/30/94, indicated damage to the fuselage skin at the aft edge of the bulk cargo door opening. The repair consisted of repairing the damaged area and installing a doubler and new fasteners.

Several minor repairs were identified and reviewed. These minor repairs were initiated from fatigue, corrosion and other damage. There were no major or minor repairs that were specific to the center wing fuel tank.

SUPPLEMENTAL TYPE CERTIFICATES

A list of all supplemental type certificates (STC) incorporated on the aircraft were reviewed. The list identifies installations of various cabin and cockpit equipment. Modifications were made to the upper deck passenger seating configuration. There were no structural STC modifications accomplished for the aircraft. (Exhibit T)

AIRCRAFT WEIGHT

The aircraft was last weighed on 12/11/92, at the completion of the "D check.

REVIEW OF ALL TWA 747 AIRCRAFT

At the time of the maintenance review, TWA had 16 Boeing 747 aircraft listed on their certificate, Twelve of the aircraft were 747-100 series, and four were 747-200 series. Two of the 747-100 series were placed on the TWA certificate after the accident in August, 1996. One 747-100 series airplane had been removed from service in September, 1994.

A ninety-day review of the aircraft maintenance logs for the remaining nine 747-100 series airplanes was accomplished. During the review, logbook entries were identified in the areas of fuel pump write-ups, electrical write-ups, fueling discrepancies, and fuel indicating system discrepancies. During the review there were no specific write-ups directed toward the center wing fuel tank. Fuel pump removals and replacements were recorded similar to that of the accident airplane.

All of the center wing fuel tank routine work cards, and where applicable, the non-routine work cards from the last Check "D" for each of these airplanes were reviewed. Non-routine maintenance performed on the center wing fuel tanks identified repairs as follows:

- A torn seal in the center tank sump access door on the right side. The seal was replaced.
- A jettison pump was removed in order to accomplish "tank work" to remove and reinstall a check valve.
- A fuel leak was found at the bottom of the center wing fuel tank on the outboard right hand side and four feet forward of the rear spar. The area was cleaned and the leak was sealed.
- Corrosion (exfoliated) was found between the web angle and center wing tank at fuselage station 1241, forward of the aileron control and 43 inches below the ceiling. The corrosion was removed and the access panels were replaced after the metal work was completed.
- A new APU fuel line was fabricated and replaced.
- Corrosion was found in the dry bay on the upper skin in places. The corrosion was removed.
- A fuel line was replaced in the #3 bay.
- An access plate was leaking on the left side. An O-ring was installed and the plate was sealed,
- New fittings were installed after finding a 1/4 inch crack in the bathtub fitting in the bolt hole running from the fuel tank to the forward cargo at station 1001.

All of the fuel pump component shop records and testing records were reviewed for each of these airplanes, The records identified similar discrepancies and overhaul procedures as in the accident airplane.

3, FM OVERSIGHT

The Federal Aviation Administration (FAA) Principal Maintenance Inspector (PMI) currently assigned to the TWA certificate is located in Kansas City, MO, the Certificate Holding District Office (CHDO). The PMI was hired by the FAA in July 1988, and served as Partial Program Manager for the Boeing 747/767 fleets, and later as Assistant PMI for two years prior to his appointment as PMI on January 7, 1996. The PMI has no other certificate responsibilities other than TWA, The PMI has an assistant and feels that he has sufficient support and manpower to accomplish proper oversight of the carrier.

The PMI stated that individual inspectors are assigned as Partial Program Managers(PPM) with oversight responsibility for the different make/model aircraft that TWA operates. The PPM's and fleets are divided as follows: DC-9, B727, B747/757/767, and L101 l/MD-80. At the time of the interview, a new position, the PPM for Powerplants was being created.

The PMI stated that the last National Aviation Safety Inspection Program (NASIP) for TWA began on September 25, 1995, and was concluded on October 6, 1995.

The NASIP for TWA was one of 141 safety audits directed by the Secretary of Transportation The audits were directed for all certificate holders conducting operations under 14 CFR Part 121 and Part 135 aircraft with a seating capacity of 10 or more in scheduled operations. Both TWA Operations and Airworthiness issues were inspected. Areas that the NASIP team focused on were: Manuals and Procedures; Records System, Maintenance Facilities; Contractual Arrangements; Reliability Program; Continuing Analysis and Surveillance Program and Aircraft Ramp Inspection.

Airworthiness Inspectors were located principally at TWA's main maintenance base located in Kansas City, MO. The Airworthiness Inspectors also traveled to additional TWA locations to accomplish their assignments. Geographic resources were used in Atlanta, GA, Dallas/Ft. Worth, TX; and Salt Lake City, UT to assist in performing 3,627 ramp inspections.

AIRWORTHINESS FINDINGS

Manuals and Procedures

During the inspection TWA's General Policies and Procedures (GP&P) Manual and the Continuing Analysis and Technical Surveillance Manual were reviewed for content, currency, and applicability to FAR 121 and FAA Order 8300.10.

It was found that in the GP&P manual, Chapter 12-1-O, Continuing Analysis and Surveillance, Page 1, it did not reflect the correct revision page date and Chapter 3-50-3 referenced a report that no longer existed.

Records System

The Records Department is responsible for maintaining and controlling all aircraft, engine, and component records for its fleet of aircraft by using a maintenance alert computer system that produces histories of all scheduled maintenance/inspection accomplishments.

The findings of sampling aircraft log pages and check inspection packages were reviewed to determine the performance and effectiveness of TWA's Continuing Analysis and Surveillance Systems.
In some cases, it was found that a failure was not properly reported. There were also some findings that TWA did not properly comply with a deferred procedure.

Maintenance Facilities

TWA's main maintenance base houses the Airframe, Component, Powerplant and Accessory Overhaul Shops. The facility has two wide body hangers and bays available to perform work on the L-1011, B-747, B-767, DC-9, and B727. Various shops and several store areas are dedicated to support maintenance performed on these aircraft.

The on-site inspections were conducted at Kansas City, MO, St. Louis, MO, and New York, NY. The inspection included technical manuals, test equipment and tool calibration, parts and materials, including control of shelf life items, hangar and support shop areas, airworthiness release authority and required inspection items, TWA's procedures for proper servicing, maintenance, and preventative maintenance of their aircraft.

During the inspection, in a few cases, discrepancies were found that identified company procedures were not followed to insure test equipment was calibrated. Calibrated and un-calibrated equipment was mixed on workbenches, and in the test equipment supply room. A few unserviceable parts were found on the shelf without tags to identify them as unserviceable. A few materials and some expired materials were not properly tagged and, in two cases, maintenance personnel were viewed not wearing safety glasses while operating equipment that required eye protection,

Contractual Arrangements

TWA has contractual arrangements with 420 contractors/vendors that only perform functions for which they are rated. A performance monitoring and audit program is used to determine if the facilities, equipment, and personnel qualifications are adequate. These contractors/vendors are monitored through the Coordinating Agency for Supplier Evaluation (CASE) program or quality assurance audits, and/or reliability data.

The contractual agreements, contractor/vendor audit files, and the CASE current registers were reviewed to determine the scope of the carriers compliance with FAA accepted procedures.
It was found that two vendors were approved by Purchasing/Repair Order Administration as an outside vendor repair agency without an approval from Quality Assurance.

Two vendor files were found to have never been audited by Quality Assurance and the station audit report for on-call contract maintenance facilities shows that four stations had never been audited.

Reliability program

TWA's reliability control program objectives are to identify, evaluate and act upon substantiated symptoms of performance deterioration and to establish and monitor prescribed maintenance control requirements.

The inspection team reviewed Engineering Report -1733, and the Monthly Mechanical Reliability Reports to determine the performance and effectiveness of TWA's monitoring function of the Continuing Analysis and Surveillance System.

It was found that in Engineering Report 1733, the approved document that gave the reliability program description and standards for determining maintenance intervals and process, indicated that only certain areas required FAA approval. There was no list of effective pages, no column revision bars to indicate changes, and the approval page did not reflect the date of approval.

The document did not identify a formal response to an alert, and there was no requirement for a periodic meeting to ascertain the effectiveness of the engineering departments reaction to the alert items.

Continuing Analysis and Surveillance Program

The Continuing Analysis and Surveillance (CAS) Program encompasses two functions The first consists of the Quality Audit Program for the continuous surveillance of the administrative and supervisory aspects of T WA's Continuous Airworthiness Program. This included outside vendors and repair stations by sustaining membership in the CASE program and on-site audits.

The second function is the monitoring of the mechanical performance of aircraft engines and components by data collection/analysis of their Maintenance Reliability Program.

The inspection team reviewed Company Audit Reports, Mechanical Interruption and Reliability Reports, Aircraft Maintenance Log discrepancies, Routine/Non-Routine discrepancies, Overhaul/Repair Reports, Component Reliability Reports, Component Analysis Reports, Unscheduled Removal Report, Letter Check Packages, Engine Condition Monitoring and AD Compliance Records to determine the program's effectiveness and compliance.

The inspection team found that the CAS system was identified in the GP&P and a specific CAS Program Manual that provided policies and procedures to facilitate the program, however, it did not identify a formal CAS organization, duties and responsibilities of CAS members, or processes by which accountability can be determined for CAS programs.

Several fictional areas of CAS were identified that were less than effective. It was found that several required quality assurance audits were not accomplished. Some audits had been accomplished, however, multiple errors or omissions on the maintenance sign off-sheets were noted. Several audits had no follow-ups to insure that the findings were corrected. Several audits listed the same findings as the previous audit with no apparent lasting corrections.

The long term CAS system monitoring is limited to "alerted" component changes in the reliability program, The review identified several component alert levels that may never "alert." The CAS system also utilizes pilot reports (PIREPS), however, the GP&P did not reference PIREPS as a source of reference or information for the CAS system. The Reliability Engineering Report - 1733 did not include a requirement to include new aircraft fleets and/or powerplants in the alerting portion of the program for the first 12 months of operation following acquisition.

The CAS system identified in the GP&P and the CAS system manual did not have a "formal" structure to assure communication and coordination within the maintenance organization. There was no standard format for meetings, no regularly scheduled CAS meetings, and no requirement for a CAS report or minutes of CAS meetings.

TWA maintenance managers did conduct a daily meeting to discuss the previous days maintenance and operational concerns and maintenance scheduling needs, however, the agenda did not include any other CAS functions identified as elements of a CAS system.

Aircraft Ramp Inspection

The ramp inspections were accomplished on "in-service" aircraft and was a technical airworthiness condition check.

A total of 53 ramp inspections were accomplished by maintenance and avionics inspectors. The inspection found that TWA was maintaining its fleet in an airworthy condition.

Some of the discrepancies that were found were corrected on the spot, or were appropriately deferred. Some cases of specific findings required additional investigation by the TWA certificate management team to support appropriate actions.

The discrepancies not corrected on the spot were:

- The right wing surge box was leaking fuel around the under wing access plate.
- A bulk cargo door insulation blanket was missing.
- During the First Officer walk-around, a blue stain down the right side of the aircraft all the way to the leading edge from the forward lavatory was not mentioned or written up. The inspector advised a maintenance person, who drained the lavatory and placarded it inoperative. The aircraft was then sent on to the next station.
- On two occasions placards were either missing or unreadable.
- Two vertical dents approximately six inches and eight inches long were found on the left side of the fudelage under the L 1 Door.

At the end of the NASIP inspection, a summary of the airworthiness findings indicated

- **5 Category A items - Any noncompliance with a Federal Aviation Regulation**
- **32 Category B items - Failure of the certificate holder to adhere to documented company procedures, related to specific regulatory requirements or safety, that have been developed by the certificate holder and approved or accepted by the FAA**
- **10 Category C items - Lack of systems that would assure the certificate holder of compliance with continuing or reoccurring FAR requirements.**

The listed findings which are incorporated into the National Program Tracking and Reporting Subsystem (NPTRS) were closed out with either an "E" indicating that the findings resulted in an enforcement action, or with an "I" indicating that additional information is contained in the NPTRS record. The Flight Standards Certificate Holding District Office concurred with the action that TWA took to correct the findings.

Debra J. Eckrote

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Maintenance Group Chairman

10/29/97